



The Economics of Rebuilding Fisheries

WORKSHOP PROCEEDINGS



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Foreword

The 2002 World Summit on Sustainable Development saw governments around the world undertake to “maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015.” However, progress towards this goal has been slow. FAO data on the state of world fish stocks indicate that 17% of the world’s fish stocks are overexploited, 7% are depleted, and 1% is recovering from depletion. A recent World Bank study estimates that approximately USD 50 billion is lost annually in global resource rent from fisheries as a result of poor governance.

Rebuilding overfished and depleted fisheries is a challenging task. Governments have had mixed success in designing and implementing effective stock rebuilding programs, with a number of high profile successes as well as notable failures. Understanding how governments, the fishing industry and others are addressing this challenge as well as how an interdisciplinary approach that combines the natural and social sciences with effective stakeholder engagement will provide important insight into the effectiveness of various strategies to rebuild fisheries.

The Workshop on the Economics of Rebuilding Fisheries was convened by the OECD’s Committee for Fisheries, and held in Newport, Rhode Island, United States on 21-22 May 2009.

The Workshop was chaired by Rebecca Lent, Director of the Office of International Affairs, NOAA Fisheries and brought together policy makers, fisheries managers, economists and fisheries biologists to exchange information and analysis on how to design rebuilding strategies to achieve sustainable and profitable fisheries. The Workshop followed the biennial Forum of the North American Association of Fisheries Economists (NAAFE), and allowed for synergies generated by such a gathering of fisheries economists, many of whom have experience in economic aspects of stock rebuilding.

The two-day Workshop consisted of six sessions that included expert presentations and plenary discussions. The first sessions set the theoretical foundation for the Workshop through presentations and discussions identifying the economic and policy issues involved in rebuilding fisheries, reviewing the state of play with respect to biological and economics technical aspects of rebuilding fisheries and identifying the key indicators and information constraints that underpin and influence the analysis. The sessions on Day 2 provided for a review of selected country case studies and international experiences in rebuilding fisheries.

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Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABC	Acceptable Biological Catch
ACL	Annual Catch Limits
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AM	Accountability Measures
BSCZSF	Bass Strait Central Zone Scallop Fishery
CAY	Current Annual Yields
CBA	Cost Benefit Analysis
CDQ	Community Development Quota
CEA	Cost Effectiveness Analysis
CPUE	Catch per Unit Effort
DAS	Days at Sea
DFO	Fisheries and Oceans Canada
DWFS	Distant Water Fishing States
EC	European Commission
ECDWT	East Coast Deepwater Trawl Sector
EEZ	Exclusive Economic Zone
ETBF	Eastern Tuna and Billfish Fishery
EU	European Union
FAO	Food and Agriculture Organization

FCA	Fishery Cooperative Associations
FFRMC	Federal Fishery Resource Management Committees
FMO	Fishery Management Organization
FMP	Fishery Management Plan
FR	Fishing Rights [legally defined] (Japan)
FSRP	Fish Stock Rebuilding Plan (Korea)
GAB	Great Australian Bight trawl sector
GHL	Guideline Harvest Level
GHT	Gillnet, Hook and Trap
GOM	Gulf Of Maine
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Commission for the Exploration of the Sea
IPQ	Individual Processing Quota
IQ	Individual Quota
ITQ	Individual Transferable Quota
IVQ	Individual Vessel Quota
LFRMC	Local Fishery Resource Management Committees
MAFF	Ministry of Agriculture, Forestry and Fisheries of Japan (Japan)
MAY	Maximum Average Yield
MBAL	Minimum Biological Acceptable Level
MCY	Maximum Constant Yield
MEY	Maximum Economic Yield
MFMT	Maximum Fishing Mortality Threshold
MIFAFF	Ministry for Food, Agriculture, Forestry and Fisheries (Korea)
MPA	Marine Protected Area

MSA	Magnuson-Stevens Fishery and Conservation Act
MSC	Marine Stewardship Council
MSE	Management Strategy Evaluation
MSRA	Magnuson-Stevens Reauthorization Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	Northeast Atlantic Fisheries Commission
NEFMC	New England Fishery Management Council
NMFS	National Marine Fisheries Service (United States)
NOAA	National Oceanic and Atmospheric Administration (United States)
NPFMC	North Pacific Fishery Management Council
NPF	Northern Prawn Fishery
NPV	Net Present Value
NSSH	Norwegian Spring Spawning Herring
OCS	Offshore Constitutional Settlement (Australia)
OECD	Organization for Economic Co-operation and Development
OFL	Overfishing Level
PA	Principal – Agent [analysis]
PFMC	Pacific Fishery Management Council
PSC	Prohibited Species Cap
RCA	Rockfish Conservation Area
RFMO	Regional Fisheries Management Organization
RRP	Resource Recovery Plan
SAFE	Stock Assessment and Fishery Evaluation Reports (United States)

SARA	Species at Risk Act (Canada)
SESSF	Southern and Eastern Scalefish and Shark Fishery
SRP	Stock Rebuilding Plan
SSB	Spawning Stock biomass
TAC	Total Allowable Catch
TAE	Total Allowable Effort
TURFs	Territorial Use Rights for Fishing
UNCLOS	United Nations Convention on the Law of the Sea
UNCOVER	Understanding the Mechanisms for Stock Recovery
UNFSA	United Nations Fish Stock Agreement
WCPFC	Western and Central Pacific Fisheries Commission
WSSD	World Summit on Sustainable Development
WWF	World Wildlife Fund

Introduction

Rebecca Lent, Chair of the Workshop
 Director of the Office of International Affairs, NOAA Fisheries
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Rebuilding depleted fisheries and maintaining sustainable fish stocks is the central objective of fisheries management. At the international level this is espoused through agreements such as the UN Convention on the Law of the Sea, the UN Fish Stocks Agreement, and most recently through the World Summit on Sustainable Development (WSSD) commitment to rebuild fish stocks to maximum sustainable yield (MSY) levels by 2015. In addition, ensuring a profitable fishing industry that supports coastal communities where few alternatives may exist, maintaining biodiversity and ensuring food security are key drivers for rebuilding fisheries. From an economic point of view, recent studies have estimated the lost rent from not rebuilding fisheries; the FAO/World Bank estimates that this could be as much as 50 billion USD each year. Moreover, many experts suggest that a necessary first step to rebuilding fisheries is evident and generally effective: a rapid reduction of fishing effort for overfished and depleted fisheries. But if that is the case, why does FAO data indicate that the percentage of overfished and depleted fisheries have been increasing, and now represent almost 30% of fisheries globally?

A closer examination of the problem demonstrates that there are many complexities involved in the development and implementation of fisheries rebuilding plans. While UNCLOS codified a 200-mile exclusive economic zone (EEZ) that provided countries with the ability and the responsibility to manage fisheries, much of the oceans are not under the exclusive jurisdiction of one country. Regional fisheries management organizations (RFMO) have been established to develop a collaborative management process for straddling and high seas stocks and are bound by the need for consensus based approaches to fisheries management, but are constrained by limited jurisdictional authorities as well as by enforcement issues and funding limitations. At the same time, exclusive jurisdiction does not necessarily guarantee sustainable fisheries. While the fisheries legislation of many OECD countries either explicitly or implicitly encourages, or perhaps requires rebuilding, there are often other factors that influence the decision making process, including the human dimension of fisheries adjustment. In order to successfully rebuild fisheries, close collaboration among stakeholders and government authorities will be necessary to ensure that the best available information is suitably utilized and that all participants in fishery rebuilding are effectively involved.

Against this backdrop of international commitments, domestic needs, and competing goals - social, biological and economic - it becomes apparent that a holistic approach to rebuilding fisheries is necessary. To be effective, fisheries rebuilding should be based on

the analysis of the biological and economic impacts and risks of various rebuilding options and the clear and transparent communication of the associated uncertainty. The additional complexities of climate change and ecosystem interactions largely exogenous to the fisheries sector also confound efforts, and must be taken into consideration to ensure effective fisheries rebuilding.

It is in this context that the OECD's Committee for Fisheries organized a workshop on the *Economics of Rebuilding Fisheries*, as part of the Committee's ongoing project on this topic. The purpose of the Workshop was to collect information for the preparation of a final report by analysing and discussing the key economic and institutional themes that emerge in the development of fisheries rebuilding plans, and how countries have been responding to these issues.

The Workshop

This Workshop brought together over seventy international fisheries experts with training in both economics and biology including academics, fisheries managers, and government representatives. The Workshop provided a forum to showcase the current knowledge of the key economic and policy challenges in the development and implementation of fisheries rebuilding plans. It also provided a solid overview of the technical and practical issues involved in developing appropriate indicators for rebuilding paths and timeframes as well as reviewing progress of plans. Discussions at the workshop also helped to identify what type of information is necessary and at what level of detail in order to develop robust rebuilding plans; for example, one participant noted that directional trends in stock size may be an indicator that is satisfactory for the selection of appropriate rebuilding paths, rather than trying to obtain precise numbers given that there is always some level of uncertainty around scientific estimates. Finally, the workshop provided an assessment of how information constraints may be addressed with respect to rebuilding fisheries.

Specifically, the objectives of the workshop were to:

- Identify and analyse the economic and policy issues involved in rebuilding fisheries.
- Identify the biological and economic uncertainties and information constraints that influence the choice of rebuilding paths and policy instruments.
- Review the role of institutional arrangements in delivering successful rebuilding programs.
- Review selected country and international experiences in rebuilding fisheries.

Some of the interim conclusions of this intermediate step in the research agenda are summarized below showing how the objectives were met.

The two-day workshop was composed of six sessions, each of which focussed on a particular aspect of rebuilding fisheries. Workshop participants shared the view that the key issues related to fisheries rebuilding are similar to those involved in general fisheries management. However, certain elements associated with fisheries rebuilding can be particularly complex, particularly regarding political economy aspects. In some cases, trust in the regulator may be severely diminished when there is a stock collapse, challenging the collaborative development of credible and effective fisheries rebuilding

plans. In addition, the dilemma of shifting the status quo becomes even more acute when rebuilding fisheries, unless due consideration is given to the structure of the fishery coming out of the rebuilding process. In this regard, a distinction can be drawn between *stock rebuilding* and *rebuilding fisheries*; the former is focussed more or less exclusively on the species and its habitat, while the latter would extend to the fishing industry and consider the human dimension as well, thus necessitating an economic component to rebuilding. In the case of fisheries rebuilding, the impacts of issues such as illegal or unregulated fishing are emphasized and cases of so-called institutional overfishing (where scientific-based TACs for depleted stocks are not applied) becomes amplified. As such, case studies of successful rebuilding plans become important as a way to identify best practices for not only rebuilding fisheries, but also to identify the fisheries management tools that can be applied to avoid depletion and maintain fisheries at sustainable levels.

In addition to the Introduction, the proceedings also include research papers focussing on the major themes that were presented at the Workshop; these papers represent a significant body of work that will inform fisheries rebuilding from an economic perspective, will be summarized briefly below. Finally, this publication concludes with biographies of the speakers who presented their papers at the workshop, including those who contributed a paper to this volume, followed by a list of workshop participants.

Day 1

The first day was structured to set out the broad analytical context for the workshop through sessions devoted to an overview of the range of economic issues involved in developing and implementing fishery rebuilding programs; a review of the economic and biological aspects linked to the choice of stock rebuilding paths, identifying the costs and benefits of rebuilding paths, reviewing valuation methods, and addressing incomplete and imperfect data; a review of the role of risk and uncertainty in the design and implementation of rebuilding programs by identifying the types of natural, economic and political risk that can influence the outcomes of rebuilding programs and reviewing the range of institutional mechanisms for mitigating risks.

During the first day, several issues that confound rebuilding from a fisheries manager's perspective were identified, namely conflicts between competing interest groups and organizations, dealing with vested interests as well as the optimum way in which to integrate economic factors and social interest. Fisheries managers are often required to balance short term interests and costs with longer term opportunities and benefits in order to effect change in situations where there are often political implications. Some examples of rebuilding approaches were provided and it was noted that in order to raise the profile of this issue, the economic context of fisheries rebuilding should be considered, particularly the economic benefits of doing so as well as the social and economic costs of delay. In the context of global food security issues, the importance of fish as a food source was highlighted.

Another point raised during the discussions of the first day was that collaboration among biologists, economists and stakeholders is needed in order to effectively evaluate the overall costs and benefits of different rebuilding paths and targets, as well as the resultant distributional impacts. This type of collaboration would also strengthen the determination of the relative efficiency and effectiveness of various rebuilding options and measures. It was also noted that the diversity of factors that are sometimes overlooked in terms of setting rebuilding timeframes and targets include: the question of how to manage multispecies fisheries where rebuilding weak stocks may have an effect

on the overall value of mixed stock fisheries; how to address factors that may change stock productivity, including climate change; and, the potential for long-term social costs that may result when there are strict rebuilding constraints (e.g. imposed through legislation or otherwise) to attain rebuilding targets or goals in a certain timeframe.

Importantly, it was noted that the definition of an optimal rebuilding strategy is subjective, and based upon the characterization and measurement of current and future benefits and goals. For example, a basic bioeconomic model would generally indicate that the shortest timeframe to rebuild a stock is ideal through cessation of fishing until the objective is reached. However, there are economic and technical factors that may rationalize a slower path towards rebuilding and should be considered; these would include elements such as the inverse relationship between landings and prices; increased marginal costs of harvest; high discount rates; the potential loss of processing capacity and market access; and, possible social disruption. It was also noted that the fishing industry generally opted for approaches that allow for a certain level of harvest over time, with few sudden peaks or lows; the point was made that while this may be considered as delaying the inevitable in the case of depleted fisheries, it may be optimal from an economic point of view to have a uniform rate of change in allowable harvest levels.

Day 2

Day 2 of the Workshop focussed on implementation experiences at the national and regional level. Specifically, there were presentations of a number of country case studies in rebuilding programs, which focussed on the economic, biological and social outcomes and identified the economic and policy issues that were of particular importance. These case studies provided an indication of the types of challenges facing governments in developing and implementing rebuilding programs. A session devoted to international experiences with stock rebuilding reviewed the particular challenges in developing and implementing rebuilding programs for international fisheries, including the role of RFMOs, enforcement mechanisms, and links to national rebuilding programs.

Discussions took place on the role of institutional arrangements in determining the success of rebuilding programs, including alternative management strategies, enforcement, stakeholder involvement, feedback and adjustment mechanisms within the programs, and the use of triggers and rules to assist decision-making.

In terms of mitigating distributional effects of rebuilding, the following factors were identified for consideration – the use of property rights as a means to shift the focus to the long term value of the resource as opposed to the short term; flexibility in management as opposed to complexity, which can for example be imposed through rigid timeframes and targets; collaboration with stakeholders to allow for a participatory and transparent process; clarity in terms of the rationale for decision rules, timeframes and goals; and, appropriate monitoring and enforcement of decision rules.

Day 2 also included several case studies of international experiences with fisheries rebuilding, as discussed in Chapter 10. In particular, this session built upon the previous discussions around theoretical concepts towards action and implementation of rebuilding plans.

For example, the status of five stocks of Atlantic cod was reviewed with a focus on the complexities involved in the rebuilding process. In particular, the role of shared stewardship was examined in a context where there are few realized benefits. In this case, the role of the regulator was described as precarious, as the fact that the stocks have

remained at low levels for a significant period of time may decrease the prospects for collaboration with industry to develop a meaningful rebuilding plan. Against this backdrop, Canada's endangered species legislation plays an uncertain role in the rebuilding process, given the emphasis on the short term aspects of cost benefit analyses by policy makers, and that it may not be well suited to the management of commercial species. The complexities of Atlantic cod are also characterized by the lack of significant recovery despite a long term fishing moratoria of some stocks and uncertainties in the science has led to the continuation of small scale fisheries to help monitor the resource. Issues of climate change and ecosystem shifts have also been discussed as possible reasons for the continued low stock status of Atlantic cod.

The Workshop concluded with a plenary discussion that drew together the various strands of the lessons learned, identified the key issues, and suggested case studies that would yield insights into fisheries rebuilding.

Research Papers

This section presents a short summary of the papers that follow in the proceeding sections of this publication, with an emphasis on points from the papers that relate to the four objectives of the workshop.

John Davis, an Associate with the Institute for Coastal and Oceans Research at the University of Victoria, presented the first paper, entitled: "Rebuilding fisheries: Challenges for fisheries managers". This paper provides an overview of the key scientific, management and political economy issues associated with fisheries rebuilding and introduces the variety of the policies and programs established in selected OECD countries designed to rebuild fisheries. Notably, the paper hinges on the idea that economics has an important role to play in the design of rebuilding plans given the numerous choices that are to be made throughout the process; this includes the time horizon for rebuilding, and the management tools to be used. The role of fisheries economists in making a successful case for the economic advantages of fisheries renewal, rebuilding approaches, and sustainability is also emphasized, as is the importance of managing the transition to rebuilding, including development of support for rebuilding from often conflicting interest groups.

The second paper, prepared by Saba Khwaja & Anthony Cox presented a review of approaches in OECD countries and identifies the range of legislative and policy mechanisms available to support or guide rebuilding through comprehensive and detailed legislation that frames each step, as compared to integrated approaches where a depleted fishery triggers a certain set of actions within the broader fisheries management framework. The paper notes that in designing and implementing fisheries rebuilding programs, policy makers need to ensure that the programs are cost efficient and effective. The paper also notes that there is also a need to ensure that economic information is integrated into decision making at key points in the process as successful rebuilding often depends more on institutional structure and socio-economic context than any other factors alone.

The third paper, entitled "Getting the economics and incentives right: Instrument Choices in Rebuilding Fisheries" was presented by Gordon Munro, from the University of British Columbia and CEMARE, University of Portsmouth. This paper equated a fisheries rebuilding program with a "natural" capital investment program, as all natural resources, including marine capture fishery resources, are properly regarded as "natural"

capital. Following this reasoning, the paper argues that the proper incentives must be in place so as to ensure that the cost of investment is borne willingly. The author notes that such an incentive would be an assured share of the future resource investment payoff while also stating that there are aspects to solving the question of the appropriate incentive that require further consideration and research. Examples from the British Columbia groundfish fisheries show that “Incentive Blocking” approaches to resource management were ineffective, while “Incentive Adjusting” approaches such as ITQs created resource rents through cooperative games among fishers, although this result is highly dependent on establishing effective monitoring schemes. The author shows that while effective at halting overexploitation, Incentive adjusting measures such as ITQs alone are not enough to induce stock rebuilding. They call for future research into what incentives can be put in place to encourage investment in the resource, or not to discourage resource investment programs, at both intra-EEZ and international levels.

Daniel S. Holland, from the Gulf of Maine Research Institute, presented the fourth paper: “Economic considerations and methods for evaluating fishery rebuilding strategies”. The paper focused on how different rebuilding strategies, including timing and setting catch and biomass targets, impact the net benefits generated by the fishery during rebuilding and beyond. Oft-neglected issues such as multispecies fisheries and changes in fishery productivity relating to climate change were also discussed, as well as the advantages of Management Strategy Evaluation (MSE) as a tool to design rebuilding strategies that are robust to uncertainty. The paper shows, using a simple fisheries model, that more gradual rebuilding strategies are likely to generate greater economic benefits if demand is inelastic or marginal costs are increasing with the level of fishing activity, and that depending on the fishery, in many cases it may be desirable to rebuild fish stocks to well above BMSy.

In the paper “Harvest Strategy Policy and Stock Rebuilding for Commonwealth Fisheries in Australia” by Peter Gooday et al, describes the development of the Australian harvest policy strategy, and in particular the shift towards the goal of maximum economic yield (MEY). The authors note the importance of having pre-defined harvest rules as a means to improve transparency and provide fishers with enhanced certainty over their current and more importantly future fishing activity. Notably, the paper describes how the implementation of the harvest strategy policy along with other measures to improve fisheries management arrangements are essential if the benefits from a recent decommissioning program to remove excess capacity are to be maintained. It is recognised in the harvest strategy policy that achieving the MEY target in fisheries that require rebuilding involves trading off short term economic gains against longer term fishery profitability. A number of issues associated with implementing an MEY target are canvassed in the paper.

Susan Hanna’s paper discusses the theme of “Managing the transition: Distributional Issues of Fish Stock Rebuilding” illustrated through three United States fisheries, and draws three key conclusions. First, the resolution of access rights is necessary in order to provide fishers with an incentive to take a long term view, rather than focussing on short term benefits and uncertain long term gains (if any). Second, the larger economic and social goals of the fishery need to also be addressed; this includes effectively engaging stakeholders in the rebuilding process. The third point raised is regarding the ability to mitigate distributional effects effectively; the case studies note that this depends on having clear decision rules with defined limit points and non-discretionary actions.

Lee Anderson's paper "Setting Allowable Catch Levels within a Stock Rebuilding Plan", defines a stock rebuilding plan as in essence a harvest control rule that specifies the level of harvest that is to be permitted at each stock size over the relevant range from the current size to the target stock size, X_{tar} . The paper develops an analytical probabilistic framework to consider how a harvest level (or TAC) given by a control rule can be modified to account for uncertain information about stock characteristics and conditions, and weaknesses in the construction of control rules. The amount by which a harvest level can be adjusted is defined as a "buffer", which has a cost in terms of lost of the net value of fish foregone, but also has a benefit in terms of decreasing the risk of deviating from the stock growth trajectory specified by the control rule. The author shows that conceptually the optimal size of this buffer occurs where the marginal reduction in the value of expected losses from missing the target (something we have little information on at the present) is equal to the marginal cost of increasing the buffer. Optimal buffer sizes also depend on the value of the loss (L) for missing interim stock sizes, or deviating from the stock growth trajectory. The author presents the optimal buffer sizes for different values of L .

In "Information Issues and Constraints in the Design and Implementation of Stock Rebuilding Programs", Andy Rosenberg and Susan B. Mogenson review two case studies (North Sea Cod and George's Bank groundfish) and develop a general scientific advice framework which identifies information needs for designing rebuilding plans. The authors identify, amongst the important considerations when designing management and rebuilding plans, uncertainty, reference points, effort control, implementation and monitoring. The importance of reducing bycatch and discarding is underlined, as well as the need to avoid adjusting measures too early in response to apparent or early signs of recovery. Three types of uncertainty are identified, including uncertainty in model formulation. The authors guard against "shifting baselines", which the tendency to assume that recent history reflects the full capacity of the resource. Instead, longer time series should be used. Recovery measures should be limited to data-rich fisheries but to data-poor fisheries as well. Recent research on how to support recovery planning for data-poor stocks is presented.

The paper entitled "Rebuilding Fishery Stocks in Korea: A National Comprehensive Approach" by Sang-Go Lee, College of Fisheries Sciences, Pukyong National University, Korea, provides a detailed overview of a new rebuilding strategy implemented in Korea in 2005: the fish stock rebuilding plan (FSRP). A novel aspect of this strategy is the establishment of a joint management system with fish harvesters, to increase stakeholder participation and sense of ownership. 10 FSRPs have been implemented so far in Korea, with some success. The sandfish fishery in the East Sea is given as an example, where the catch per unit effort (CPUE) increased from 0.44 in 2005 (before the FSRP) to 0.78 in 2007. Consequently, fishing income has increased by 10%.

The final two papers presented in this publication are case studies of national fisheries. The first, "Rebuilding the stock of Norwegian Spring Spawning Herring: lessons learned", by Per Sandberg, from the Norwegian Directorate of Fisheries, is a case study of the rebuilding of the Norwegian spring spawning herring stock, one of the largest pelagic fish stocks in the world. The author assesses the regulatory measures adopted to facilitate the recovery of the stock and discusses economic consequences of improving the exploitation pattern and exploitation rate in the fishery. The second paper, "Community-based Management for Sustainable Fishery: Lessons from Japan" was presented by Hirotugu Uchida, from the Department of Environmental and Natural Resource Economics, University of Rhode Island. Inspired by the success of co-

management approaches for rebuilding stocks in Japan, driven by fishery cooperative associations (FCAs) and legally defined fishing rights, the author presents the three necessary conditions for successful co-management: well-defined boundaries, an affordable exclusion mechanism, and a condition of “privileged.” The author argues as well for successful rebuilding, enhancing profitability of the fishery is important because without tangible rewards, such as more profits, fishermen will not be interested in or sustain their interest in stock-rebuilding efforts.

Summary of interim conclusions

This section provides a summary of the main interim conclusions regarding fisheries rebuilding as discussed by the Workshop participants. This section brings together the areas of agreement, organized around the stated goals of the workshop.

Objective 1.

Identify and analyse the economic and policy issues involved in rebuilding fisheries.

Integrating economics throughout the rebuilding process: There was overwhelming agreement among Workshop participants that **integrating economics throughout the fisheries rebuilding process** is not only feasible, but necessary to enable sustainable fisheries. The discussion then turned towards *how* economic analysis and information can be fully utilized early on in the design and implementation of fisheries rebuilding plans, as well as identifying obstacles that prevent the explicit inclusion of economic considerations. There was considerable discussion around using maximum economic yield (MEY) as a target, given that it allows for optimization of rent as well as it is more precautionary with respect to biological targets.

While it was argued that economics should already be an integral part of fisheries management, there is an added significance in this context regarding transparency about the economic tradeoffs associated with various rebuilding paths. In most instances, economic information is generally present as a backdrop to the development of fisheries rebuilding plans, given that decision makers consider a broad range of factors in the design of rebuilding targets, objectives and measures. As such, there is a need to find credible approaches to embedding economic information in the development of rebuilding plans, in order to be explicit about economic impacts (both costs and benefits) and also to arrive at targets and outcomes that are both biologically and economically beneficial. The exclusion of economic considerations can lead to severe measures such as extended fisheries closures that may lead to favourable outcomes from a biological perspective (more rapid rebuilding of a stock), but may have devastating economic consequences (e.g. lead to the loss of existing markets and access should substitutes be readily available and idle harvest and processing capacity may weaken harvest efficiency once the fishery is rebuilt). In this regard, Workshop participants shared the view that economics can play a significant role in fisheries rebuilding by identifying the rebuilding trajectory, measures and timeframes that address biological, social and economic goals and communicate clearly the tradeoffs that are being made.

As part of a comprehensive approach that includes the environment, biology, economics as well as stakeholder consultations towards fisheries rebuilding, it was agreed that the application and use of economics is an essential early warning system that can trigger action to rebuild fisheries rather than biological signs of depletion or overfishing on their own. The pressure to take action to rebuild fisheries often is realized when profits

decrease, as opposed to reductions in TACs or catch alone; in some cases, subsidies can blur these signals and mask the signs of stock depletion. Often, an economic crisis is required to prompt a political and management response in terms of rebuilding.

An integrated approach, where a broader suite of policy measures is developed, creates a stable foundation for fisheries rebuilding. Introducing flanking measures that reinforce rebuilding, concurrently with fisheries plans and management measures that ensure that appropriate support mechanisms are in place, protects the investments made towards sustainable fisheries and address the underlying issues that are a factor in stock depletion. Such short term measures as decommissioning schemes and capacity reduction programs can be applied to enable adjustment and rationalization of fisheries in parallel with measures to rebuild stocks, given that they are time bound and targeted. These measures are necessary to effectively rebuild fisheries in that they shore up the specific measures aimed at fisheries rebuilding by considering the post rebuilding phase – the eventual structure of the fishery.

In addition, an integrated and holistic approach requires the review and realignment of the broad suite of policies that affect the fisheries, from harvesting to the processing sectors. This would place fisheries on a stable footing and also supplement short term efforts such as capacity reduction with a broad suite of coherent policies that deal with longer term issues in order to smooth the transition and allow future adjustments to be self-directed.

Finally, a comprehensive approach also extends to the suite of measures used to rebuild fisheries. For example, limiting harvest is often not the only solution as consideration must be given to the carrying capacity of a particular species. In this regard, habitat restoration also becomes important.

Fisheries rebuilding can be viewed as an **investment program**. As is the case with all natural resources, capture fisheries can be identified as capital assets from a societal perspective. To this end, rebuilding fisheries can be considered as an investment program; as such, the optimal stock capital must be determined as well as the rate of investment (rapid versus gradual rebuilding). In order to efficiently address these two points, **aligning incentives** becomes critical for effective fisheries rebuilding. If the right incentive structures are not in place, there is no assurance that investment costs will be borne willingly. In some cases, this may include introducing property rights to support fisheries rebuilding, or some other such schemes whereby fishers are encouraged to be as precautionary as needed to ensure durable access at sustainable harvest levels. This institutes a vested interest in right holders and increases the probability of success in agreeing to and in implementing rebuilding. These property rights also may be a solution towards long term assessments in regards to the management options in fisheries rebuilding by somewhat addressing distributional issues – by ensuring that fishers have an established right to the resource, they are provided an opportunity to reap the future benefits of a rebuilt stock, after managing through conservation measures (e.g. reduced fishing seasons, allowable harvests) and the associated costs. In the context of aligning incentives, it is also important to note that governments may also wish to examine any possible disincentives that are in place that hamper effective management and rebuilding of depleted resources, including various subsidies that do not encourage self-rationalization of fleets.

There was considerable discussion on the **toolbox available** to governments in terms of rebuilding fisheries. Specifically, it was recognized that fisheries departments alone cannot achieve rebuilding and maintain stocks at a viable status, given the social and

other transition issues that accompany the inevitable pain of strict measures that often lead to significant short term costs in order to rebuild fisheries. In order to ensure that the policy response is coherent, the transition to a post rebuilding period must also be considered when designing rebuilding plans; for example, social policies should be used in the event of social disruption rather than fisheries management tools. To that end, a broader suite of tools should be considered in the development of rebuilding plans that may extend further than the mandates of fisheries departments. In cases where significant disruption to the fishery may be required to rebuild fisheries, a comprehensive policy response may also include income support and retraining. This would imply a close collaboration among government agencies that are responsible for broader economic development and social policies.

Objective 2.

Identify the biological and economic uncertainties and information constraints that influence the choice of rebuilding paths and policy instruments

Dealing with risk and uncertainty: Further work is required to provide policy makers with a clear analysis of the ways in which risk and uncertainty on biological, management and economic variables should be viewed and incorporated into rebuilding plans. These issues are generally acknowledged as areas where due consideration is required. However, in many instances, risk and uncertainty around rebuilding measures are not always communicated effectively to stakeholders. For example, some rebuilding plans may seemingly indicate that fisheries will rebuild to a certain level after a certain number of years with the introduction of conservation measure; however, there is often some level of uncertainty associated with these projections, and there is also probably some level of risk, particularly in cases where climate change or ecosystem shifts may be a factor.

In these cases, it would be crucial to not only reasonably estimate these risks and incorporate the uncertainty in the models, but it would also be essential to articulate them clearly to policy makers and stakeholders alike. This would be with the view to reduce future conflicts or misunderstandings should the projections outlined in rebuilding plans not hold true.

Dealing with multispecies and mixed stock fisheries: This is a very complex and contentious issue and it was clear from the discussions that it was one where there is a big demand for sharing of insights and experiences across OECD countries. A distinction is made between the mixed stock and multispecies fishery; the first involves a variety of species caught while only one is targeted while the second is where various species are targeted. The key issue relates to weak stock management, where fisheries are precautionary managed to protect the weakest stock. In these instances, fisheries for healthy stocks may be curtailed given the incidental catch of weaker stocks; in these cases, substantial sacrifices may be required by fishers who are obliged to forgo catch of stronger stocks to protect the weaker stocks.

Additional research regarding information needs to address economic aspects for rebuilding fisheries is required. In order to complete a robust bio-economic or economic analysis to support fisheries rebuilding, it is necessary to address data requirements at the outset, as part of the design of statistical data collection tools. Adding a few economic indicators to scientific surveys (e.g. fish size and distribution of catch may be useful information in terms of assessing market impacts) can go a long way in allowing for a meaningful examination of the economic costs and benefits of rebuilding plans.

Furthermore, it is recognized that there would be situations where neither perfect data nor even data would be available. It is precisely in these contexts that an assessment of how to manage data poor fisheries would be required.

Objective 3.

Review the role of institutional arrangements in delivering successful rebuilding programs

The importance of the **role of stakeholders in the rebuilding process** was a recurring theme in the Workshop, regardless of the institutional arrangement. Stakeholder involvement and transparency from the outset is of paramount importance to a successful rebuilding plan; communicating effectively and disseminating information on economic impacts is also crucial. However, it was emphasized that fishers need to be provided with the appropriate incentives for fisheries rebuilding and sustainability of stocks. Currently in many areas, fishers are motivated to fish to the greatest extent possible; if not, another fisher will harvest the available fish and reap the associated benefits. To that end, economic analysis and information can be used to demonstrate the potential benefits from fishing sustainably (e.g. in the form of future harvests, profits) as well as provide transparency on the short term costs that fisheries rebuilding may entail. Stakeholders may also be able to enhance both biological and economic analyses through datasets that they may maintain, and also may validate scientific surveys. Fishers are in a position to supplement data through their own fishing records and may also provide additional information regarding costs and earnings, as well as financial breakeven points. Access to fishers' data would allow for a meaningful assessment of the impacts of various rebuilding measures and scenarios. In this regard, developing **clear decision rules** was also identified as a successful feature of rebuilding plans in that there is a common understanding prior to the implementation of rebuilding measures as to the next suite of actions to be taken if milestones are not achieved. In this approach, agreement is made at the outset as to any ensuing rebuilding measures should targets not be reached by a certain date, as well as identifying when measures could start to relax. This would redefine the way that course corrections are implemented and provide much needed clarity to the process.

Policy coherence was discussed throughout the Workshop in terms of assessing the goals and objectives of fisheries policy (biological, social or economic) in light of the overarching objective of sustainable development. The continued development of policies across government departments which together reinforce overall objectives as opposed to those that work at cross purposes was emphasised as a necessary way forward in terms of rebuilding. Specifically, the role of subsidies, the use of fisheries as a form of economic development or as a means to support coastal communities in light of other policy initiatives that could also be applied, require further examination.

Managing the transition is a key area that merits additional research and consideration. Specifically, the matter of how policy makers and fisheries managers address issues of transition when major changes to the fisheries are undertaken to support rebuilding efforts. In particular, the role of stakeholder involvement, distributional effects, compensation strategies, coherence with social, tax and regional development policies, post-rebuilding management are aspects that require consideration during the design of rebuilding plans. Specifically, it is clear that using the fisheries to address social, economic as well as biological objectives leads to conflict amongst these options. For instance, a fishery organized around a social goal may lead to a policy of maximising employment at the expense of maximising profitability and increased pressure on the

resource to maintain jobs. In that regard, it becomes important to recognize that there are other agencies that are more suited to dealing with those issues.

Objective 4.

Review selected country and international experiences in rebuilding fisheries.

The session on **rebuilding fisheries in RFMOs** outlined the broad difficulties faced by such international organizations in the development of rebuilding plans. Fisheries rebuilding within RFMOs face specific challenges given issues such as unregulated fishing, the emergence of new players and the free rider dilemma, as well as reporting and enforcement challenges. Nevertheless, there have been notable successes such as Atlantic swordfish that can yield valuable lessons in the management of depleted stocks in such a context. Participants also discussed management beyond the EEZ and that consideration should be given to dividing up the rest of the ocean – essentially extending the EEZ beyond 200 miles - to enable national jurisdictions to exercise control over all areas.

The example of the International Commission for the Conservation of Atlantic Tunas (ICCAT) management of the Atlantic swordfish stocks provided a case of a rebuilt fishery. ICCAT's objective is to sustain fisheries at levels which allow for the greatest sustainable harvest for food and other purposes, by maintaining stocks at the MSY level. To that end, ICCAT has instituted a transparent process with respect to scientific data; all member countries to this RFMO may present data, and advice is widely available. Management and rebuilding of the stock have not only resulted through stringent measures that have increased over time, but also to the fact that catches have generally been below the set total allowable catches; in addition, swordfish lends itself to rebuilding given its species characteristics such as relatively widespread populations coupled with various spawning areas and comparatively rapid growth. Challenges to the rebuilding process were identified as maintaining TACs with the scientific advice. For example, as the stock was showing signs of recovery in 2008, the TAC was set higher than advised; the results of this action are unknown to date. The treatment of MSY as a target reference point rather than an upper bound means that it is possible to inadvertently exceed this point without necessarily overfishing, as recruitment naturally fluctuates. Furthermore, possible distinctions among populations at units smaller than the current management units, indicates that perhaps a finer scale level of management may be required.

Conclusion

As indicated in previously, this Workshop was intended to scope the economic and institutional issues associated with rebuilding, identify key areas of agreement and those requiring further research.

The Workshop confirmed that the role of economics in fisheries rebuilding is crucial to clearly identify and evaluate rebuilding options and to setting targets, objectives and measures. The participation of various stakeholders early in the design and development of rebuilding plans is imperative, as has been demonstrated throughout the case studies that were presented. A co-management or shared stewardship approach allows for a collaborative decision-making process increasing the level of buy in through all stakeholders. It was also emphasized that the underlying stock conditions and the surrounding environment must be favourable for rebuilding to occur; for example, an adequate amount of suitable habitat must be available for stocks to re-establish themselves. There was also considerable debate and discussion on how economic analysis

and information can be integrated in decision-making processes in a clear and transparent manner; it became evident that to do so successfully requires early consideration of economic factors during the development of biological surveys to the design and implementation of rebuilding plans. Rights based management approaches was identified through various case studies as an approach that has led to successful rebuilding, by instituting a vested interest in maintaining a sustainable resource.

There was overall consensus that methods to provide the appropriate incentives to all stakeholders in combination with clear decision rules would lead to more effective rebuilding programs and improved fisheries management in general. The challenge now is to appreciate what progress is being made towards implementing rebuilding plans and achieving their goals in light of various national and international commitments by examining current approaches and by demonstrating how economic factors are integrated in the decision making process, as a complement to biological assessments and stakeholder input.

Chapter 1.

Rebuilding fisheries: Challenges for fisheries managers

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Abstract

To set the stage for the workshop, this chapter provides an overview of the challenges and opportunities related to economic and policy issues for managing domestic and international fisheries, rebuilding depressed stocks, and achieving sustainability. The nature and characteristics of domestic and international fisheries are reviewed, with emphasis on the scientific, social, economic, and policy issues associated with managing and effecting needed management approaches and policy changes to achieve sustainability.

Specifically, factors related to why it is difficult to achieve change are examined with examples drawn from domestic and international situations. Conflicts between competing interest groups and organizations, economic factors related to vested interests, balancing short term interests with longer term opportunities and effecting policy change in such situations with political implications, form the basis of such difficulties in domestic fisheries management. In the international context, treaty arrangements, protocols, international agreements, conservation and sustainability on the high seas, and related laws and governance add complexity.

Examples of successful rebuilding approaches, factors leading to such outcomes, tools and strategies for achieving rebuilding, and potential opportunities are summarized with emphasis on the importance of managing the transition to rebuilding. Of particular importance in the future, and where fisheries economists can play a key role, will be making a successful case for the economic advantages of fisheries renewal, rebuilding approaches, and sustainability. Given the looming global food crisis related to world population trends, the importance of fisheries resources as a food source, and the need to address sustainability in the face of escalating demand and competition, will require a major effort in achieving success. Policy change, international governance, achieving popular support for fisheries rebuilding and sustainability as a foundation for domestic and international fisheries management will be essential elements in addressing the social and political challenges associated with fisheries rebuilding.

Why fisheries stewardship and fisheries rebuilding are critical

We have often heard the phrase “too many fishermen chasing too few fish” which succinctly describes the situation in many domestic and international fisheries. Associated with this reality are concerns about overcapacity, wasteful practices, conservation, fishing down top trophic level species, environmental and ecosystem degradation and frustrations with respect to achieving management objectives and effective regulatory and governance regimes. Indeed, analysis of the main series of the Food and Agriculture Organization of the United Nations (FAO) world fisheries catch database over the last 50 years indicates that 366 fisheries collapses occurred- nearly one of every four fisheries examined. Moreover, no reduction in the rate of collapse took place over that 50 year span, indicating that management improvements were not evident over time (Mullon, *et al*, 2005).

United Nations estimates the global human population will increase from the current level of over 6 billion to around 9 billion by 2050. Associated with this huge increase are major concerns about the Earth’s ability to sustain humanity and about an expanding global food crisis with its social, political and economic implications. It is clear that the fisheries resources of the globe will increasingly be affected by this demand and while aquaculture will provide some relief, harvesting pressure, management and fisheries rebuilding challenges will intensify as an increasingly hungry world turns to the sea, rivers and lakes as a source of food (Engelman, 2004). Exacerbating the world food crisis, will be anticipated impacts of global climate change which will affect key food-producing areas, many with large populations. Dyer (2008) predicts major social, economic and political destabilization as nations seek to feed their people, disputes over water result, and migrations of affected individuals take place. Climate change will impact aquatic resources in diverse and not clearly understood ways, complicating the task of sustainable management and fisheries rebuilding.

Given this situation, the task of sustainably managing, conserving and rebuilding fisheries resources is a critical one of vital importance to the human race. As an introductory talk to this OECD workshop on rebuilding fisheries, while not purporting to be an exhaustive review of a huge subject, this chapter aims to set the stage by broadly scoping the challenges, issues and potential approaches and opportunities and to suggest how fisheries managers, decision-makers and fishery economists can make a difference in addressing the important task of fisheries rebuilding.

The challenge of managing and rebuilding sustainable fisheries

Fisheries management is a complex task usually involving two major elements- a human element and a biological element. Typically there are multiple human interests and stakeholder groups, many of which extract economic and social benefits from the fisheries resources and are thus dependant on them. In addition, there are groups and individuals concerned with conservation, environmental issues and non-consumptive uses. From the biological perspective, fish are dynamic resources that cannot be easily observed, studied and evaluated. Unlike terrestrial resources, we cannot see most of the resources we are tasked with managing and must rely on sampling, survey methodology, estimates, models and data sets, usually catch and effort, in order to say something about the status of the stocks, their age structure and trends in abundance.

Scientific and technical information is thus used to make decisions, adopt management measures, impose conservation regimes and explain and justify those decisions to user groups. This often results in controversy, as those opposed to management measures may question the science or place alternate weight on certain indicators that support or contradict various perspectives. In addition, our oceans, rivers and lakes are not quiescent places where nothing changes. Aquatic systems are subject to natural and man-made variation and to fluctuations which alter physical and biological features of the ecosystem. This may result in changes in survival and abundance of the species or group of species being managed and require adjustment of management plans and conservation measures, with the need for resultant interactions with those harvesting the resource.

The concept of sustainable fisheries management implies managing the resource in such a way that it is available in abundance for the future and can sustain harvesting without damage to the long-term availability of the stock or its ability to withstand natural variations in the environment. Rebuilding fisheries resources involves creating the conditions to restore them to previous levels of abundance, usually as a result of reducing fishing pressure or restoring key habitat characteristics. Typically, we think of “rebuilding” as related to restoration of historic abundance or achieving the maximum productive fisheries capability of the system. This of course makes the assumption that conditions exist or can be created for such restoration to take place which may or may not be true. Typically restoration implies reducing or eliminating harvesting activities. Accordingly, such measures will likely cause harvesters and those related to the fishery to incur economic or social loss or change in order to permit the resource to recover for the future. Restoration of habitat and environmental improvement may require expenditures as well as restriction of use or impact on those activities that have resulted in environmental and habitat degradation. Thus, fisheries rebuilding and habitat restoration typically require changes in human activities and behaviours in order to achieve objectives. Social and economic impacts are associated with these changes. Accordingly, there is a tendency to oppose such changes, fear them, and support the maintenance of the *status quo* rather than the benefits of rebuilding the fishery.

Fisheries users and fisheries interests play a major role in the management and rebuilding challenge. In the North American context several major interest groups typically compete for fisheries resources- commercial, recreational and aboriginal fishers. In addition, conservation interests, supporters of non-consumptive use of natural resources, and environmental groups add complexity and often voice a different view from those engaged in resource harvesting. Frequently conservation groups press for a more precautionary and conservation-oriented approach than that being taken in the management regime. Managers and decision-makers conduct their activities in the presence of these often competing and frequently conflicting perspectives, which adds a social and political dimension to the task. Conflict and controversy typically centres around interpretation of science and information, status and trends related to fish stocks, access and allocation, management actions that restrict or affect access or entitlement, perceptions of equity and fairness, traditional use, and differing perspectives between competing groups, organizations and interests. These conflicts can become intense as the livelihood and way of life of individuals and groups may be significantly affected by a management action or conservation measure. Similarly, debate often centres around the issue of maintaining immediate benefits as opposed to a longer term view of conservation and rebuilding and the benefits that might arise by foregoing catch now, to create more robust fisheries resources for the future.

Recognition of native rights and entitlements, treaty settlements and legal precedents related to aboriginal people add another major element that must be addressed by managers and decision-makers. Many aboriginal people have a long-standing social and cultural relationship with fisheries. In Canada this has been recognized by the courts and indeed, this special relationship of aboriginal people to natural resources is recognized in the constitution and there are special fiduciary responsibilities that must be respected by fisheries managers in their relationship with aboriginal fishers. Accordingly, aboriginal fishing takes precedence in allocation decisions, subject only to conservation, and there is a special requirement for managers in Canada to consult in a meaningful way with aboriginal groups when taking decisions that may affect them.

This general pattern of competition and concern about protecting established entitlements and interests in the face of conservation and rebuilding requirements is a world-wide characteristic of the sustainable fisheries management challenge. The nature of the players may vary from location to location but the same underlying characteristics of human behaviour, economic and social benefits and established competitive entitlement apply. An interesting perspective, is that while fisheries managers describe their roles as “managing fish and fisheries” what they actually do is manage people by controlling their impact on the fish. Rules, regulations and management tools are all about controlling access, allocating resources to users through time, area, allowable catch, quotas, controlling gear and vessel requirements, protecting vulnerable stocks and areas, respecting reproductive sensitivities and life stages of stocks, etc. Thus, what we really do is manage people in order to manage the fish.

How well we do at this varies with the fishery, location and the social and political situation at hand. Several gadoid stocks in the North Atlantic are currently considered severely overexploited (Cardinale and Svedang, 2008). They argue that managers and politicians have had the necessary science to manage stocks without collapse but that they failed to do so as they tried to minimize the impact of policy on those that are most affected, *i.e.* the fishing industry. Similarly, Shimamura (2005) in examining fisheries policymaking in Japan describes a triangular relationship between management agency bureaucrats, legislators and the fisheries industry that has been institutionalized. At issue in these and many other situations is whether the scientific advice in setting allowable catch, application of precautionary principles, and establishment of allowable catch limits is adhered to, or whether, because of the very nature of the interaction between the decision-makers and the established interest groups, there is a tendency which is counter-productive to preventing overfishing and ensuring conservation objectives are met.

In contrast, while there is a tendency to often attribute collapses and declines in fisheries to overfishing and mismanagement, environmental factors can also play a key role. In examining a long time series of Alaskan fishery catches, Litzow and Urban (2009) concluded that climate effects, particularly on high trophic level taxa, act as the major driver of variability in these species. This certainly applies to many British Columbia Pacific salmon stocks, where fluctuations in marine survival are thought to be the major factor in changes in abundance, rather than overfishing. In addition, Halliday and Pinhorn (in press), in examining the cause of the large decline in groundfish populations in the Northwest Atlantic about 1990, argue there are indications this was largely due to environmental variation, rather than the prevailing view that it was predominantly due to fishing. In this context, the story of the Northern cod demise in the North Atlantic is a sad one. Rose (2007) provides a comprehensive review of the ecological history of the North Atlantic fisheries and the “perfect storm” of

circumstances, many of which were fisheries-related, that led to the depletion of Northern cod.

International fisheries: An added challenge

An interesting aspect of United Nations Third Law of the Sea outcomes is that fisheries management responsibility for a number of fisheries areas and resources moved from international waters to domestic waters and thus to domestic control. Munro (1981) pointed out that this resulted in extensive fisheries resources of the world being moved from international common property to the property of individual coastal states. In general, this was likely advantageous from a resource conservation and rebuilding perspective. However, fish stocks do not respect national boundaries and there are many challenges in managing and conserving highly migratory and straddling stocks as well as those that remain or pass through international waters. Arrangements on the high seas and governance of those waters is a complex matter, characterized by the presence of common property resources, law related to international waters, and impacts of “distant water” fishing fleets. From a governance perspective, there are many issues related to the effectiveness of monitoring, enforcement, fisheries policies, treaties and agreements, and the effectiveness of organizations and their stewardship of fisheries in international waters.

Like the competing domestic fishery interests described earlier, resource nationalism and a tendency towards a sovereignty-focused approach, tend to characterize international fisheries arrangements and relationships (Stephens, 2008). There is a significant literature on how countries relate to one another in the European Union (EU) arena and with respect to the EU’s Common Fisheries Policy (Penas, 2007), (Symes, 2007), (Payne, 2005). For example, McLean and Gray (2009) concluded that some nation’s perceptions tend to reflect euroscepticism where EU institutions are seen as obstacles to domestic fisheries interests whereas other nation’s perspectives relate to their national priority of environmentalism. Indeed, there is a view that countries have tended to focus more on bargaining over institutional rules than on conservation (Payne, 2005).

One key to this perhaps is separating out organizations and structures where vested interests compete with each other from those that generate neutral scientific advice needed for conservation and fisheries rebuilding. International scientific organizations can provide a neutral forum where a broad group of marine scientists can work together to gain a common understanding of the marine environment and its processes. ICES, the International Council for the Exploration of the Sea, is an example of this (Tasker, *et al*, 2000), as is the PICES organization in the Pacific (Tjossen, 2005). Again, as in the domestic fisheries situation, a key element in effective conservation and fisheries rebuilding in an international context is ensuring the scientific advice is followed and that national self-interest and short term objectives do not detract from the need to effectively conserve and manage fisheries resources sustainably and achieve rebuilding objectives where needed. Thus, the key to effective international arrangements for sustaining and rebuilding fisheries populations involves both good objective and mutually agreed science and the will to follow through to achieve sustainability and rebuilding objectives, with a common vision that overarches individual nationalistic self-interest.

Examples point the way to effective governance and fisheries rebuilding

While there are a number of examples of stock collapses and management difficulties, there are some examples of processes that work and characteristics that are important in managing sustainable fisheries and rebuilding them. Dr. Munro will describe some examples for sablefish and groundfish fisheries in British Columbia waters and others will be described in this workshop. One such example is the Pacific coho salmon stock rebuilding program in British Columbia Canada. In that case scientists and managers were very concerned about continued declines in both northern and southern British Columbia wild coho salmon populations and alerted senior management and the Minister of Fisheries and Oceans, the Hon. David Anderson. The Minister announced a comprehensive program of conservation and coho stock rebuilding that had unprecedented consequences on the coastal fishery. All users were affected, and major fisheries closures were enacted which substantively reduced the coast-wide catch of coho and other species. A vessel and licence buy-back was implemented which led to a significant reduction in commercial fishing capacity. Despite intense political pressure, the Minister was determined to implement the measures required and all user groups recognized he would follow through. The actions taken changed the nature of the salmon fishery in British Columbia in a lasting way.

Today, these measures have worked well for the northern coho in British Columbia and recovery is evident. For the southern coho, the outcome is less certain as poor marine survival of all five salmon species in southern British Columbia has affected abundance and trends will not be apparent until ocean conditions are more favourable. In this case however, it is clear that success for the northern coho rebuilding effort resulted from two things- strong and effective conservation and rebuilding measures coupled with political resolve to take lasting and effective action despite strong opposition.

A second example of effective fisheries management in an international context and of nations working together is the work of the Pacific Halibut Commission. In the 1920's as a result of concerns about halibut declines, fishermen on both sides of the Canada-USA border petitioned their governments to take action. The Pacific Halibut Convention, the first international fisheries treaty signed by Canada, formed the Commission which was jointly funded by both governments. For many decades now, the Commission has managed the halibut fishery with benefits of a sustainable fishery going to both countries.

A fundamental key to the success of the Commission and its management of the resource, which is regarded as a model for effective management, is its process. Fishermen, processors, government scientists and Commission technical staff work closely together, share information, and decide on management measures. Recommendations on quotas and regulations are made by the Commission, and forwarded to the two governments where they usually are generally accepted, and are strengthened by domestic rules and regulations. For example, Canada applies 100% observer coverage/electronic monitoring to the Pacific groundfish fleet, and 100 % dockside catch verification, thus augmenting the stock assessment and research role of the Halibut Commission. A key feature of the process is that those involved are integral to developing advice and thus have a meaningful role in the decision-making process. While actions over the years have not been perfect, the Commission has managed to retain the support and respect of governments and the fishing industry. It serves as an example of an effective inclusive international process, based on good information, collaboration between interests and governments and provides an arms-length international stock

assessment and scientific advice function which complements processes related to domestic fisheries management.

Tools and approaches for effective conservation and fisheries rebuilding

With respect to the biological considerations and stock management, a critical factor we must all remember is prevention of stock collapse. Stock rebuilding implies that something has happened that has depressed stocks, usually overfishing, habitat loss or perhaps natural variation, or often a combination of these factors. What we really want to do is avoid having to rebuild stocks because we have managed them well. Our management plans need to anticipate the factors that may result in reduction in abundance and include measures to compensate for them. Good management plans should take into account natural and man-made influences and respond accordingly. When conditions are less favourable for a stock, we need to be more cautious in our management approach.

An additional consideration is deciding what stocks to rebuild or manage to, in complex multi-stock associations where fishing activities take several stocks or species at once. It may not be possible to rebuild very weak minor stock components of a mixed stock fishery without shutting down the fisheries on healthy stocks, hence there is an important socio-economic issue involved and some possibly difficult trade-offs. Managers and policy makers will need to decide on the best approach which considers the socio-economic considerations, the need to protect genetic diversity, and the impacts of measures taken. Managing to the weakest stock components in a mixed stock fishery will entail social and economic impacts due to immediate foregone catch; however there may be future benefits due to protection of genetic diversity and perhaps even greater future abundance of a number of the stocks involved. In such situations, the key stakeholders and interested parties who will be affected by the proposed approach should be involved in these kinds of decisions. In engaging users, the choices and options available should be presented in an open and transparent way to assist with decision-making.

A key point for consideration at this workshop is recognition of the importance of managing the transition from depressed stocks to rebuilding and the process by which this transition is achieved. This is one of our most difficult challenges as it involves changing human behaviour and in making the case for the sacrifices that need to be made to achieve rebuilding. Transition therefore, is broader than just making fisheries management and policy decisions- it involves human behaviour, sociological, and economic considerations of both a short and long term nature. Incentives are an important key to success, whether they be in the form of ITQ's or other measures, and that a sense of ownership, stewardship, and having a say in the future well-being of the stocks and those that exploit them is very important. If people feel they are involved in the decisions, that they are being heard, and that they may benefit from future stock abundance or the availability of fisheries resources for the future, they may well be willing to make sacrifices to achieve rebuilding. Also, if people are going to sacrifice, the approach needs to be perceived as being fair to competing interests and values, transparent so people know what is going on, and credible, in terms of the measures being proposed.

Inherent in any stock rebuilding approach, may be considerations of timing. For example, for a salmon population we might propose to rebuild the stock within a sequence of reproductive cycles. We might aim to achieve rebuilding within several reproductive cycles, each of which spans the time from emergence of the young fish from the egg stage until the time the adults return to their place of origin to spawn. A fast pace

of rebuilding might involve two or three such cycles and considerable reduction of fishing effort in order to achieve rebuilding. A slower pace of rebuilding might involve four or five cycles and less impact on the fishery. The faster paced approach would achieve rapid rebuilding with considerable short term social and economic impact on the users while the slower approach would entail less impact on those users but a slower, and perhaps uncertain outcome with respect to stock rebuilding. These considerations again involve people making difficult choices. In the case of a decision to move rapidly, there will also likely be strong opposition from those affected and the need for effective policy and political support for the measures being implemented.

We have seen that meaningful involvement of fishermen and beneficiaries of the resource in the management process and in decision-making appears to be a key element of success and in achieving policy agreement and support for management approaches. Penas (2007) has pointed out that more progress must be made in the EU context and in developing a fruitful dialogue among fishers, scientists and managers. Similarly, co-management and participative governance are regarded as important elements of effective governance and institutional reform (Symes, 2007). Symes (2006) also highlighted “three distinct but interconnected levels of governance: the first dealing with day to day issues of management; the second concerned with institutional arrangements; the third focusing on the construction of images, values, principles and criteria to guide fisheries policy making along a consistent path”.

Indeed, progress is being made on these values, principles and criteria as illustrated by the United Nations Food and Agriculture Organization’s Code of Conduct for Responsible Fisheries, 1995 and the Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995 (United Nations, 1995). Cole (2003) concluded that a process of fisheries governance is confirmed, emerging from a new environment of fisheries relations. Building on this view, Dobson and Regier (2007) emphasize the importance of the role of science and risk assessment, the precautionary principle, the public trust doctrine, an effective female work model, effective commons management as key elements of sustainable and equitably shared fisheries. Regier (2004) advocates interrelating efficient management of supply and demand into an “ethical context of equitable justice among humans and other species”. Regier envisions a future where “places for humans and their friends, the fish, are secure”. These concepts can form the basis of “aquatic stewardship” initiatives as a key to fisheries sustainability. Thus to guide fisheries rebuilding and conservation efforts, important social and ethical beliefs and values enter the equation, beyond simple user-oriented considerations related to self-interest and maintenance of the *status quo*.

To facilitate effective fisheries rebuilding and support an effective world vision and objectives related to global sustainability of healthy fisheries resources, a number of tools and approaches may be helpful. Much has been said about the need to move from our single species management approach to a multi-species ecosystem approach that recognizes the connections and interrelationships amongst species and their environment. In Canada, a major piece of oceans legislation, the Canada Oceans Act, is built upon the ecosystem approach, making it one of the first major legislative vehicles to incorporate this approach. In truth, we are only just at the beginning of incorporating the ecosystem approach into management practice, and it is a reality that we mostly still manage aquatic resources on a species by species basis and most of our scientific information used for management remains single species information.

Other useful tools likely involve the concept of marine protected areas which can act as places to rebuild depressed populations, as sources of offspring, special use zones, places to protect endangered species and their habitats and as conservation tools of a flexible nature depending on need. Protecting biodiversity, habitat protection and environmental quality, habitat restoration, and ensuring key elements of important ecosystems such as integrity of forage fish populations are also important considerations for effective fisheries rebuilding. In addition, while concerns exist with respect to aquaculture activities and their impacts, particularly with respect to salmonids, it is clear that in the face of global food supply issues, aquaculture will be an important component of feeding a hungry world population. Sustainable aquaculture, conscientiously practiced and regulated, will augment wild capture fishery production and provide some relief from overharvesting tendencies and conservation challenges.

Market-based incentives also offer an effective tool to both encourage responsible management and conservation as well as raise public awareness and support for conservation and rebuilding efforts. Eco-labelling and certification initiatives are powerful tools to achieve these ends if they are supported by the public and key players in global markets will only endorse fish products that are certified as meeting objective standards of good management and sustainability.

The transition to rebuilding: Understanding how people perceive change is key to making changes

In addition to the incentives and tools used to rebuild fisheries, we have discussed the fact that managing fisheries, in addition to understanding fisheries science as a basis for decision-making, is all about managing people. Thus the social sciences and psychology have a major role to play in bringing about change and awareness and in creating an environment where policy can be changed and new values and beliefs can guide a path to effective fisheries rebuilding. Psychologists tell us that people resist change for a number of reasons:

- The risk of the status quo is seen as less risky than the change;
- We fear loss of benefits, involvement, status;
- People fear hidden agendas or the unknown;
- We associate our beliefs with others of similar belief rather than a new idea;
- Doing nothing is much easier than accepting the uncertainty of change;
- We may not understand or believe in the proposed change.

Accordingly, developing and implementing effective fisheries rebuilding approaches, bringing people onside for new policy implementation, and gaining the support of affected users and groups will require sensitivity to how people perceive, support and accept change. Gaining the support for policy change from those who are affected by the change and achieving the necessary domestic and international conditions to implement changes will require addressing these human characteristics as an integral part of the approach taken.

Furthermore, when we work in complex governance situations with a wide array of interests, there may be social, cultural, or other perspectives beyond our own at play, particularly in an international context or where highly developed and developing countries are involved. Conservation and rebuilding efforts may be the last thing in the mind of individuals or groups desperate to feed their families, pay for their boats, or maintain their livelihood with little other opportunity apparent to them. Thus, understanding these realities and developing inclusive approaches that are sensitive to them and a broader context for rebuilding activities, including the involvement of an array of disciplines, incentives and support programs will be keys to effective fisheries rebuilding success. Indeed, at this workshop you will explore various incentives such as ITQ's and other measures that are effective tools for gaining the co-operation and support for rebuilding and sustainable management approaches from fishers. All this means that we must think beyond traditional fisheries management and fisheries economic perspectives and adopt a broader and more inclusive approach that incorporates both the social sciences and the natural sciences in an effective way.

The role of fisheries economists in fisheries rebuilding

At this workshop, participants will be involved in the consideration of fisheries rebuilding initiatives from the perspective of fisheries managers and decision-makers and as fisheries economics professionals. Participants can all play an important role in making a difference and in implementing sustainable fisheries management and rebuilding initiatives by acting through their own organizations and contacts to spread the outcomes of the workshop and share perspectives on what considerations will lead to effective fisheries rebuilding. The well known concept of “think global and act local” applies in this case and actions leading towards examples and processes that achieve rebuilding will serve to guide other groups and organizations to additional successes, thus promoting a broader application.

In my opinion, there is a special role that fisheries economists and decision-makers can play in making the important case for fisheries rebuilding. That role relates to developing and gaining support for fisheries rebuilding by contributing to the vision of exactly what benefits to individuals, nations and society will accrue through sustainable use of fisheries resources, effective conservation, and stewardship of healthy fisheries resources for the future. In considering the human perceptions that act to oppose change described earlier, it is clear that most people opt for what is known now rather than what might be achieved in the future. Economists and fisheries decision makers will have to paint the picture of the benefits associated with stewardship and rebuilding in the face of the global imperative of a world food crisis and the necessity for domestic and international action and co-operation. We will need to do that in a way that convinces the public, resource users, conservation and environmental factions and political leaders in order to bring about the necessary conditions for change. What is needed is a global vision, similar to that advocated by Regier (2004), where “places for humans and their friends, the fish, are secure”. Economists and decision-makers can play a key role in illustrating what that vision can be in terms of a sustainable supply of fish for the future, how aquatic systems can contribute to feeding an increasingly hungry world, and how there are future social and economic benefits for individuals and societies which are valuable and worthy of both domestic and international support..

In this context, we need to remember that taking effective action is urgent, given the growing global food crisis, the important role that fisheries will play in feeding an increasingly hungry world, and the unknown impacts of global warming on aquatic organisms and their environment. Finally, it is clear to me that fisheries economists and managers need to be involved early in any processes that involve rebuilding transitions and sustainability regime development in order to paint the picture of the benefits and advantages of the changes being proposed. This information will help people make intelligent choices in the face of the urgent need to take effective action.¹

Note

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Chapter 2.

Rebuilding fisheries: An overview of issues and policy approaches in the OECD

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Abstract

Pressure to take strong action to rebuild depleted fish stocks has been increasing over the past couple of decades at the international, regional and national policy levels. At the World Summit on Sustainable Development in 2002, governments around the world committed to an ambitious goal of rebuilding fish stocks. The Johannesburg Plan of Implementation specifically requires countries to “maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015.”

This chapter provides an overview of the key economic and institutional issues in designing and implementing fisheries rebuilding programs and provides a brief review of the policy approaches and strategies adopted in selected OECD countries. In designing and implementing fisheries rebuilding programs, policy makers need to ensure that the programs are cost efficient and effective. Once a fisheries rebuilding target is determined, there are multiple potential paths: stock rebuilding can be achieved over different time periods, using different tools (quotas, time/area closures, gear restrictions, etc.), and under different institutional arrangements. Each target and path has a unique set of economic and social costs and benefits that need to be weighed in the historical, cultural and political context and fisheries settings of individual countries. There is therefore a need to ensure that economic information is integrated into decision making at key points in the process.

Introduction

The most recent statistics from the FAO indicate that almost 30% of global fish stocks are in need of rebuilding measures (FAO, 2009). The overfishing of stocks has had significant consequences on both the biological sustainability and the economic viability of commercial fisheries. This has led to a world fishery that is characterized by falling productivity, economic inefficiency and stagnant incomes for fishers. Recent work by the World Bank indicates that the economic benefits from rebuilding and effectively managing fisheries are substantial, estimated at around USD 50 billion a year (World Bank/FAO, 2008).

Against this backdrop, countries have committed to international principles and targets and have developed national approaches to address depleted fisheries. In particular, at the World Summit on Sustainable Development (WSSD) in 2002, governments committed to an ambitious goal of rebuilding fish stocks to levels that can produce the maximum sustainable yield by 2015. Recognizing that rebuilding international fish stocks must occur within a cooperative governance framework, the UN Fish Stocks Agreement (UNFSA, December 2001) has enabled RFMOs to address the overfishing of straddling and highly migratory stocks fished primarily on the high seas.

The objectives in this chapter are to identify the key economic, social and institutional issues in designing and implementing fisheries rebuilding programs and to provide a review of the national policy approaches to fisheries rebuilding in selected OECD countries. The primary motivation for the OECD work on the economics rebuilding fisheries stems from a recognition that policy makers need to not only ensure that rebuilding paths are scientifically well-founded and achievable, but also that the programs are cost-effective and efficient in achieving their objectives. This requires the integration of a broader amount of economic information in decision making processes than is generally the case in many OECD countries.

The challenge of rebuilding

Efforts to halt overfishing and rebuild depleted commercial fisheries have been under scrutiny in the last few years, resulting in increased pressure on governments to take stronger action to rebuild fish stocks at the international, regional and national levels. A recent report from the FAO indicates that the overall proportion of stocks that require rebuilding appears to have been relatively stable over the last 10-15 years; nevertheless, of the global fish stocks assessed in 2007, 18% of the world's fish stocks are overexploited, 8% are depleted, and 1% are recovering from depletion (FAO, 2009).

The task of rebuilding fisheries is a challenging policy problem. The collapse of several high profile fish stocks, such as the North West Atlantic cod, and their failure to recover despite a reduction or moratorium on fishing effort has raised concerns over the success of recovery plans for overfished stocks (Caddy and Agnew 2004; Rosenberg *et al.* 2006; Wakeford *et al.* 2007). Recent data suggests that highly migratory and straddling stocks, as well as those exploited exclusively or in part on the high seas, are even more vulnerable to overfishing (FAO, 2009), indicating an important role for RFMOs in stock rebuilding.

It is generally recognised that the causes of overfishing that give rise to the need to rebuild fisheries are generally found in economics and governance, as are the solutions.

Perverse economic incentives arising from management regimes governing access to resources, excess capacity, and the provision of subsidies are some of the key factors leading to the overfishing of certain stocks. For example, while there are few examples of pure open access fisheries in OECD countries, there exist a number of “regulated open access” fisheries (i.e. managed by a total allowable catch system, sometimes coupled with licence or entry restrictions) that tend to create perverse incentives leading to overfishing. Governments have historically heavily subsidised their fishing industries in order to protect an important source of employment in coastal communities where few alternatives may exist or to maintain a culturally traditional way life. Depending on the management regime in place, subsidies blur the price signals which may encourage fishers to exit a fishery when it is depleted or no longer profitable, ultimately leading to a case where there are too many fishers chasing too few fish.

However, the process of developing fisheries rebuilding plans has become gradually more complicated by an increasing understanding of the impact of changes in the ecosystem from factors such as climate change or regime shifts, in addition to well fishing pressure. The effect of climate change and ecosystem shifts on stocks adds another layer of complexity and uncertainty to fisheries management, and to rebuilding strategies. McFarlane *et al* (2000) highlight the link between major climate events and the effect of the abundance of certain fish stocks including the marine survival of Pacific salmon and patterns of recruitment for groundfish, as well as the distribution and abundance of hake. In the case of salmon, for example, the decline of catches by about 60% since the late 1980s/early 1990s would generally be attributed solely to overfishing. However, the authors conclude that the change in productivity was also closely linked to the major change in the marine environment in 1989. Reduced salmon returns to hatcheries despite the maintenance or increase of hatchery production since that time is cited as further substantiation that climate shifts may have a significant effect on some fish stocks and should be considered in the development of rebuilding plans.

Similarly, the challenge of rebuilding fisheries has been made more complex by a broad institutional shift, at both national and international levels, towards an ecosystem approach to fisheries management. This shift has meant moving beyond single species approaches to fisheries management, and considering the broad spectrum of relationships within an ecosystem (such as that which exists between predator and prey) in designing management and rebuilding plans. It is clear that, in terms of fisheries rebuilding, the ecosystem approach requires policy makers to take into account of the impacts of fishing on ecosystems, the impacts of ecosystems on fishing, and the interactions between fish and other species in the ecosystem.

Policy context

While the importance of developing, implementing and enforcing rebuilding plans may seem obvious to many observers, it is important to recall the policy context within which fisheries rebuilding plans are developed. In particular, fisheries rebuilding has been the subject of several major international commitments on developing sustainable fisheries and it is universally recognized as necessary for protecting biodiversity and the health of oceans, as well being important from an economic and social perspective for many coastal communities. As such, while it is universally recognized that rebuilding and maintaining robust fisheries are desired, there are other factors considered in the management process in addition to the science advice.

International agreements

Governments around the world have sought to address the issue of depleted and overfished stocks on a global scale through various international agreements in order to enable a prosperous and thriving fishing sector. To that end, political commitments have been made through a series of hard (binding) and soft laws (non binding).

With the adoption of the United Nations Convention on the Law of the Sea (UNCLOS) in 1982, coastal states were provided with jurisdiction over a 200 nautical mile exclusive economic zone (EEZ), within which they are required to protect aquatic resources against overfishing. This was considered to be an important step in enabling countries to protect and conserve stocks found more or less exclusively in their EEZ. Building on this framework, there have been numerous complementary agreements that seek to establish standards for fish conservation and management on a global scale. Key international accords include:

- The 1995 United Nations Fish Stocks Agreement focuses on the conservation of straddling and highly migratory fish stocks by expanding on UNCLOS, including the responsibility to apply the precautionary approach by setting limit reference points for maximum sustainable yield. This provides a foundation for regional fisheries management organizations (RFMOs) with respect to rebuilding stocks.
- The 1995 FAO Code of Conduct for Responsible Fisheries is a non binding instrument that has been accepted by all 188 members of the organization. This code states that overfishing should be prevented, along with excess fishing capacity, and that sustainable management measures be promoted. This code demonstrates the commitment by all member nations to the importance of rebuilding depleted fisheries.
- The pressure to address overfishing was discussed at the World Summit on Sustainable Development in 2002, where governments committed to an ambitious goal of rebuilding fish stocks. Specifically, the Johannesburg Plan of Implementation requires countries to “maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015”.

The development of these international agreements demonstrates the desire of governments to respond to the problem of overfishing, and the need for sustainable fisheries for both biological and socio-economic reasons. The current challenge is to practically and effectively implement the principles advocated in these agreements.

Protecting biodiversity

Protecting biodiversity is the key ecological argument for stock rebuilding. Diverse ecosystems are considered to be more resilient and have a greater ability to withstand changes in the environment, such as ecosystem shifts and climate change.

Given the interdependence between species and their complex set of interactions, the overfishing of one stock may have consequences for other aquatic organisms and the ecosystem as a whole. For example, the abundance of northern shrimp and crab stocks in the North East Atlantic may be a result to some degree of the overfishing of their predator, Atlantic cod (in addition to potential changes in oceanic conditions).

Predator-prey interactions are often poorly understood, and may not be adequately considered in the management of fisheries resources. For example, large sharks (which are slow maturing, long living species) play a role as a key predator in the ecosystem. The collapse of many shark populations in the North Atlantic due to overfishing has led to increase in the number of some skates and rays, species that were typical prey of sharks such as the great white or the hammerhead; this has had significant consequences on fishing communities, as the increased number of skates and rays have affected commercial fisheries for bay scallops and other shellfish (Myers, 2007).

Social and economic benefits and consequences of rebuilding fisheries

The economic benefits from rebuilding fish stocks, as from sound fisheries management, are potentially significant. At an international level, the World Bank/FAO Rent Drain study estimates that approximately USD 50 billion is lost annually in global resource rent from fisheries as a result of poor governance (World Bank/FAO, 2008). In a study of a number of US fisheries, Sumaila and Suatoni (2006) estimate that the potential increase in net present value (NPV) from rebuilding 17 different overfished stocks amounts to around USD 567 million, or approximately three times the estimated NPV of the fisheries without rebuilding.¹

While these two figures use different methodologies and are not strictly comparable, they nevertheless provide an indication of the magnitude of potential gains. Of course, the figures should also be weighed against the costs of undertaking rebuilding programs and subsequent management of the stocks.

Beyond the immediate loss of revenue for the fishing industry, fisheries collapse can lead to serious longer-term consequences, such as lost market access and distribution channels, neglected infrastructure and an exodus of skilled fishers. Even if a stock is rebuilt, fishing may not yield the same level of pre-collapse revenues, as there may be a lag (especially for a smaller fishery) to re-establish itself and therefore regain access to markets.

Stock collapses may also have social implications such as loss of a fishing culture and expertise which can be difficult to regain. At a regional level, the socio-economic benefits from rebuilding stocks include protecting a way of life, as well as maintaining employment in coastal communities where few alternatives exist. In this context, stable access to a well managed resource could decrease economic uncertainty and enable fish harvesters to secure access to capital to remain competitive, leading to the production of higher quality, and higher value fish products.

Recent studies of rebuilding approaches

There have been several recent studies analysing the effectiveness of stock rebuilding programs that have largely been prepared from a biological perspective, while some have also examined economic, institutional and policy issues.

One of the first major overviews of stock rebuilding programs was undertaken by Caddy and Agnew (2004). The paper is based on an invited plenary lecture to the 2003 ICES Annual Conference and reviews eight case studies of successful and unsuccessful stock rebuilding programs from the US, Canada, New Zealand and the EU. The paper also develops a number of insights from the reviews and proposes tentative guidelines for

best practice in fishery recovery plans. The paper endorses a call by ICES for the development of an internationally-coordinated database of stock recovery programs.

Swasey and Rosenberg (2006) undertook a major evaluation of the rebuilding plans for depleted stocks in the US and the results are summarised in Rosenberg *et al.* (2006). The study provides a detailed scientific review of the rebuilding plans and management for 67 fish stocks. It was found that, as of 2005, overfishing (where the fishing mortality rate exceeds the level that should support MSY) continued in 45% of the stocks under rebuilding plans and around 72% of stocks remained overfished. Three stocks had been rebuilt, but fish stock abundance appeared to be increasing in 48% of the stocks under rebuilding plans. The study methodology was based on publicly available data, and was assisted in its execution by the availability of precautionary reference points as requirement under the US fisheries legislation.

Within the European Union, UNCOVER is a major project funded by the European Commission that seeks to develop insights into strategies for stock recovery in a number of fisheries.² The project objectives are to identify changes experienced during the decline of fish stocks, to enhance the scientific understanding of the mechanisms for fish stock recovery, and to formulate recommendations for fisheries managers how to best implement stock recovery plans. Four case study areas will be analysed: Barents and Norwegian Seas (covering NE-Arctic cod, Norwegian spring spawning herring and capelin); North Seas (cod, plaice and autumn spawning herring); Baltic Sea (sprat and Eastern Baltic cod); and Bay of Biscay (Northern hake and anchovy). The overall work plan for the project is focused on modelling alternative strategies for stock recovery in the case study areas. It includes an economic component focusing on bioeconomic modelling of selected stocks, the development of four community socio-economic profiles for Spain, France, the Netherlands and Scotland, and social impact assessment of one of the recovery strategies on a pilot scale for Denmark.

As part of the UNCOVER project, MRAG undertook a review of institutional arrangements and the key factors associated with successful recovery plans (Wakeford *et al.* 2007). The paper reviews 33 case studies from the US, Australia, New Zealand and Europe and used 13 performance criteria to evaluate the relative importance of institutional, economic, social and environmental factors in stock rebuilding plans. Amongst the key findings from the study, the authors found that recovery is effective when:

- Catches are significantly reduced over a short period of time, creating a positive shock to the stock;
- The recovery plan is part of a legal mandate which is automatically triggered on reaching pre-defined limit reference points;
- The economic efficiency of the fleet is evaluated and monitored throughout the rebuilding process; and
- Effort reductions are created using input controls in addition to TAC reductions, rather than through output controls.

The difficulties in evaluating stock rebuilding efforts have been underscored by a number other recent papers. Wiedenmann and Mangel (2006) highlight a number of technical scientific issues that complicate assessment of rebuilding plans. These issues

relate to cases where stocks are experiencing overfishing during the rebuilding period, cases where stocks are considered rebuilt but the age distribution is far from the stable age distribution normally associated with a robust stock, and the role of uncertainty over rebuilding trajectories. The issue of defining viable paths to rebuilding stocks is also analysed by Martinet *et al.* (2007), while Walters and Martell (2006) highlight the potential role for adaptive management of rebuilding trajectories based on experimental policies for rebuilding fish stocks.

Rice *et al.* (2003) analysis of the collapse of North West Atlantic groundfish stocks in the 1990s note the following key observations and lessons learned:

- The potential for recovery is variable by stock so management approaches should be tailored accordingly, including the assessment of economic impacts. Some Atlantic cod stocks reacted favourably to moratoria and sustained commercial fisheries for a time, but have since declined again. Others have consistently remained at low biomass levels
- Without addressing the underlying issues that led to overfishing, such as the permanent removal of excess capacity, the risk of overfishing will reoccur should the stock recover.
- Deferral of rapid and decisive management action to reduce harvest because of uncertainty about stock status and concerns about the impacts of the reductions on the fisheries contributed to the severity of the collapse and ultimate severity of the measures needed to commence recovery.

Finally, environmental non-governmental organisations have also been active in promoting action to rebuild fish stocks and in proposing mechanisms for developing rebuilding programs. For example, WWF has published a guide to the development of successful recovery plans for Europe's fish stocks (WWF n.d.). They have also proposed detailed recovery plans for specific stocks in Europe including for plaice, spurdog and Baltic Cod (Rosenberg and Mogensen n.d.).

Overview of economic and institutional issues

Convincing policy makers and fisheries stakeholders that it would be wise to undertake stock rebuilding is only a first step. Policy makers also need to know how to go about it in a cost efficient and effective way. Once a stock rebuilding target is determined, there are multiple potential paths: stock rebuilding can be achieved over different time periods, using different tools (quotas, time/area closures, gear restrictions, etc.), and under different institutional arrangements. Each target and path has a unique set of economic and social costs and benefits that need to be weighed in the historical, cultural and political context and fisheries settings of individual countries. Integrating economic information into the decision making process is a key element of ensuring a sustainable and cost-effective outcome in rebuilding plans.

However, it can be argued that the economic and institutional aspects of rebuilding fisheries have not benefitted from the breadth of research that has been conducted on the technical or biological aspects of rebuilding. Management measures such as setting mortality targets, recovery timelines, closures etc. alone may not lead to sustainable fisheries in the long run unless effort is directed towards the root causes of fishing pressure as well as ensuring that a holistic approach to rebuilding depleted stocks is taken.

For rebuilding measures to achieve any success, issues of aligning industry incentives with conservation objectives and of excess capacity have to be confronted. As emphasized by Larkin *et al.* (2007), existing economic tools can provide valuable insights and approaches to assist with stock management and the design of successful rebuilding plans.

Both the technical aspects of cost-benefit analysis (cost-benefit analysis in assessing rebuilding paths and choice of policy instruments) as well as the integration of economic information in broader decision making processes are important considerations with respect to the economics of rebuilding fisheries. The following sections outline some of the economic and institutional issues that need to be considered in the design and implementation of fisheries rebuilding plans and programs.

Definitional issues

A key issue that needs to be addressed at the outset concerns the definitions of key concepts such as overfishing and overfished, as well as what is meant by “rebuilding” and “success”. Several countries and international organizations have developed broad definitions of overfishing that are generally linked to the MSY concept, while others have not. In the case of the New Zealand Ministry of Fisheries, for example, a specific distinction is drawn between overfished and depleted stocks; this is an explicit recognition that in some cases ecosystem shifts or climate change may be a significant factor affecting the rebuilding of some stocks. In the United States, on the other hand, legislation defines overfishing under the Magnuson-Stevens Act as a rate or level of fishing mortality that jeopardizes a fishery's capacity to produce maximum sustainable yield (MSY) on an ongoing basis.

There are two broad approaches to rebuilding fisheries. The first approach is the explicit use of targeted stock rebuilding programs, focusing on a particular stock or aggregation of stocks and employing specific measures to reduce fishing effort. Such programs are generally time-limited, have legislative backing, and employ precautionary reference points and harvest control rules within the rebuilding framework (Box 2.1). The second approach is to include stock rebuilding as one of a number of objectives within regular fisheries management plans. Such plans may include precautionary reference points and harvest control rules as part of the management approach, but these may not necessarily be mandated by legislation. The approach to stock recovery is more open-ended compared to targeted stock rebuilding programs and there may be a greater emphasis on the on-going management of the fishery both during and following stock recovery.

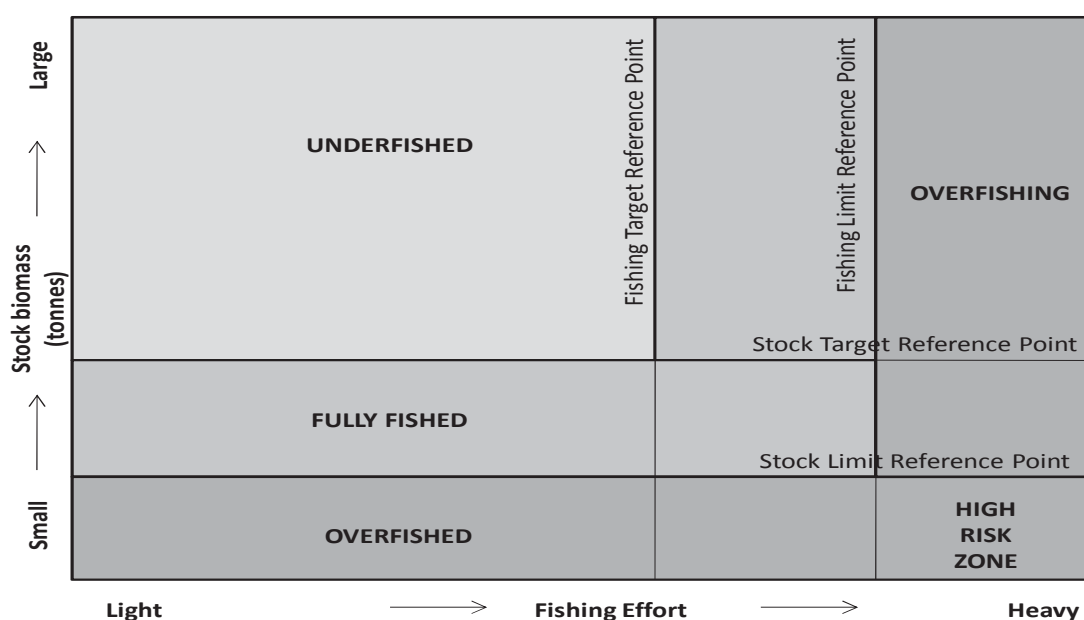
Wakeford *et al.* (2007) note that there is an important technical and legal distinction to be made between recovery plans and rebuilding plans in some jurisdictions. Recovery plans are generally focused on the recovery of critically endangered species from the risk of extinction and does not necessarily imply rebuilding to commercially sustainable levels. Legislation to address this threat is generally to be found in the endangered species legislation of countries, rather than in the fisheries management legislation. Rebuilding plans, on the other hand, are generally associated with the recovery of depleted marine capture fisheries and the rebuilding of the stock to more productive levels of exploitation. In some countries, the endangered species legislation may serve as a catalyst for stock rebuilding. In Japan, the term restoration plan is used in reference to fisheries building. Given the various tools and terminology, a valid argument could be made to extend

research to include rebuilding plans or measures for depleted or overfished marine commercial fish stocks, regardless of the legislative base for the plan.

Box 2.1. Precautionary reference points

Precautionary reference points are used in fisheries stock assessments and fisheries management to assess the long term sustainable levels of fishing mortality and stock biomass. Limit reference points establish threshold limits when fishing effort is too high or when stock biomass levels reach dangerously low levels. These are depicted as the “fishing limit reference point” (or F_{lim} in the stock assessment jargon) and the “stock limit reference point” (or B_{lim}), respectively, in the figure below. Target reference points establish the optimum targets for fishing mortality and stock biomass (whether in terms of maximum sustainable yield or some other measure). These are depicted as the “fishing target reference point” (or F_{MSY}) and the “stock target reference point” (or B_{MSY}), respectively, in the figure below.

Fisheries that experience overfishing (that is, exceed F_{lim}) may not necessarily have depleted stocks that require rebuilding. Management action is required to reduce fishing effort, but stock rebuilding would not be necessary unless the situation persisted. If, however, fisheries experience overfishing and there is a serious decline in stock biomass, (that is, the stock is below B_{lim}), then urgent action is required to prevent stock collapse.



Source: Wakeford *et al.* (2007), FAO (2006).

Another definitional issue is what is meant by “success” in terms of stock rebuilding programs. In the long term, a stock rebuilding program can be defined as a success when the target stock biomass is achieved and the conditions are established for the fishery to be economically and environmentally sustainable over the longer term. However, such a goal can take a considerable amount of time, and governments may wish to have short term or intermediate goals against which to define and measure success (or progress towards success over the longer term). In the short term, a stock rebuilding program can be said to be successful if the actual fishing mortality rate is less than the target and the stock biomass is increasing. This places a greater policy emphasis on the issue of

overfishing in the short term and provides measurable intermediate goals towards the longer term objective of a rebuilt stock.

Choice of rebuilding targets and rebuilding paths

Resource managers and decision makers are generally faced with more than one option in terms of rebuilding fish stocks; based on the best available information, they determine the quantity of the stock that can be reasonably and sustainably harvested and the length of time that is acceptable from a societal and biological perspective to reach a target state of the resource. In consideration of a variety of factors, a decision may be made to quickly rebuild a stock to its target level with a high social and economic cost, or a path may be chosen that leads to a more gradual rebuilding of the stock to reach a stated goal in consideration of the benefits and costs to all stakeholders. Clearly then, the choice of objectives, targets and rebuilding paths is not solely a biological issue.

Recent analyses have noted that there are increased costs with respect to fishing depleted stocks; the scarcer the resource, the higher the marginal cost of fishing. In the case of depleted stocks, the cost per unit increases while fewer fish are caught (Röckmann *et al.* 2006). As such, rebuilding fisheries and selecting an economically optimal approach can significantly lower marginal harvesting costs and eventually lead to increased profitability.

Studies indicate that setting an economic target will generally mean setting a lower allowable catch rate in order to reach that target. There is now increasing evidence that a rebuilding strategy based on maximum economic yield (MEY) is going to be more stringent than a MSY driven rebuilding strategy because the target biomass that produces MEY is greater than the target biomass that produces MSY. In a widely quoted paper, Grafton *et al.* (2007) have shown that the biomass which maximizes the MEY is always greater than that which maximizes the MSY, which means that even a fishery harvesting at the MSY might be overexploiting a stock, at least in economic terms. Grafton *et al.*'s findings indicate that, contrary to previous studies (Clark, 1973), this always holds true under reasonable assumptions, and even for long-lived, slow-reproducing species. This illustrates the importance of setting rebuilding targets based not only on biological parameters, but also on economic parameters such as the costs of fishing and market prices. They also have important implications for the choice of rebuilding paths and targets because this means that reduction in fishing mortality rates may have to be even greater in the present in order to allow stocks to reach the higher levels of biomass which produce the MEY.

The fact that rebuilding paths which lead to economically optimal stock levels at MEY may be more restrictive than those that lead to biologically optimal stocks level at MSY suggests that economic factors do not inherently conflict with biological goals. The example of the MEY approach suggests that the transparent inclusion of economic considerations can lead to both an economically and biologically optimal rate of harvest that allows fisheries to rebuild more quickly and efficiently. A detailed chapter on Australia's implementation of the MEY approach can be found in the chapter by Gooday *et al.*

Choice of management instruments

To enable fishery managers to choose optimal stock rebuilding paths amongst competing options of varying timelines, measures, tradeoffs, etc., cost-benefit analysis

(CBA), or at least cost-effectiveness analysis (CEA) - when a complete valuation of benefits is practically impossible - should be used so as to be able to compare these different options on a common metric. The option chosen should be the one that has the greatest, positive net present value, when all economic, biological and social costs and benefits have been properly valued. When selecting appropriate rebuilding strategies, fisheries managers will generally select from management regimes ranging from solely input/output control regimes to those including a rights-based component.

Management measures selected to reach rebuilding targets will be influenced by a range of interconnected factors. For example, the timeframe chosen for rebuilding has a strong influence on the management measures selected to reach the target state of the resource. Similarly, if policy makers wish to use a particular management tool, then this may affect the timeframe within which the stock may be able to be rebuilt. In some instances, the biological basis for choosing one rebuilding timeframe over another is not always evident; this may be the case when a variety of options towards rebuilding are presented, with no particular weight given to any one option. The decision regarding the acceptable rate of rebuilding often then becomes a management issue.

Successful rebuilding strategies should also address the way fisheries are managed, and the selection of management instruments is influenced by biological, social and economic factors, as well as the legal and management structure in place. There is a broad range of management instruments available in the toolbox, each with its own strengths and weaknesses under different biological, social and institutional circumstances.

For example, “pure” input/output control regimes aim to limit fishing mortality and can thus be referred to as “direct conservation measures” (FAO, 2002). Controls can be placed on either inputs (fishing effort) or outputs (harvest) to a fishing process. Input controls, or effort controls, seek to restrict the amount or intensity of inputs used to harvest fish, such as a fishing vessel, fishing gear, number of trips or days at sea, fishing season lengths, etc. Output controls seek to restrict in some form the amount of fish harvested (the “output” of a fishery), and include measures such as total allowable catch (TAC), limits on bycatch etc.

Rights-based regimes such as individual quotas (IQs), individual transferable quotas (ITQs), individual vessel quotas (IVQs) and community / cooperative quotas, are another category of management instruments that can be employed. These regimes seek to emulate private property rights in a fishing context, so as to encourage sustainable and long-term usage of the resource through ownership.

Rights-based regimes are complementary to input/output controls, as a means to decrease fishing effort on depressed stocks while also allowing for the alignment of conservational and economic incentives through some degree of property rights. For example, ITQ based fisheries are also managed with output controls such as TACs and bycatch or fish size/gender harvest restrictions. Rights based fisheries are also likely to be regulated through input controls as well, such as gear restrictions, although the presence of these may make the ITQ-based regime less effective by hampering optimal input mixes that would occur had input controls not been in place.

Rebuilding plans have typically used input or output controls, or a combination of both, as well as using technical measures such as gear restrictions, etc. While this management approach may lead to stock recovery, it does not always lead to an economically efficient industry, nor does it address underlying issues that may have contributed to the state of the resource. In some cases, this approach has led to input

substitution, whereby controlled inputs are substituted by uncontrolled inputs (e.g. “fat” boats to circumvent vessel length limits), while leaving capacity unchanged and profitability diminished.

The example of the different management strategies employed by the US and Canadian governments for their respective stocks during the downturn in the sea scallop fishery illustrates the different results that are achieved when input/output controls are solely employed, as opposed to when rights-based regimes are introduced. The Canadian response to managing the declining resource was to move towards a rights-based regime, while the US chose an input control approach. A comparison of both approaches indicates that the number of boats and fishers had decreased while profitability and product quality had increased in the Canadian fishery. In the US fishery, substantial overcapacity remained and resulted in lower profits and thus less margin for investing in product quality or increased efficiency (Repetto, 2001). This latent excess capacity, such as in the US example, is also often a factor that can compromise the ability for a stock to remain robust as well as hamper any future rebuilding efforts, as vocal lobbying for fisheries to remain open as soon as stocks appear to be rebuilding may be maintained.

In order to address these concerns, some fishing industry groups have requested that their governments introduce rights-based regimes, such as the ITQ regime in the case of the Canadian offshore scallop fishery. By giving quasi-property rights to fish harvesters, these regimes have allowed a more sustainable use of the resource by aligning economic incentives with resource conservation objectives.

However, while there are several examples where the introduction of rights-based management regimes in conjunction with other measures led to successful stock rebuilding effort, rights-based regimes and ITQs in particular may not always be the most appropriate management approach to accompany rebuilding efforts. This is because for these regimes to be effective, proper enforcement is key, as ITQs can create incentives to “cheat” by discarding smaller fish to keep only the bigger, more valuable ones (highgrading); to avoid this, measures such as onboard video surveillance, at sea observers and full weighing and verification of landings must be implemented to ensure that individual quotas are respected. In addition, these measures may not always be available to certain jurisdictions as they can be very costly or legally difficult to implement.

There can also be significant opposition to ITQs and similar regimes, as they may lead to a concentration of fishers if concentration limits are not enforced (such as placing limits on the % of the TAC that can be owned by a single fishing enterprise). Barriers to entry may be created as the acquisition of licences may be prohibitively expensive. Other issues with ITQ regimes are related to possible windfall gains: if market prices for species under ITQs suddenly increase, for example due a stock collapse elsewhere, the ITQ fishery may experience a significant windfall, which is secured for fishery participants because of the restricted access. This may lead to considerable pressure on the regulator to allow new entrants; however, an influx of new entrants may lead to additional pressure on the resource, endangering rebuilding efforts.

Various spatial and area management techniques have also been used in fisheries rebuilding strategies, ranging from marine protected areas to “no take” zones and area/time closures. Such tools can be designed to protect essential fish habitat or be structured to protect nursery and spawning grounds or other sensitive areas. However, fishing effort could be displaced to other areas or fisheries, and except in the case of sedentary species, area management zones are unlikely to encompass a significant portion

of the range of most fish stocks. Nevertheless, protected areas, marine reserves and MPAs may prove to be a complementary fisheries management tool to the traditional input/output controls.

Legislative basis and stakeholder involvement

The institutional and legislative structure of a country also has a role to play in stock rebuilding. In the United States, stock rebuilding is mandated as part of the national fisheries management legislation; this has led to a prescriptive approach with tight timelines and limited flexibility. Analyses of case studies indicate that there is a higher likelihood of stock rebuilding success in jurisdictions that have specific and strict legislation governing stock building, as has been demonstrated in the United States, in contrast to jurisdictions such as the EU which do not have mandated timelines for rebuilding (Caddy and Agnew 2002; Wakefield *et al.*, 2007).

Most government policies and programs now explicitly require that stakeholders be engaged in the development of rebuilding plans from the initial stages to allow for the broadest level of support in the rebuilding plan. This may extend to stakeholder involvement in the provision of biological and economic data, participation in the development of rebuilding targets and paths, as well as the analysis of social and economic impacts.

Stakeholder involvement in the design of rebuilding plans is particularly important to ensure that all the best available information is used in the decision making process. In addition, the degree of uncertainty in scientific assessments should be clearly articulated to stakeholders, given that many decisions will be made with less than perfect information. Obtaining the agreement of fishers on a set of pre-established harvest control rules as the status of the stock changes in response to rebuilding measures is of the utmost importance. This will serve to limit the calls for increasing quotas or removing restrictions when there are signs of improvement instances as well as demonstrate that adaptive management is the approach that is being pursued in the face of varying levels of uncertainty about the stocks response to rebuilding measures, and external factors such as climate change (Caddy and Agnew, 2004).

Risk and uncertainty

A clear understanding of the range of risks and uncertainty is crucial to establishing rebuilding objectives or targets, choosing appropriate management instruments and communicating the targets and constraints clearly to stakeholders. In a world without uncertainty, where information would always be complete, all relationships would be perfectly known and choosing the best instrument and setting targets would be a simple affair. As this is not the case, it is important to understand how biological (e.g. species reaction to rebuilding measures) and economic (e.g. market prices and consumer preferences) uncertainty affect stock rebuilding, and how risk can be incorporated in rebuilding plans.

Yamazaki *et al.* (2008) demonstrated that it is not only the presence of uncertainty but also the types of uncertainty that are important in choosing the right management instrument, while a recent study compared the outcomes of choosing output (TACs) or input (Total Allowable Effort - TAEs) controls in an uncertain environment (Kompas *et al.*, 2008).

These studies indicate that in cases where there is a well-defined and understood growth function for a fishery, but uncertainty around the catch-effort relationships, output (TAC) controls may be preferable to input controls. Input controls would be preferable in the opposite situation, where there is considerable uncertainty in terms of the rate of growth of the biomass. Kompas *et al.* (2008) stress that this is the only case when a TAE approach may be preferable to a TAC one, and it would still lead to a higher variability in profit levels. Central to their argument is because as TAE controls limit harvest indirectly, there is often overshooting (lost profits) or undershooting (risk of overfishing) of optimal harvest levels, which leads to greater variability – an undesirable consequence under risk aversion assumptions. This means that considerations about risk and uncertainty should influence the choice of instruments to attain management goals in rebuilding stocks.

It is also important to consider risk and uncertainty issues in terms of setting objectives and adequately communicating options and results. As discussed earlier, no matter how well planned a rebuilding strategy is, reality is sufficiently complex that there will always be risks that rebuilding objectives are not met; hence attempts should be made to quantify risks and uncertainty so as not to create unrealistic expectations and to clearly indicate the tradeoffs being made through the rebuilding process.

There is never a guarantee that rebuilding will occur even if the fishing mortality is reduced, good management practices are introduced and other favourable measures are implemented. In the case of the Irish cod rebuilding plan, while many management measures were well implemented, the lack of communication about the associated risks led to significant frustration among fishers and fishery managers alike, which in turn jeopardized the entire rebuilding plan (Kelly *et al.*, 2006). As such, these researchers recommended improving the Irish rebuilding plan by including “clear, measurable performance targets, underpinned by sufficient data collection to assess performance of rebuilding, and an understanding of the inherent uncertainty involved.” Scientists and economists should also communicate clearly the uncertainty and levels of risks involved in any rebuilding strategy.

Post-rebuilding management

A key, but often neglected, issue in the design and implementation of fisheries rebuilding plans is the management of the fishery once the stock is rebuilt to the target level. This is important for two key reasons. First, failure to resolve any underlying management issues that contributed to the need to rebuild the fishery in the first place will lead to them resurfacing again once any rebuilding measures (such as catch, effort or gear restrictions) are removed. The period of rebuilding may be regarded as requiring special measures that may be seen as dramatic and time bound by fishers (and managers). There is a need to ensure that the post-rebuilding management measures alter the fundamental incentives facing fishers are appropriate and do not encourage the excess capacity or effort in the future.

Second, the discussion and agreement on post-rebuilding management amongst stakeholders at the design stage of rebuilding plans will provide a greater degree of certainty for stakeholders. This, in turn, will likely ensure a higher level of support for the entire rebuilding package, reducing the risk of default or backsliding by participants, and potentially reducing the costs of enforcement. This may also require a significant up-front investment in negotiating and planning the parameters of the rebuilding process.

Political economy issues and managing the transition

Biological, political and socio-economic obstacles to fish stock rebuilding are often characterized by uncertainty, lack of data, issues around transparency and varied institutional and governance structures. One study concluded that “successful recovery depends more on management infrastructure and socio-economic context than on stock calculations, whose accuracy has often been overestimated, especially where there has been a heavy reliance on retrospective analysis of age structure” (Caddy and Agnew, 2004).

Box 2.2 provides an excerpt from a previous OECD study entitled “The Political Economy of Fisheries Reform” (Sutinen, 2007) that describes these obstacles to effectively managing overfished and depleted fish stocks.

In the context of stock rebuilding, biologists are tasked with defining a minimum stock level to be maintained, such as the MSY. However, overemphasis on levels of uncertainty and the varied approaches associated with biological reference points and limits are often cited by opponents to massive reductions in fish quotas. In addition, the use of MSY as a *target* has been criticised in favour of a more precautionary approach that would treat the MSY as an upper limit to be avoided.

Box 2.2. The political economy of reform

Despite 30 years of fishery management programs, most coastal nations have not yet succeeded in effectively controlling activities in their waters, or maintaining healthy fish stocks. It has been estimated that in 2005, half of marine fish stocks were fully exploited and about one quarter of stocks was overexploited, depleted or recovering from depletion. Nonetheless, it is not uncommon that statistical data and scientific evidence are ignored in policy setting. For example, total allowable catch rates are frequently set above the rates recommended by fishery scientists as necessary for sustainability. Reasons for such “governance failures” include: i) special interest effects; ii) rational voter ignorance; iii) bundling of issues; iv) short-sightedness; v) decoupling of costs and benefits; and vi) bureaucratic inefficiencies.

Short-sightedness of the principal actors and decoupled benefits and costs of fishery products have a powerful influence on the choice of fishery management policies. Politicians often exhibit short-sightedness by enacting special legislation and appropriations for fisheries. Fishermen, in turn, tend to be short-sighted because they have no secure claim on future outcomes in their fishery, and because of the great uncertainty about future fishery policies, fish stocks and markets. Thus, effective conservation policies tend to be disfavoured because they concentrate short-term costs upon resource users in exchange for benefits in the future that would not necessarily accrue to the users who make the sacrifice.

Only when those who sacrifice in the present can expect to receive benefits in the future can the political marketplace of fishery be expected to produce effective conservation policies. To correct or minimise governance failures in fisheries, national administrations can introduce strong property rights (e.g. transferable individual licences and individual quotas), decentralise rights and responsibilities to individuals and user groups and implement cost recovery and various forms of sustainable financing mechanisms in order to change the incentive structure. But, ultimately, the success of any of these measures depends on the interests of and support from private sector actors.

Source : Sutinen (2007).

In some instances, TACs recommended by scientists are overridden by governments, primarily due to political pressures. While this may be partly the case, the lack of an integrated approach which would include economic and social considerations as part of the initial rebuilding advice may also be a factor, coupled with what some consider an

overemphasis on the uncertainty associated with scientific assessments. Fisheries managers and decision makers are often left to “fill the gap” by introducing less than robust estimates of the social and economic impacts that may result from stock rebuilding options.

Socio-economic obstacles to fish stock rebuilding have resulted from the use of subsidies to support the fishing sector, not addressing the issue of excess capacity, and the idea of a guaranteed level of profit per vessel or fisher. There are also distributional impacts of fisheries rebuilding that may not be fully appreciated or addressed in designing packages. Fisheries rebuilding typically results in upfront costs to fishers that are experienced in the short term as TACs are reduced or a fishery is closed, leading to reduced income and fewer opportunities for employment in the fishery. On the other hand, the commercial or biological benefits may not be realized for a considerable amount of time. In addition, certain fisheries may bear a disproportionate amount of the impact, while other groups may receive a greater benefit. In these cases, the issue of the distribution of costs and benefits over time and across stakeholders becomes an important matter. For example, it can be extremely complex to allocate an allowable harvest between artisanal, commercial and recreational fishers, as each has a competing interest.

These obstacles highlight the importance of transparency in decision making, an inclusive approach to stock rebuilding, and adaptive management strategies. Furthermore, the management of fisheries after they have been rebuilt is important. This highlights the importance of addressing the root causes of depletion or overfishing such as excess capacity, lack of adequate habitat, and poorly defined access rights to fisheries. To that end, some countries have put in place compensation mechanisms, introduced retraining schemes, dedicated funds to habitat restoration and stock enhancement, and adopted market mechanisms that seek to tackle these issues and as a way to ease the transition, while developing rebuilding plans.

In terms of political obstacles to fish stock rebuilding, the lack of clearly defined rules and procedures governing fisheries management decisions provides incentives for groups to directly lobby politicians to reopen fisheries at the initial stages of rebuilding for stocks. It is crucial that governments provide sustained support for reforming fisheries to ensure their sustainability and profitability and do not regress back to temporary solutions such as subsidies that may only provide short term relief.

Overview of national approaches in selected OECD countries

This section presents a brief overview of national approaches to fisheries rebuilding in a selected number of OECD countries in order to provide some policy context for consideration of the issues in incorporating economic information in rebuilding plans. It is clear from this overview that the approaches to rebuilding fisheries differ between countries, sometime significantly. This highlights the fact that there is not a “one size fits all” approach to the issue of designing and implementing cost-effective and efficient fisheries rebuilding plans, and that considerable attention needs to be paid to the range of ecological, economic, social and institutional characteristics underlying each country’s circumstances.

European Union

The challenge to rebuild depleted stocks has been taken up at the regional and national level to varying degrees and through various mechanisms. In the European Union, Council Regulation (EC) No. 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy enables the Commission to take steps to rebuild fish stocks.

Long term (multi-annual) management plans are used to rebuild EU fisheries. In particular, they are used to ensure that stocks are exploited within safe biological limits and that progressively the production of the stocks is maximised towards MSY. In some cases, where stocks are exploited outside safe biological limits, a recovery phase is initiated to bring them within safe biological limits. The main basis for this recovery phase is the precautionary approach and takes account of limit reference points recommended by relevant scientific bodies. The first long term plan which the EU introduced for its own waters was the recovery of North Sea cod in 2004. Since then, the formula has been applied to a range of stocks in EU waters, and the Commission intends to progressively implement similar plans for all major commercial fish stocks over the coming years. Today, ten plans are implemented and another six are in the pipeline for 2009/10. A number of important international plans are also agreed with non-EU countries. The Commission can also take immediate and direct action on a set of emergency measures (not lasting more than six months) if there is evidence of a serious threat to the conservation of a marine resource.

The EU's "Fishing Opportunities for 2009: Policy Statement" indicates that for stocks where the status is known, 68% are at high risk of depletion, and 32% are known to be fished sustainably. EU scientists have also advised that fishing be ceased for about 19% of European managed stocks given their poor status.

The EU has also developed compensation programs to ease some of the underlying issues associated with overfishing. The 2007 European Fisheries Fund allows members to finance the gradual restructuring of the sector which currently suffers from overcapacity and includes the decommissioning and re-categorisation of vessels, training, and the development of alternative economic activities. The 2008 "Impact Assessment Regarding the Commission's proposal establishing revised measures for the recovery of cod stocks" indicates recognition that the initial strategy to rebuild cod stocks was insufficient and did not meet its intended goals. In the development of an updated rebuilding plan, the EU will revise long term objectives *from* targeting specific biomass measures *towards* an approach of striving to achieve an optimum exploitation rate to lead to the highest sustainable yield. In response to comments from member countries, the complexity of the management system will be reduced while at the same time bestowing flexibility for countries in terms of implementation. Finally, the updated plan will also deal more directly with the issue of discards and will benefit from the development of clearer harvest rules so as to lessen the amount of impromptu decisions.

United States

In the United States, stock rebuilding was first mandated under the 1996 Sustainable Fisheries Act which amended the Magnuson-Stevens Fishery and Conservation Act (MSA) and by the more recent 2007 amendments to the same law. These amendments provided a legal mandate for NOAA Fisheries to end overfishing and rebuild overfished fish stocks. Legal authority to recover listed species and selected marine mammals is also

provided to NOAA Fisheries under the Marine Mammal Protection Act and the Endangered Species Act. The MSA law sets out specific timelines for action to rebuild depleted fisheries, establishes requirements for the rebuilding management plans, and requires accountability for implementing plans in a timely manner (Rosenberg *et al.* 2006). Rebuilding plans are normally undertaken as an amendment to an existing Fisheries Management Plan, which are developed by the regional fisheries management councils and implemented by NOAA Fisheries. There are also provisions to use Limited Access Privilege Programs as a market measure to help rebuild overfished stocks and for the use of annual catch limits to ensure that overfishing does not occur.

NOAA is required to produce an annual report to Congress reporting on the status of US fish stocks. As of the last quarter of 2008, 52 rebuilding plans were active in the United States. Currently, NOAA Fisheries has adequate information to determine the status of 173 fish stocks and, of these, 45 are overfished and 128 are not overfished.

The MSA mandates that, once a stock has been determined to be overfished, it must be rebuilt in as short a period as possible, not to exceed 10 years, with certain exceptions. The mandatory 10-year rebuilding time-frame has prompted criticisms that the law is excessively rigid and unrealistic. As a consequence, some members of Congress have recently introduced *The Flexibility in Rebuilding American Fisheries Act of 2009* citing unfairness and excessive consequences on fishing communities resulting from the limitations placed on fisheries managers to meet legislative timelines.

Larkin, Sylvia *et al* (2007) contrasted the approach to rebuilding in the United States with the more flexible approach employed in New Zealand. Their research indicates that having the ability to adjust a rebuilding timeframe in New Zealand according to a broader set of goals, including socio-economic, could increase the net present value of commercial harvests. A more flexible approach may allow for rebuilding plans that meet biological targets in a socio-economically optimal way, while continuing to actively engage the users of the resource in the decision-making process. On the other hand, supporters of the existing MSA rebuilding provisions claim that the 10-year time-frame is feasible in practically all situations, that adequate exceptions are allowed, and that strong and early actions to rebuild overfished stocks make more economic sense over the longer term. In summary, rebuilding requirements continue to generate controversy.

Canada

In Canada, fish stock rebuilding may take place under its Fisheries Act which provides the legislative authority for the conservation of fish stocks and the management of fisheries, or the Species at Risk Act (SARA) which sets out specific requirements to protect and implement recovery strategies for all listed endangered or threatened species (terrestrial and aquatic).

In the years immediately following the implementation of moratoria in the early 1990s, Canada developed stock recovery strategies for depleted cod stocks in Atlantic Canada and Quebec. These recovery strategies were reviewed and adapted as needed following consideration of cod for possible listing under SARA, and three federal-provincial Action Teams were established in 2003: Canada-Newfoundland and Labrador; Canada-Quebec; and Canada-Maritimes. The Action Teams are mandated to develop integrated stock recovery and long-term management strategies for the cod stocks (DFO 2005). The terms of reference for the Action Teams are focused on building an understanding of the current status of the cod stocks, increasing co-operation between

stakeholders, and identifying and evaluating current science priorities and information with respect to management of the stocks. However, the Action Teams are not mandated to provide recommendations to the Minister of Fisheries and Oceans on cod stock management or annual TACs. Nor are they mandated to address access or historical share issues within the fisheries or to undertake new scientific research.

Specific to the precautionary approach and stock rebuilding, the recently published "A fishery decision-making framework incorporating the Precautionary Approach" (2009) for key commercial target stocks in Canada indicates that healthy, cautious and critical stock status zones are to be based on defined upper stock and limit reference point. This policy requires the implementation of a stock rebuilding plan when the abundance of a key stock falls below its limit reference point. The rebuilding plan must include measures to limit fishing mortality with the aim of rebuilding the stock above its limit reference point in a timely fashion. Canada is currently piloting a draft framework for incorporating socio-economic analysis into fisheries management plans with a view to explicitly dealing with the economic context around fisheries management decisions.

Japan

Under Japan's Basic Law on the Fisheries Policy established in 2001, the government has been formulating resource restoration plans and introducing a total allowable effort system for species that require urgent resource restoration (Fisheries Agency, 2007). A related framework for resource recovery plans to enable the implementation of the necessary measures for rebuilding resources in a comprehensive and planned manner was established. Under the framework, national or regional level governments develop resource recovery plans in co-operation with stakeholders.

For single species fisheries, Resource Recovery Plans are developed in which specific recovery targets are set for the period of the plan and various measures are put in place to help achieve the target. These measures include reduction in fishing effort through vessel reduction and suspension of fishing operations, release of seedlings, and conservation of the environments of fishing grounds. For multi-species fisheries, Comprehensive Resource Recovery Plans are developed, and tend to focus on set net and trawl net fisheries.

Over the last twenty years, Japan has increased its monitoring of its primary fish stocks. The Japanese public research institute classifies assessed stocks into three categories (high, middle, low) in terms of the relative abundance. The 2004 assessment indicates that the resource levels of 12 stocks, including saury, common squid, and sea-bream, are classified as high, 49 fish stocks such as common mackerel, sardine, Alaska pollock, and snow crabs are low and 30 stocks, including Jack mackerel and sand fish, are classified as middle. As of February 2008, 51 plans for specific fish species and 20 comprehensive plans covering geographic area and fishing types are already developed or under development.

Australia

Australian legislation provides for the Australian Fisheries Management Authority (AFMA) to introduce measures to rebuild Commonwealth fish stocks that have been overfished. Rebuilding of fish stocks is done in accordance with the Australian Government's Commonwealth Fisheries Harvest Strategy Policy and Guidelines, September 2007 (HSP). The policy and guidelines specify that AFMA maintain stocks,

on average, at target reference points and cease targeted fishing for stocks identified to be below limit reference points and implement management actions directed to rapid rebuilding of those stocks. Currently there are four commercial fish stocks managed by AFMA that are identified to be below limit reference points. These species are all subject to a rebuilding strategy and include orange roughy (*Hoplostethus atlanticus*), eastern gemfish (*Rexea solandri*), school shark (*Galeorhinus galeus*) and blue warehou (*Serirolella brama*).

On 1 January 2008, and in line with the HSP, AFMA implemented fisheries management changes in plans for a number of overfished stocks. The HSP requires formal rebuilding strategies for all species that are below their biomass limit reference point. In 2008, formal rebuilding strategies developed for Eastern Gemfish and School Shark, both recently listed as Conservation Dependent species under the Environment Protection and Conservation Biodiversity Act 1999. A rebuilding strategy has been in place for orange roughy since 2006 when it was listed as Conservation Dependent.

In 2001, stock assessments suggested that the brown and grooved tiger prawns in Australia's Northern Prawn Fishery were depleted and fishing effort too high to promote recover to the fishery's target of BMSY (the stock size required to achieve the maximum sustainable yield). The level of depletion of the prawn stock was not such that it would be regarded as "overfished" as the biomass had not gone below the HSP limit reference point. However, as it was below the fishery's target, a rebuilding program was implemented and the most recent assessment suggests that the biomass of both species is around or above this target. In 2004 the fishery adopted Maximum Economic Yield as the target. The primary fisheries management instruments are input controls such as limited entry, seasonal and area closures, number of fishing vessels, and gear and mesh size restrictions. Output controls such as individual transferable quotas as part of a total allowable catch are also used in many of the fisheries and many fisheries are moving to this form of management.

In 2007, 96 fish stocks were assessed in terms biological status (overfished status and overfishing status). The number of stocks classified as not overfished increased to 27 in 2006 and 28 in 2007, following a 7-year period in which they remained stable at around 19. The number of stocks classified as overfished and/or subject to overfishing fell to 19 in 2006 and again to 16 in 2007. During the years 1996 to 2005, the number of stocks classified as overfished and/or subject to overfishing increased steadily, peaking at 24 in 2005, before falling to 16 in 2007.

New Zealand

The Fisheries Act of 1996 requires the Minister to maintain stocks at or above a level that can produce Maximum Sustainable Yield (MSY), which is defined as the largest average annual yield (catch) that can be produced over a prolonged period of time while maintaining the stock's productive capacity. For stocks that are below MSY, stock assessments are required to analyse the whether or not the current harvest rate is at a level to allow for stock rebuilding to MSY (summarised in the Ministry's Fishery Assessment Plenary Report). If a stock is below the target level, then under the Fisheries Act of 1996, the Minister must take corrective action to rebuild the stock to or above the average stock biomass or level corresponding to MSY (known as B_{MSY}), or a related target level.

It is important to note that MSY and B_{MSY} are not unique numbers for a given stock; rather, they are a function of environmental conditions and the harvest strategy employed.

A harvest strategy consists of the methods used to harvest (i.e., to fish) a species and the criteria used to calculate how much to harvest in a given year. An MSY harvest strategy is one that is designed to maximise long-term yields depending on the methods used for harvesting (which determine, for example, the size classes of fish that will be captured) and the criteria used to make the calculations (e.g. whether or not fishers are willing to take variable catches from year to year). In New Zealand, two general types of MSY harvest strategies are commonly used as references: a constant catch strategy, which generates the Maximum Constant Yield (MCY), and a constant fishing mortality strategy, which generates the long-term Maximum Average Yield (MAY) and a corresponding series of Current Annual Yields (CAYs).³

Under the Harvest Strategy approach, New Zealand has requirements for the development of formal stock rebuilding plans. These consist of three core elements

- A specified target about which a fishery or stock should fluctuate.
- A soft limit that triggers a requirement for a formal time constraining rebuilding plan.
- A hard limit below which fisheries should be considered for closure.

Priority is given to stocks that are currently under review. Of the 101 stocks for which there is sufficient information to characterise stock status, 72 (71%) are near or above target levels. These represent the main commercial stocks. Management action to rebuild stocks has been put in place for the remaining 29 stocks. Two recent notable rebuilding successes are those for southern rock lobster and for the western stock of hoki.

Conclusion

The political, ecological and economic imperatives underlying the need to rebuild fisheries are clear. The WSSD commitment to rebuild fish stocks to levels that can produce the maximum sustainable yield by 2015 underscores the urgent nature of the task. The rebuilding efforts to date have had mixed results, with a number of sound successes as well as some signal failures. To help improve on these outcomes, it is necessary to further develop robust and effective fisheries rebuilding plans, drawing on the full range of analytical information and policy tools available to fisheries managers. As a result, the integration of economic, social and institutional information in to the design and implementation of fisheries rebuilding plans will complement the existing scientific information that forms the basis of much of the policy advice to date. Moreover, the policy context confronting the fishing sector will undoubtedly continue to evolve in the future. Efforts to rebuild stocks will need to continue to take into consideration climate change impacts, the ecosystem approaches to fisheries, and other natural and policy developments. Rebuilding programs are therefore likely to need to be more holistic in their approaches, taking into account a much broader range of users and interactions.

Notes

1. This estimate could be considered a lower bound, as it includes direct use values (recreational and commercial fishery) but does not consider value added (processing or retail values), nor does it include ecosystem values.
2. UNCOVER is the acronym for the full name of the project, **U**nderstanding the Mechanisms for Stock **R**ecovery. The project is a consortium of 17 fisheries research organisations across Europe and is scheduled to be finished in February 2010. www.uncover.eu
3. Approaches to the management of New Zealand's fisheries are currently in a state of evolution. The Guide to Biological Reference Points for the 2007-08 Fisheries Assessment Meetings contained in the Introductory section of the 2008 Fishery Assessment Plenary Report provides a description of the approaches that were developed in New Zealand in the late 1980s. Since then, these approaches have evolved and alternative approaches have been developed.

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Chapter 3.

Getting the economics and the incentives right:

Instrument choices in rebuilding fisheries

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Abstract

It is now generally agreed that all natural resources, including marine capture fishery resources, are properly regarded as “natural” capital. From this it follows that, when one talks about rebuilding capture fishery resources, one is talking in terms of a “natural” capital investment program. After discussing the basic economics underlying an optimal fisheries capital investment program, the chapter will go on to discuss the incentive structures that are to be in place, at both an intra-EEZ level, and at an international level, if the resource investment program is to be successful. This chapter will draw heavily upon work that the author has been doing for the FAO, in conjunction with The World Bank and FAO study: The Sunken Billions: The Economic Justification for Fisheries Reform.

Introduction

In reviewing the economics of the rebuilding of marine capture fishery resources, we commence with the fundamental proposition that these resources, like all natural resources, constitute capital assets – “natural” capital – from the point of view of society. Consequently, a fishery resource rebuilding program is an investment program, with all that that implies.

In order for such an investment program to succeed, appropriate incentive structures must be in place. All investment in real capital involves a cost that is incurred today in the hope of a return – a payoff – at some point in the future, with the return, or payoff, being very much an expected return/payoff. If the right incentives are not in place, the cost of investment will not be willingly borne.

It will be argued that the relevant incentives have to be viewed, both from an intra-EEZ perspective – incentives involving fishers – and from an international perspective – incentives involving fishing states and entities. It will be further argued that there is a key interrelationship between the two sets of incentives.

This chapter draws heavily upon work that the author has been undertaking for the FAO, in conjunction with the World Bank and FAO study: *The Sunken Billions: The Economic Justification for Fisheries Reform* (World Bank and FAO, 2008).

Fishery resources as capital and the basic economics of rebuilding fishery resources

The World Bank in its 2005 report, *Where is the Wealth of Nations? Measuring Capital for the 21st Century* (World Bank, 2005), maintains that both the current national income, and the future development, of any nation rest upon that nation’s portfolio of real (as opposed to financial) capital assets, where a capital asset can be defined as any asset capable of yielding a stream of economic returns through time. The national real capital portfolio is seen by the World Bank to consist of produced, natural and intangible capital assets, with the latter to be seen, in turn, as a mix of human and social capital. Development is to be viewed as a process of real asset portfolio management through time (World Bank, 2005).

The World Bank 2005 report divides natural capital into two components, exhaustible natural resources, such as hydrocarbons and minerals, and living, or renewable, natural resources. Renewable natural resources, unlike exhaustible natural resources, are capable of growth and are, as a consequence, capable of providing a sustainable flow of net economic benefits (resource rent in common parlance) into the indefinite future. They are, to quote the World Bank, “truly a gift of nature” (World Bank, 2005, *ibid.*). Marine capture fishery resources constitute a segment of the world’s stock of natural capital, in the form of renewable natural resources, and are thus “truly a gift of nature.”

Sustainable harvesting of a renewable resource, such as a capture fishery resource, involves, in simplest terms, the skimming off the net natural growth of the resource. Within limits, positive investment in such fisheries capital can be achieved by harvesting less than the net natural growth of the resource, with the maximum rate of resource investment being achieved by setting the harvesting rate equal to zero, i.e. declaring a harvest moratorium.

In examining any proposed real capital investment program, economists have to ask themselves two questions.

- What is the optimal, or target, stock of capital?
- What is the appropriate rate of investment; should one approach the target stock as rapidly as possible, by investing at the maximum rate, or should one approach the target stock at a more gradual rate?

The basic economics underlying these two questions, as they apply to capture fisheries capital, was developed some thirty plus years ago (Clark and Munro, 1975; Clark, Clarke and Munro, 1979). The answer to the first question, which is really just an application of the economist's theory of capital, focuses on the cost of such investment - forgone harvest opportunities today - versus the payoff from such an investment. The payoff is seen in terms of the discounted stream of (expected) additional sustainable resource rent (i.e. the present value of such resource rent), arising from the addition to the resource stock. Resource rent, let it be added, should properly be very broadly defined to include all non-market, as well as market, economic benefits flowing from the resource.

The key investment decision rule just says go on investing in the fishery capital up to the point that the cost of the marginal investment in the resource is just equal to the payoff - the present value of (expected) additional sustainable resource rent arising from the resource investment. Another way of stating the investment rule is to say; invest up to the point that the yield, or rate of return, on the marginal investment in the resource, expressed in percentage terms, is equal to the rate of return on alternative investments of comparable degree of risk¹ (Clark and Munro, 1975). Remember that fisheries capital is just one class of assets in the social manager's real capital portfolio.

What assurance do we have that the attempts at resource investment will, in fact, have a positive resource rent payoff? There are two issues that have to be addressed. The World Bank/FAO report, *The Sunken Billions*, in its estimate of resource rent loss, operates on the assumption that "existing biological overfishing is entirely reversible in the long run" (World Bank and FAO, 2008). The assumption is of questionable validity for a non-trivial number of fishery resources. There is evidence of depleted fishery resources that, either cannot recover to their former levels of abundance, or can be expected to do so, only after several decades (Hutchings, 2000; Clark, Munro and Sumaila, forthcoming). What is required then is investigation into what constitute what we might term a feasible set of fishery resource investment opportunities. This is more of a task for marine biologists, than it is for economists.

Secondly, suppose that we have before us our feasible set of fishery resource investment opportunities, but suppose that our fisheries management regime is such that, should we succeed in rebuilding some of these resources, any resource rent arising from the rebuilt resources will just leak away. The leakage could occur, for example, through uncontrollable build up of excess capacity in the fisheries - a not unknown occurrence.

In terms of our basic economics of investment in fisheries capital, this leakage could undermine the resource investment program. Indeed, we could go further and say that the leakage might be downright dangerous to the investment program.²

The answer to our second question on the appropriate rate of resource investment (assuming that we have a resource capital target worth aiming for) is much more complex. It is critically bound up with, to use some jargon, what economists call

“malleability” of capital, where the relevant capital in this case is produced capital in the form of fleet capital and processing sector capital, and human capital, in terms of fishers and other workers involved in the fishery. “Malleability” of capital refers to ease with which such capital can be shifted in and out of the fishery, and is analogous to the concept of “liquidity” in the world of finance.

As a general rule of thumb, once the target stock of capital (of any form) is identified, one should move towards the target with all possible speed, unless there are penalties associated with rapid rates of investment. The most rapid rate of resource investment (positive) is achieved, as we have noted, by declaring a harvest moratorium, i.e. setting a TAC equal to zero. If the fleet/processing capital and human capital are highly “malleable” from the perspective of the fishery in question, then a rapid rate of resource investment is generally optimal in economic terms.³

If the aforementioned forms of capital are less than perfectly malleable – it is difficult and costly to shift the fleet and the workforce from the fishery – then we know that declaring an outright harvest moratorium will be socially disruptive and costly. It is also turns out to be bad economic policy as well. To achieve the maximum economic returns from the resource through time, a slower, less drastic, rate of resource investment is in order (Clark, Clarke and Munro, 1979).⁴

The prima facie case for a worldwide capture fishery capital investment program

Where do we currently stand in economic terms with respect to the existing stock of capture fishery capital? For answers, we turn to the World Bank/FAO report, *The Sunken Billions* (World Bank and FAO, 2008). The report argues that the world is losing resource rent from these resources at a rate of USD 50 billion per year, because of less than optimal resource management. It would be one thing, if the report is stating that, while the world capture fishery capital is yielding a positive resource rent return, the return could be higher. A close reading of the report reveals that what it is actually stating is that the current yield on world capture fishery capital is negative (World Bank and FAO, 2008, Table 5). While there are some prosperous capture fisheries, from an overall standpoint, the world capture fisheries capital is to be seen as a set of non-performing assets.

The report also estimates that, in order to achieve an economically optimal outcome, there would have to be a two to threefold increase in the capture fishery biomass (World Bank and FAO, 2008, *ibid.*). In other words, the report is implying that a major marine fisheries capital investment program is indeed in order.⁵ Let it be repeated, however, that some of the implied investments may be infeasible on biological grounds and secondly that, if appropriate fishery management structures are not in place, the resource investment program could prove to be futile from an economic perspective.

To gain a better understanding of the management structures, the incentive schemes, that are required, we need first a better understanding of how we arrived at our current state of affairs. Most know about the problems arising from the “common pool” nature of capture fishery resources, but not all recognize that, until the turn of the 20th century, few, if any, worried about the overexploitation of ocean capture fishery resources.

Origins of the overexploitation of capture fishery resources and the loss of resource rent

It has long been recognized that marine capture fisheries are very difficult to manage effectively. The fish, by and in the large, cannot be seen prior to capture; the fish are, with few exceptions, mobile. There are, moreover, species interactions and the effects of environmental shocks that are unobservable. As a consequence, it was, in the past, difficult, or more to the point costly, to establish effective property rights to the resources, be these property rights private or public. Capture fishery resources were seen as the quintessential “common pool” (open to all) resources.

Up until the 20th century, the inherent, and inescapable, difficulties of capture fisheries management did not seem to matter a great deal. Capture fishery resources were viewed as “free capital,” beyond overexploitation. Arguably, one of the greatest of the biologists to emerge in 19th century Britain was Thomas Huxley, who served for a time as Inspector of Fisheries, during the 1880s. While in that position, he stated the following:

The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all of the great sea fisheries, are inexhaustible: that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently ... to be useless: (Gordon, 1954).

The belief that the great sea fishery resources are inexhaustible had helped to enshrine the “common pool” nature of high seas ocean fisheries in international law, in the form of the Freedom of the (high) Seas, first set forth in the early 17th century. The high seas were seen to consist of all ocean waters beyond the narrow coastal state territorial seas (historically extending out from shore to only three nautical miles).

Under the Freedom of the Seas doctrine, the resources of the high seas, including fishery resources, were deemed to be *res communis*. That is to say they were to be seen as the property of all (Orrego Vicuña, 1999). The belief in the inexhaustibility of the ocean fishery resources had an economic basis. When the doctrine of the Freedom of the Seas was propounded in the early 17th century, the state of fisheries technology was such that heavy exploitation of high seas fishery resources was prohibitively costly (not to say dangerous). This remained more or less true until after the mid-19th century.

The economic protection of high seas fishery resources was, in fact, beginning to fray, even as Huxley spoke in the early 1880s. Fishing technology was changing rapidly, bringing with it a fall in harvesting costs. The shift from sail to steam is a prime example.

The vanishing of this economic protection, and the transformation of “free” natural fisheries capital to scarce natural capital, took time to be recognized fully. While there were a few attempts at serious capture fishery resource conservation in the early 20th century, such as in the North Pacific fur seal fishery (1911) and the Pacific halibut fishery (1923), the management of ocean fisheries remained minimal, until after the close of the Second World War (National Research Council, 1999).

Once the economic protection of ocean fishery resources had been stripped away by fisheries technological progress, the perverse (from society’s point of view) incentive consequences of the “common pool” nature of the resources then manifested themselves. The primary consequence pertains to investment/disinvestment in this form of natural capital.

From our brief discussion of the economics of capital and investment, it is clear that no rational investor will undertake an investment, unless the expected stream of net economic returns from the investment, (discounted at the appropriate rate of interest) — the present value of the net economic returns — is at least equal to the cost of the investment. In a “common pool” fishery, an individual fisher can count on no positive return on an investment in the resource. If a fisher refrains from harvesting in order to build up the resource, he/she may do nothing more than increase the harvests of his/her competitors.

It can be shown that, in such fisheries, fishers will act as if they are applying a rate of discount (interest) to future returns from the fishery equal to infinity. Tomorrow’s returns from the fishery count essentially for nothing (Clark and Munro, 1975). This, in turn, means that the rational fisher is given every incentive to treat the resource as a non-renewable resource, namely as a resource to be mined.

A striking example, to which we shall return again, is provided by the Norwegian Spring-Spawning Herring resource of the North Atlantic. The resource has intense schooling tendencies, which makes it very vulnerable to over-exploitation (Bjørndal, 2008).

Segments of the resource, in the middle of the North Atlantic, were, until the 1960s, protected economically from gross overexploitation. By the 1960s, however, technological developments in fishing led to this economic protection being eliminated.

The International Commission for the Exploration of the Sea (ICES) estimates that the minimum level of spawning stock biomass (SSB) of the resource, below which it should not be allowed to fall, is 2.5 million tonnes (Bjørndal, 2008). In the late 1960s, the evidence of gross overexploitation of the resource, of the clear breaching of this minimum, became overwhelming. A harvest moratorium was declared. The SSB continued to decline, reaching an estimated low of 2 thousand tonnes in 1972, i.e. 0.08% of the ICES declared SSB minimum. In other words, the resource had been mined almost to the point of extinction (Arnason, Magnusson and Agnarsson, 2000). The herring resource, partly through good fortune, was to recover, but only after a 20 year harvest moratorium.

The growing recognition, after the end of World War II, of the fishery resource mining problem led to responses, such as domestic and international controls on harvesting, and the placing of much of the ocean capture fishery resources under coastal state jurisdiction, through the implementation of the EEZ regime under the 1982 UN Convention on the Law of the Sea. That these measures have been less than entirely successful is evidenced by the continued mining of the resources.

The controls on harvesting, domestic and international, did nothing to change the fisher incentives to mine the resources, and did nothing to halt the harvesting cost reducing advances in fishing technology. As harvesting cost fell through time, fishery resources, hitherto enjoying economic protection, became open to exploitation, thereby necessitating yet further harvest controls. Typically, the new controls have been implemented, only after extensive resource overexploitation has already occurred. With the perverse fisher incentives in place, there has, in effect, been a race between harvest control measures and advances in fishing technology.

There is more. Many fishery resources should be viewed as spatially linked sub-stocks (Sanchirico and Wilen, 2005). If the sub-stocks far from shore are commercially un-exploitable, then these sub-stocks constitute natural reserves, which protect the stock

complex from severe overexploitation. With fisheries technological advances, and the ongoing fall in harvesting costs, what was hitherto commercially un-exploitable, becomes profitable to exploit. The natural reserves disappear, and the stock complex becomes vulnerable, for example the Norwegian Spring Spawning Herring.

Even where harvest control measures have been effective in halting the mining of the resources, the control measures, when applied in the past, often had destructive economic consequences. Introducing harvest controls through the implementation of TACs, or the equivalent hereof, and doing nothing else, all but guarantees the emergence of excess fleet capacity and severe economic waste.

As is well known to economists, in these circumstances the restricted season by season harvest becomes the “common pool,” with the almost inevitable consequence of the build-up of excess capacity and concomitant reduction of season length. The cost magnifying consequences of redundant capacity and sharply reduced season lengths can easily lead to the full dissipation of resource rent.

The usual response to the competition for shares of the “common pool” harvest – the “race for the fish” - is to introduce measures to restrict the number of vessels allowed to engage in the fishery. These schemes, commonly referred to as limited entry, or license limitation, schemes, are often accompanied by decommissioning schemes designed to remove excess fleet capacity built up before the introduction of license limitation.

Traditionally, under such license limitation schemes, the owners of the licensed fishing vessels are allowed to compete for shares of the TAC, or the equivalent. It seemed clear that, if the fleet was reduced to a size commensurate with the expected TAC, nothing more was required.

The experience in many such fisheries has been that effective fleet capacity is, in fact, very difficult to control. With the fishers competing for harvest shares, capacity continues to grow, even if the number of vessels remains constant. Fishing capacity has many components. Controlling all of them is beyond the capabilities of most resource managers.

An example is provided by the Canadian Pacific halibut fishery. The Canadians share the Pacific halibut resource with Americans, in Alaska. At a very early stage, 1923, Canada and the United States established a cooperative resource management arrangement (International Pacific Halibut Commission), which produced exemplary results, in terms of resource conservation.

In 1979, after Canada had implemented its EEZs, the Canadian authorities introduced a limited entry scheme for its share of the Pacific halibut fishery. The licensed vessels competed for shares of the halibut TAC.

Over the following decade, the number of vessels remained effectively controlled. The actual resource harvesting capacity was not controlled, however. The harvesting season steadily decreased, clearly indicating growing capacity. The Pacific halibut harvest season has a maximum length of about 240 days per year. By the end of the 1980s, the season length had been reduced to 6 days per year.

There was no evidence of resource depletion. Indeed, the TAC was actually increased over the decade because of increased resource abundance. With respect to economic rent, however, such evidence as exists suggests strongly, that, once resource management costs are factored in, the resource rent being generated by the fishery was distinctly negative (Munro, Turris, Clark, Sumaila and Bailey, 2009). The potentially valuable Pacific

halibut resource was, from the Canadian perspective, a non-performing natural capital asset.

All of these problems of overexploitation and economic waste have been seriously aggravated by subsidies, often introduced to relieve the economic distress arising from overexploitation and economic waste. Not all subsidies are harmful. It has been estimated, however, that approximately 50% are damaging both biologically and economically (Munro and Sumaila, 2002), by serving to intensify the aforementioned perverse fisher incentives. *The Sunken Billions* report estimates, for example, that subsidies that have a direct impact on fishing capacity, and that are definitely harmful, are in the order of USD 10 billion per year (World Bank and FAO, 2008, Table 1).

There is finally a major source of difficulty in the management of capture fishery resources, and a significant contributor to fishery resource overexploitation, that has come to be recognized fully, only following the advent of the EEZ regime. The establishment of the EEZ regime was seen as placing large amounts of hitherto “common pool” capture fishery resources under coastal state jurisdiction. Most capture fishery resources are mobile, however, with the consequence that the typical coastal state finds that it is sharing some of its EEZ fishery resources with neighbouring coastal states (transboundary stocks) or with distant water fishing states (DWFs), in the high seas adjacent to the EEZ (highly migratory and straddling stocks). It can be easily be demonstrated that, if states sharing such resources do not cooperate effectively in the management of the resources, the outcome may well be comparable to a classic open access fishery, i.e. resource overexploitation (Munro, Van Houtte and Willmann, 2004; Lodge, Anderson, Løbach, Munro, Sainsbury and Willock, 2007).

Indeed, the lack of effective cooperative management of highly migratory and straddling stocks, and the resultant resource overexploitation following the close of the UN Third Conference on the Law of the Sea in 1982, led to the UN convening another international conference to address the management of these resources, the 1993-1995 UN Fish Stocks Conference. The 1995 UN Fish Stocks Agreement (UNFSA, 1995), arising from the Conference, has led to the now ongoing implementation of the Regional Fisheries Management Organization (RFMO) regime (UN, 1995).

What the 1995 UNFSA does not address are the remaining discrete high seas stocks. Hitherto, most of these stocks had not offered commercially viable fishing opportunities, in other words they had enjoyed economic protection. The history of world ocean capture fisheries provides all but absolute assurance that the protection will prove to be temporary.

The significance of these shared fish stocks, transboundary, highly migratory, straddling and discrete high seas, is not trivial. It is estimated that harvests of these stocks may account for as much as one-third of the global ocean capture fishery harvests (Munro, Van Houtte and Willmann, 2004). Thus, in looking to incentive structures that will lead to successful investment in capture fishery resources, particular attention will have to be given to internationally shared fish stocks.

Getting the incentives right: Intra-EEZ considerations

In this section we shall confine ourselves to a discussion about the incentives necessary for successful investment in capture fishery resources from a strictly intra-EEZ

basis. The resources under consideration are either not shared, or if shared, are such that the sharing is found to lead to no management complications.

The very first step is to introduce a management regime, an incentive scheme that will ensure that the fishery is capable of generating resource rent. The point has now been made that, if a fishery capital investment program is undertaken, in which the additional resource rent proves to be no more than a temporary, the investment program could be fatally undermined from the outset.

We shall illustrate the issues at hand by first discussing two cases, in which rent loss and rent re-capture, were by accidents of history isolated from resource depletion. The author can claim some knowledge of these cases due to a study commissioned by Fisheries and Oceans Canada (Munro, Turris, Clark, Sumaila and Bailey, 2009). These cases will then be followed by reference to two other cases in which there had been resource overexploitation, and in which the correction of incentives brought the resource overexploitation to an abrupt halt.

The two cases to be examined in detail are the Canadian Pacific Halibut fishery and the British Columbia sablefish fishery. The conservation of the Pacific halibut resource has been the joint responsibility of Canada and the United States since 1923. The joint conservation of the resources, which has been exemplary, causes no management difficulties for Canada. The advent of the Canadian and American EEZ regimes in the late 1970s allowed each state to manage its share of the TAC. Canada introduced a then standard limited entry scheme for its share of the halibut fishery, in which the number of vessels in the fishery was strictly limited, with the licensed vessels then competing for shares of the TAC.

The British Columbia sablefish fishery was essentially a post-EEZ fishery for Canada. Strict TACs were introduced, along with a limited entry scheme mirroring that for the Canadian halibut fishery. The resource was effectively conserved (Munro *et al.*, forthcoming).

Several years ago, the FAO introduced the concepts of Incentive Blocking and Incentive Adjusting approaches to fisheries management (FAO, 1999). The former approaches concern measures designed to prevent fishers from responding to the perverse incentives described earlier. Incentive Adjusting approaches are concerned with measures designed to transform perverse fisher incentives into benign ones. Both the imposition of TACs and the limited entry schemes described could be seen as Incentive Blocking approaches. In the case of the two fisheries under consideration, the Incentive Blocking approach in the form of TACs was undoubtedly successful in conserving the resources.

In attempting to analyse the history of the two British Columbia fisheries, the Munro *et al.* study undertaken for Fisheries and Oceans Canada employs two closely related modes of analysis. The authors of the study note one inescapable fact of life in the two fisheries, namely the strategic interaction between and among the fishers, and between the fishers as a group and the resource managers, which in the case of Canada are to be found wholly within Fisheries and Oceans Canada. The obvious mode of analysis then is the theory of strategic interaction, more popularly known as the theory of games, which has been used extensively in the study of international fisheries (Munro, Van Houtte and Willmann, 2004).

There are two broad categories of games: non-cooperative, or competitive, games; and co-operative games. In co-operative games, the “players” are assumed to be coldly rational, with each “player” being prepared to cooperate, only if it believes that it will be

better off by cooperating, than it would be by playing competitively. The stability of such co-operative games is always at risk of being undermined by “player” non-compliance (cheating), and by free riding, which can be defined as the enjoyment of the fruits of co-operation by non-participants in the game (i.e. poaching). The concepts of non-cooperative and cooperative games will be seen of relevance to the strategic interaction among the fishers.

Within the theory of games, there is a sub-class of non-cooperative games known as leader-follower games, a version of which is referred to as Principal Agent analysis (PA analysis), used widely by economists, in many fields. PA analysis is of direct relevance to the interaction between the fishers in the two British Columbia fisheries and Fisheries and Oceans Canada.

The principal, be it a person, a firm, a country or a state/province, wishes to see undertaken certain tasks that it is unable to do itself, and so acquires the services of one, or more, agents to undertake these tasks. Classic examples are an owner of a firm hiring a manager, and a landlord leasing farm land to a tenant farmer. The PA analysis has application far beyond these simple examples, e.g. industry regulators and the firms being regulated (Sappington, 1991).

In any event, in the context of Canadian fisheries, Fisheries and Oceans Canada could be seen as constituting the principal, while the fishers constituted the agents. The PA paradigm can be formally described as follows (Clarke and Munro, 1987).

A strict hierarchical relationship exists in which the principal (leader) chooses an incentive scheme (e.g. set of regulations) to be applied to the agents (followers). The principal's incentive scheme, along with the actions taken by the agents, determines both the returns to the agents and to the principal. As seen from the perspective of the principal, a first best situation exists when the principal can, at minimal cost, contractually and enforceably specify the actions of the agents. Wishes, urges and desires of the agents, contrary to the best interests of the principal, are entirely suppressed. The agents are essentially robots.

In the normal second-best situation, the principal lacks the power, or more to the point finds it too costly, to force a set of actions upon the agents. The agents thus have some freedom of choice. The principal can hope to influence the agents' choices, only indirectly through the incentive scheme. This gives rise to the concept of an incentive gap, which is the difference between the actual return to the principal, and what it would receive under a first-best situation. It reflects the insufficiency of the principal's incentive scheme in compensating for its inability to monitor perfectly the agents' actions. At the heart of the PA problem is monitoring imperfection (Clarke and Munro, *ibid.*).

Consider now these two closely related modes of analysis in the case of the two British Columbia fisheries. The comfortable view of many economists at the beginning of the 1980s was that, while there would be competition among the licensed fishers in a limited entry fishery, the competition (interaction) would be very limited and easily controlled. If the vessels plus crew had been identical, if input substitution in the fishing fleet had been impossible, and if the technology had been frozen, in the two Canadian fisheries, then indeed the competition (interaction) would have been very limited and easily controlled. None of these conditions held. Technology, for example, was anything but frozen in the two fisheries. The result was that circumvention of the intent of the limited entry scheme was feasible, which meant, in turn, that competition among the licence holders was definitely possible. Even if all fishers had been aware that such

competition was mutually harmful, in terms of their economic returns from the fishery, each and every fisher would, in the absence of scope for meaningful co-operation, have had no option but to compete. Any fisher, who held back from competing, was all but guaranteeing the loss of a part, if not all, of his/her share of the TAC.

One of the most famous of all non-cooperative games is known as the Prisoner's Dilemma, which derives its name from a story told by the author to illustrate his point. The author's point is that, in a non-cooperative game, the "players" will be driven to adopt strategies that they know are harmful. In the situation described in the two fisheries, the fishers were engaged in what might be described as a non-cooperative sub-games, which provided, in turn, almost text book examples of the Prisoner's Dilemma.

In both fisheries, season lengths declined to small fraction of their potentials, indicating severe excess capacity. While no precise estimates were possible, one could conjecture, as has been noted, that the resource rents, from a national perspective, were negative and that the Pacific halibut and sablefish resources were properly classified as non-performing natural capital assets. The authors of the report state that, in PA terms, the non-cooperative sub-games among the fishers had led to a yawning and unsustainable incentive gap. Out of desperation, Fisheries and Oceans Canada, with industry support, shifted to an Incentive Adjusting approach in the form of IQs, later to become ITQs (Munro, *et al.*, *ibid.*).

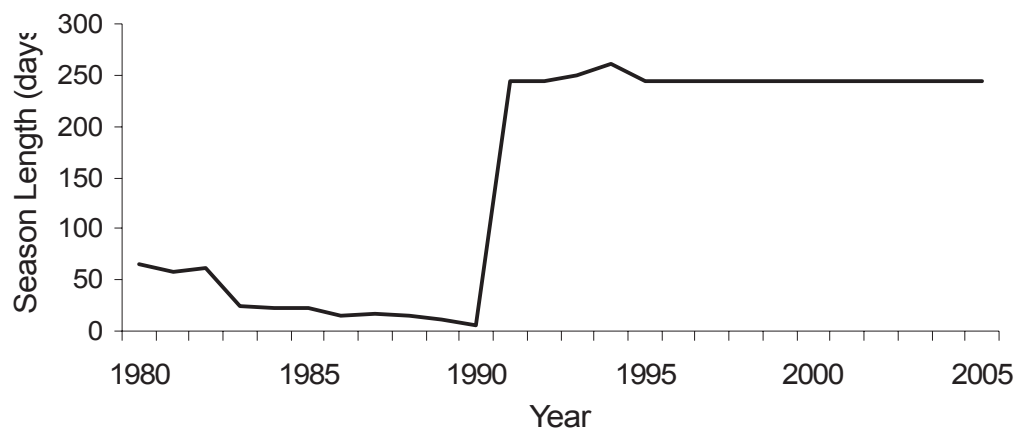
The authors of the study then ask, if there was any evidence that the ITQs eliminated strategic interaction among the halibut fishers, or the among the sablefish fishers. The answer is that there was no such evidence. They conclude that, if the IQ schemes do no more than re-establish non-cooperative games among the two sets of fishers, perhaps under a different guise, then little or nothing is to be gained. Success will be achieved (the incentive gap reduced to tolerable proportions), they argue, if and only if, the IQ scheme lead to the fisher sub-game being transformed from a competitive to cooperative one.

In order for there to be a cooperative game, there must first be in place a workable mechanism for the sharing of the economic benefits among the "players". IQ schemes were seen to provide such a mechanism. The existence of the sharing mechanism, in of and by itself, is, however, not sufficient.

A fundamental condition that must be satisfied, if a cooperative game is to have a stable solution, is that each and every player must be convinced that it will receive a return – a payoff – at least as great as it would under competition (FAO, 2002). If non-compliance (cheating) is left unchecked, or, if free riding (poaching) is rampant, this condition, known as the Individual Rationality Constraint, will not be met, even if the allocated shares appear to be "fair".

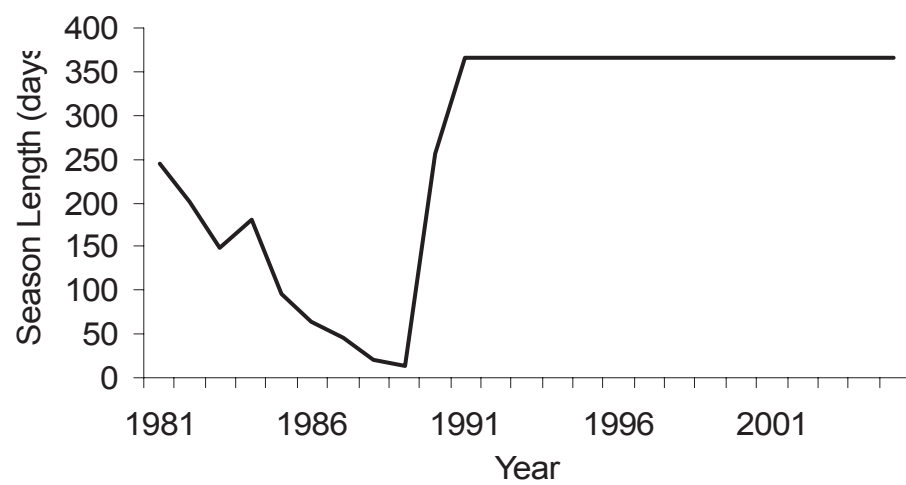
The evidence that exists, while not absolutely conclusive, suggests that effective cooperative fisher games have replaced the destructive non-cooperative games in these two fisheries. Consider first the season lengths in the two fisheries, before and after the introduction of ITQs.

Figure 3.1. Canadian pacific halibut season length: 1980-2005.



Source: Munro, Turrís, Clark, Sumaila and Bailey, 2009, Figure 1.

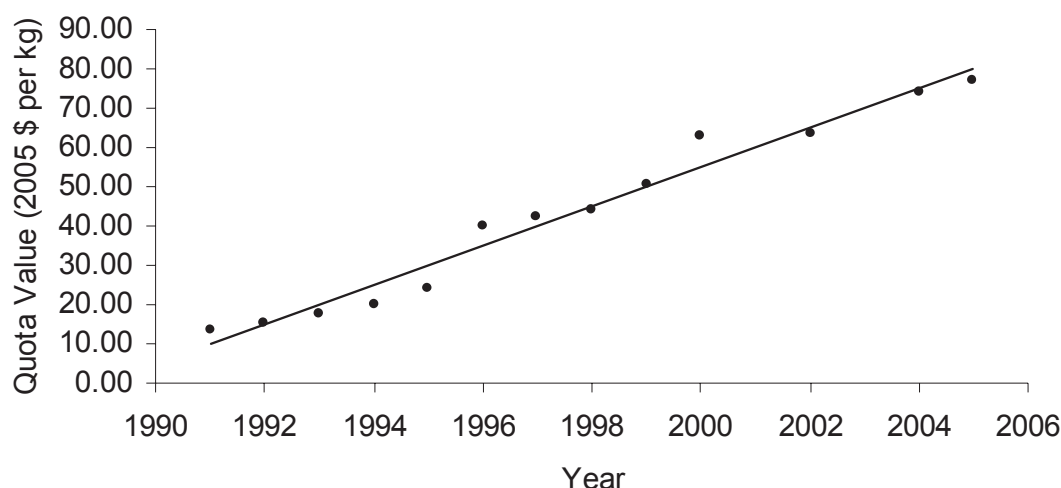
Figure 3.2. British columbia sablefish season length: 1981-2005.



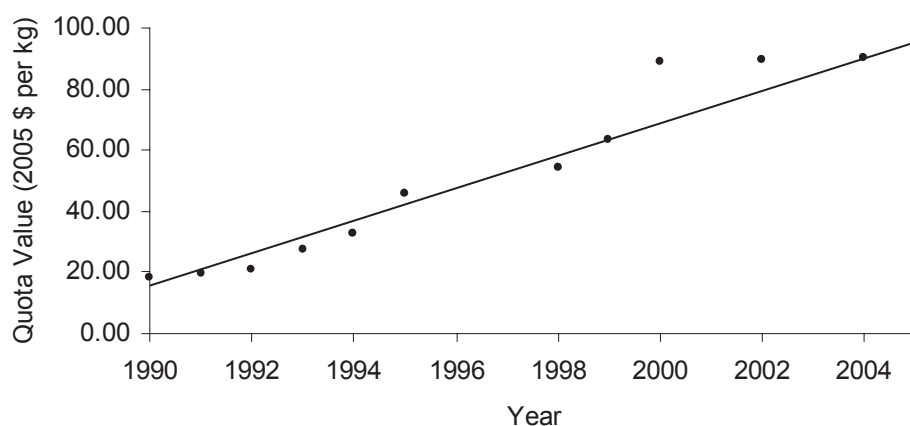
Source: Munro, Turrís, Clark, *et al.* 2009, Figure 4.

Excess capacity, if not eliminated in physical terms, was “defanged”. In the case of both fisheries, season length rose rapidly to the maximum, after the introduction of ITQs.

Adequate fleet cost data were not available to the authors of the study. The harvest quotas were and are actively traded. Quota price data are available. Since the quotas are de facto long term (Munro, *et al.*), the quota prices could be seen as reflecting the market participants’ estimates of future private sector net returns from the fisheries.

Figure 3.3. Canadian pacific halibut quota values and trend lines.

Source Munro, Turris, Clark, *et al.*, 2009, Figure 3.

Figure 3.4. British Columbia sablefish: quota values and trend line.

Source: Munro, Turris, Clark, *et al.*, 2009, Figure 6.

The authors note that the ITQ schemes involve higher management costs, and accompany the figures with tables showing substantially increased licence fees received by the government. Overall the evidence suggests that significant positive rent is flowing from the fisheries. In other words, the relevant natural capital assets are now seen to be yielding positive economic returns.

From this experience, one can conclude the following:

- The Incentive Blocking approach to resource management, as it pertained to fleet and human capacity, was completely ineffective. The inability to control capacity led to rent destroying non-cooperative games among the fishers.

- The introduction of ITQs did, in these instances, lead to a resource rent creating cooperative games among the fishers. If the key lies in transforming destructive non-cooperative fisher games into cooperative ones, then it is obvious that instruments other than ITQs could be used to achieve the same results, such as community based fisheries management (TURFs) or fisher cooperatives. The choice of instrument should be made on a fishery by fishery basis.
- In order to effect this transformation, substantial management capacity was demanded of the resource managers. To take one example, if the resource managers had proven to be incapable of establishing an effective monitoring scheme, the ITQ schemes would have degenerated into non-cooperative fisher games, with consequences that require no further elaboration.

The two additional fisheries to be mentioned in passing are the Icelandic cod fishery and the hake fishery off Namibia. Both fisheries had experienced resource overexploitation. Both fisheries were reformed through the introduction of Incentive Adjusting management measures (ITQs), which helped bring the resource overexploitation to a halt and to lead to the generation of resource rent. Interestingly, the resources have not been restored in either case (Arnason, 2008; Sumaila and Marsden, 2008).

It is easy enough to see why the ITQ schemes should have helped to bring the resource exploitation to a halt. With the individual fishers/vessel owners/companies having the promise of enjoying future returns from the resource they should no longer have the incentive to mine the resource, i.e., they will no longer discount future returns at a rate equal to infinity.⁶

The next question, and the truly important question, is the following. Once a management is in place that makes rent generation feasible, what further modifications must the Principal (resource managers) make to the incentive scheme in order for the Agents (fishers) to be willing to invest the resource, or at least not impede the progress of resource investment programs? The question does not arise in the halibut and sablefish cases cited, but does very much so in the cod and hake cases.

This is a question, let it be admitted, that cannot be fully answered at this stage. Much more thought and research is required.

Since all investment involves a cost, the first part of the question is who is to bear the cost of investment in the fishery capital? If the relevant produced/human capital is highly malleable, then the problem is minimal, as the produced/human capital can be shifted to equally remunerative undertaking. Return to the example of Norwegian Spring Spawning herring. After the resource crashed in the late 1960s – early 1970s, the remnants of the resource were confined to Norwegian waters. The Norwegian authorities found it easy to declare an outright harvest moratorium, in part because the relevant fleet/human capital could be readily shifted to other fisheries, and was thus highly malleable from the perspective of the herring fishery (Gréboval and Munro, 1999). The cost of the resource investment, such as it was, was borne by the state.

In many cases, in which the fleet/human capital is less than perfectly malleable, one could, in the first instance, think of a scheme in which the state bore the cost of investment, by compensating the fishers for temporary reduced harvest opportunities (Grafton, Kompas and Hillborn, 2007). That such schemes could be accompanied by the threat of possibly severe moral hazard problems is obvious.

If the fishers are to bear part, or all, of the resource investment cost, then the following incentive requirements are straightforward enough. The fishers must be assured of a share of the future returns from the investment, which means, in turn, that they must not be given the incentive to discount heavily future returns from the fishery, e.g. as a result of seemingly capricious resource management policies. Secondly, the future returns accruing to the fishers should be contingent on the success of the resource investment program. Thus, for example, within the context of an ITQ scheme, one would want quotas that are long term, *de facto* if not *de jure*, and which are expressed as percentages of the TAC, or equivalent thereof.

One of the case studies commissioned by The World Bank and the FAO to accompany The Sunken Billions study does provide us with a developing fishing state example of a fishery, in which a state of pure open access and resource overexploitation was transformed into one in which a successful resource investment program could be undertaken. The case is that of the Indonesian Arafura shrimp fishery. The author of the study deems the optimal, or target, stock level to be that associated with maximum sustainable resource rent (Purwanto, 2008).

Up until early in this decade, the fishery was plagued with rampant non-compliance and poaching by Indonesians and foreigners, with consequent overexploitation of the resource and dissipation of resource rent. It is estimated that in 2000 the biomass was no more than 50 % of the optimal level. The resource rent was positive, but was equal to less than 6 % of the optimal level (Purwanto, 2008, Table 4.1). Under the new Indonesian fisheries legislation, promulgated in 2004, surveillance and enforcement were greatly strengthened, the right incentives were created by devolving management authority upon the relevant provincial government, which, in turn gained the active support and co-operation of the relevant fishing communities. By 2005, the biomass had increased to almost 75 % of the optimal level. The resource rent was estimated to be equal to more than 90 % of the optimal level (Purwanto, 2008, Table 4.1).

Two points need to be made about this example. First, the principle of subsidiarity appears to be at work here, a point worth noting in devising other resource investment supportive incentive schemes. Secondly, since shrimp is a rapidly growing resource, the waiting period for the payoff was very short. Obviously, the longer one has to wait for the payoff, the greater the difficulty in designing the appropriate incentive scheme.

Beyond this, the author can say little about the optimal incentive scheme at this stage, other than to say that Icelandic cod and Namibian hake might present interesting case studies on what is required to get an effective resource investment program underway, given that a well working Incentive Adjustment management scheme is in place. Clearly, the issue will require a great deal of further research, planning and thought.

Getting the incentives right: international considerations

We turn now to international fisheries, where the needed incentives involve, in the first instance, fishing states, as opposed to fishers. It will be recalled that internationally shared fishery resources account for as much as one-third of the harvest of marine capture fisheries (Munro *et al.*, 2004).

The economics of the management of internationally shared fish stocks is reasonably well understood. It does, by necessity, draw upon the theory of strategic interaction

(theory of games), due to the fact that strategic interaction between and among the states exploiting the resources lies at the heart of the problem.

The economics of non-cooperative management of shared fishery resources, based upon the theory of competitive games, is straightforward. Non-cooperative management carries with it the high risk of overexploitation of the resources. This is a manifestation of the famous “Prisoner’s Dilemma,” discussed at an earlier point. In other words, non-cooperative management of shared fish stocks carries with it the high risk that fishing state incentives will be exactly wrong, leading not to positive fishery resource investment, but rather to ongoing fishery resource disinvestment.

The truly complex part of the management of internationally shared fishery resources is focussed on the means of ensuring stable cooperative management of these resources through time. The economics, not surprisingly, draws upon the theory of cooperative games. A cooperative game, subject to instability that remains uncorrected, soon degenerates into a competitive game, accompanied by resource destroying state incentives.

The economics informs us that the ease of achieving stability through time depends, in the first instance, upon the number of “players,” *i.e.* the number of states involved in the exploitation of the resource. Where the number of “players” is only two, achieving stability is relatively easy. Thus, for example, it is no surprise that the cooperative management of Pacific halibut, and the cooperative management of groundfish resources in the Barents Sea, have proven to be stable over time. In each case, two states are dominant. Once the number of “players” exceeds two, difficulties arise, with the difficulties increasing almost exponentially as the number of “players” increases.

The greatest difficulties are to be found in the management of internationally shared fishery resources to be found in all, or in part, in the high seas, *i.e.* outside of the coastal state EEZs, namely highly migratory and straddling stocks that are to be found in the EEZs and the adjacent high seas, and discrete high seas stocks. Highly migratory and straddling stocks are, under the terms of the 1995 Fish Stocks Agreement, to be managed through Regional Fisheries Management Organizations (RFMOs) that are to have both coastal states and relevant distant water fishing states (DWFSS) as members (Lodge, Anderson, Løbach, Munro, Sainsbury and Willock, 2007; UN, 1995). The Northwest Atlantic Fisheries Organization (NAFO), the Northeast Atlantic Fisheries Commission (NEAFC), and the Western and Central Pacific Fisheries Commission (WCPFC) are all examples.

Achieving the stability through time of the cooperative fishery games that are the RFMOs is aggravated by the fact that the number of “players” is typically large, and by the fact that the high seas portions of areas under RFMO jurisdiction are, in many instances, plagued with “unregulated” fishing, *i.e.* free riding by non-RFMO members. An additional source of instability arises from the fact that RFMOs are required, by the 1995 UN Fish Stocks Agreement (U.N., 1995), to accommodate new members, which are typically DWFSSs, which could not, or did not, see fit to become “charter” members of the RFMO. The so-called “new member” problem is one of the most difficult confronting the emerging RFMO regime (Lodge *et al.*, 2007).

Two of the case studies commissioned by The World Bank and FAO, in conjunction with The Sunken Billions study, illustrate well the issue of incentives confronting fishing states sharing fishery resources. One involves a tuna resource, the Northeast Atlantic and Mediterranean bluefish tuna resource, which has been seriously overexploited, and where

a major resource investment program has been called for. The prospects for success of the investment program are not encouraging. The other is a case study on Norwegian Spring Spawning Herring, a resource to which we have referred many times. A massive investment program has occurred, which to date has been strikingly successful. The author of the case studies assumes, in each case, that the optimal stock level is that associated with maximum sustainable resource rent (Bjørndal, 2008; 2009).

To begin with Northeast Atlantic and Mediterranean bluefin tuna, the RFMO for these bluefin tuna fisheries takes the form of the International Commission for the Conservation of Atlantic Tunas (ICCAT). The bluefin tuna resource, when in a healthy state ranges from the Canary Islands to Norway, through the Mediterranean to the Black Sea. The harvested fish are some of the most valuable in the world, with an individual fish being able to command a price of up to USD 100 000 (Bjørndal, 2009).

At the present time, some 25-30 states are involved in the fishery. At the peak of the fishery, up to 50 states were involved. The fact that the number of active states involved in the fishery has been substantially reduced is due, argues Bjørndal, to the fact that the resource has been severely depleted (Bjørndal, 2009). Bjørndal maintains that the resource rent maximizing spawning stock biomass is in the order of 800 000 tonnes. The current spawning stock biomass is estimated to be in the order of 100 000 tonnes. This is the lowest spawning stock biomass for the resource in recorded history. Indeed, the resource faces a significant risk of outright collapse (Bjørndal, 2009; MacKenzie, Mosegaard and Rosenberg, 2009).

The root of the problem is easy to identify. The cooperative fishery game in the form of the ICCAT based RFMO governing the tuna resources has degenerated into a competitive game. ICCAT management advice is largely ignored (Bjørndal, 2009). The economics of non-cooperative management of shared fishery resources predicts that the competitive shared fishery can readily take on all of the characteristics of a pure open access one. Bjørndal maintains that the bluefin tuna fishery is to all intents and purposes, just that. The steady, almost inexorable, decline in the spawning stock biomass over the past 30 years is entirely consistent with a pure open access fishery (Bjørndal, 2009, *ibid.*)

ICCAT, with the support of the EU, has called for the implementation of a program of resource investment. Consider the difficulties to be faced. Given the seriously reduced state of the biomass, argue MacKenzie *et al.*, recover may take many years, if not decades, even if fishing mortality is drastically reduced (MacKenzie *et al.*, 2009). In other words, the states currently exploiting the resource will be called upon to bear heavy investment costs.

The economics of cooperative fisheries management makes it abundantly clear that the needed co-operation will be forthcoming, only if compliance is ensured. If a moral and otherwise law abiding, member state of the RFMO is convinced that cheating by other RFMO members will go unchecked, this otherwise law abiding member state will likely conclude that it would be no better off under co-operation, and probably less well off, than it would be under competition. Co-operation will founder. Ensuring compliance in a cooperative fisheries game with 25-30 “players” is a formidable undertaking.

There is yet another problem. Suppose that somehow the compliance problem is effectively resolved, and suppose that substantial resource investment is achieved. The fishery at its peak had up to 50 participating states. What is to prevent the 20-25 states that left the fishery demanding re-admission to the club, once the resource investment program has achieved success? If those returning states were readmitted and granted

significant shares of the TAC, they would effectively be free riders, having borne none of the cost of investment. It is not at all clear that, under the 1995 UN Fish Stocks Agreement, the would-be returning states could be denied re-admission.

If the would-be returnees cannot be denied re-admission, then it would be foolish to suppose that the current members of the RFMO could not anticipate the future free riding. The anticipated free riding could lead many current members to conclude that they would, in fact, be better off under competition. Once again, the proposed cooperative resource investment program would be stillborn (Kaitala and Munro, 1997; Munro, Van Houtte and Willmann, 2004). It can be argued that, without a resolution of the so called “new member” problem, the outlook for the future of the resource is bleak. The fishing state incentives will be incompatible with a program of preventing ongoing resource disinvestment, let alone a program of encouraging positive resource investment.

A stark contrast is provided by Norwegian Spring Spawning Herring. The RFMO involved with the management of the resource operates under the aegis of the Northeast Atlantic Fisheries Commission (NEAFC).

The herring resource, when in a robust state, has historically been one of the largest and most valuable in the Northeast Atlantic. The resource, when robust, migrates from its spawning grounds in Norwegian waters as far west as Iceland. In so doing, the resource passes through international waters, which means that it is to be classified as a straddling stock (Bjørndal, 2008, *ibid.*).

It will be recalled that the resource crashed in the late 1960s-early 1970s, and that spawning stock biomass (SSB) of the resource was reduced to 2 000 tonnes, 0.08 % of the critical minimum level of 2.5 million tonnes. Absolutely massive resource reinvestment was called for. The massive resource investment did, in fact, occur. Today the resource is healthy, with the SSB at 6.5+ million tonnes (Bjørndal, 2008, *ibid.*). So what went right?

First, the remnants of the resource were confined to Norwegian waters. Thus, it ceased, for the time being, to be a shared fishery resource. Secondly, as indicated at an earlier point, the Norwegian fleet and human capital involved in the fishery was highly malleable, with respect to the fishery. It was politically easy for the Norwegian resource managers to declare a harvest moratorium, which more or less remained in place for 20 years. Finally, there was an element of luck, in that environmental conditions allowed for a recovery of the resource from its desperately low state.

By 1994, there were signs that the recovered resource was recommencing its migratory pattern, and was thus becoming once again a shared stock. There was a realization among the relevant states that cooperative resource management was required, if another disaster was to be averted. Indeed, the states undoubtedly recognized that, if the stock were to crash again, the crash might be irreversible.

The first attempts to develop a cooperative regime involved Norway, Iceland, Russia and the Faroe Islands. These attempts were largely unsuccessful, with an important reason being that an important player, in the form of the EU, had been left out. The EU can claim a very small coastal state interest in the resource, but more importantly, its fleets were able to operate in the high seas through which the resource passed in its migration – the typical free rider problem.

By late 1996, the EU was brought in to the cooperative resource management arrangement. The recently concluded 1995 UN Fish Stocks Agreement provided a useful framework for the now inclusive agreement (Munro, 2001).

For several years, the cooperative game in the form of the Norwegian Spring Spawning Herring cooperative resource management arrangement seemed to be stable and to be effective, both in terms of conservation and resource rent generation. In contrast to the Northeast Atlantic/Mediterranean bluefin tuna cooperative resource management arrangement, the number of “players” was small (a cooperative straddling stock fishery game with only five “players” is small indeed). There were no troublesome would be new members appearing on the horizon. One can conjecture that the lack of a new member problem was not unconnected with the fact that two of the “players” were, and are, politically very powerful – the EU and Russia.

Then a problem arose in 2002, which was of a type that can afflict any RFMO. When one talks about the stability of the RFMO cooperative fisheries game, it is not sufficient to talk about current stability. One has to be concerned with the stability of the RFMO through time, with what economists refer to as the “resiliency,” or more technically the time consistency, problem. Any RFMO can be expected to be subject to unpredictable shocks, which may be political, economic or environmental in nature. If the RFMO lacks the resilience and flexibility to respond to and absorb these shocks, the RFMO may founder (Miller and Munro, 2004; Munro, 2009).

The harvest sharing rule among the “players” in this herring fishery game is based upon the perceived migratory pattern of the resource. In 2002, the Norwegians insisted that the resource migratory pattern was markedly different from what had thought to have been the case in 1996, and that they were not, as a consequence, receiving their “fair” share of the TAC. The Norwegians demanded a larger share of the TAC, and were met with an outright refusal by their fellow “players”. The cooperative resource management arrangement, while not being formally terminated, seized up. In short, the cooperative resource management arrangement displayed a lack of resilience, in that there was no mechanism in the arrangement to deal with shocks such as those arising from shifting migratory patterns. The cooperative herring fishery game began to show worrying signs of degenerating into a competitive one.

A new cooperative resource management arrangement was finally agreed upon, but only after three dangerous years of paralysis. During the hiatus, the collective harvests began exceeding by a considerable margin the hitherto agreed upon TAC, holding out the threat of another resource crash (Bjørndal, 2008).

The interrelationship between intra-EEZ and international incentive structures

We have discussed the intra-EEZ incentives that must be in place, if intra-EEZ resource investment programs are to be successful. We have stressed the fundamental importance of fishing states sharing fishery resources having the incentive to cooperate in the management of the resources through time, if programs to rebuild such resources are to have any hope of success. It is now appropriate to ask, if there is any interrelationship between the two sets of incentives. The answer is very straightforward, namely that there is, of course, an interrelationship.

Let us take as an example a relatively simple case of a shared fishery resource having no high seas complexities, a transboundary stock, shared by two or more coastal states.

Let it be supposed that the states sharing the resource have ineffective intra-EEZ management of their respective shares of the resource, so that the intra-EEZ rent from the resource is completely dissipated. In the theory of strategic interaction (theory of games), there is the concept of the cooperative surplus, which is the difference between the sum of the payoffs to the players under co-operation and the sum of the payoffs to the players under competition. If the intra-EEZ rent from the resource is completely dissipated, the prospective cooperative surplus may be negligible, which means in turn that the incentive to establish a cooperative management regime will be at a minimum (Munro, 2007).

Conversely, suppose that each state sharing the fishery resource is attempting to establish an intra-EEZ effective harvesting rights scheme, but suppose further that the states are unsuccessful in establishing a stable cooperative resource management regime. It is easy to show that this lack of international success can readily undermine the attempts to establish intra-EEZ effective harvesting rights schemes – the Prisoner's Dilemma once again.

Conclusion

Captures fishery resources, like all natural resources, are to be seen from the perspective of society as capital assets. Calls for the rebuilding of such resources are, therefore, to be seen, in turn, as calls for an investment program, with all that that implies, in particular the fact that there is no such thing as a costless investment.

That such an investment program is required is no longer in dispute. Beyond the admonitions from the 2002 World Summit on Sustainable Development, The World Bank and FAO report that world capture fishery capital is, overall, providing the world economy with a rate of return, which at best is equal to zero, and that, if these resource assets are even to approach the goal of yielding maximum sustainable resource rent, the resource assets will have to be at least doubled in size (World Bank and FAO, 2008).

There will not be a capture fishery resource investment program that is successful from an economic standpoint, unless the correct incentive structures are in place, at both the intra-EEZ and international levels. Within the EEZs, there must, at a minimum, be incentive structures that will ensure ongoing generation of resource rent. Inter alia, this calls for the removal harmful fisheries subsidies, which currently are immense. If intra-EEZ resource rent is continuously dissipated, then there will be no promise of positive payoffs on fishery resource investments.

The major question, as yet unanswered, is what incentives need to be in place to cause fishers to willingly invest in the resources, or at least not impede the investment program. If the fishers are to be called upon to bear all, or part of the cost of investments, then obviously, they must be assured of a share of the future resource investment payoffs. There are aspects of this question, however, which are as yet not fully answered. Substantial further thought and research is required.

At the international level, there must be a set of incentives in place to drive the relevant fishing states to engage in cooperative management of shared stocks through time. The issue of cooperative resource management arrangements resiliency over time was stressed.

The needed intra-EEZ and international incentive structures are, of course, interrelated. If we do not get these two interrelated sets of incentive structures right, the

risk is that, rather than having an effective fishery capital investment program in place, we will be faced with ongoing fishery capital disinvestment.

Notes

1. There are many additional complications that we shall not attempt to discuss here in detail. For example, suppose that there is extensive species interaction. Then one has to talk, not about the return on one species, but rather about the return on a sub-portfolio of species assets.
2. The anticipation of the resource rent leaking away to zero could lead to it being optimal, in economic terms, to turn around and *deplete* the resource. The importance of ensuring the sustainability of the additional resource rent, generated by the resource investment, cannot be overstated. See Clark and Munro, 1975, particularly Part 3 on so called non-autonomous models, for further details.
3. There is an important qualification to this rule. Suppose that the producer/human capital is perfectly malleable, but suppose further that the price of harvested fish is a function of the amount harvested – the more that is harvested and sold, the lower is the price – and/or that the unit cost of what is referred to as fishing effort varies with the amount of fishing effort employed in the fishery. Then the most rapid rate of resource investment is not optimal, since there will be penalties associated with rapid rates of resource investment or disinvestment. See Clark and Munro, 1975, for details.
4. There is an exception to this rule. If the resource has been severely depleted, a temporary harvest moratorium might be in order. It would *not* be appropriate, however, to maintain the moratorium until the target biomass has been achieved. See Clark, Clarke and Munro, 1979, for further details.
5. The report's target or optimal stock (biomass) levels are those that would be associated with maximum sustainable resource rent. By implication, the report is assuming that the appropriate rate of interest, or discount, is zero (Clark and Munro, 1975).
6. See the earlier discussion on the incentive consequences of a pure open access fishery, and Clark and Munro, 1975.

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Chapter 4.

Economic considerations and methods for evaluating fishery rebuilding strategies

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Abstract

Many fish stocks throughout the world have declined to levels that are believed to reduce their sustainable yield and/or create a risk of economic or even biological collapse. Most OECD nations have legislation and regulations requiring that these “overfished” fisheries be rebuilt -- generally to the biomass levels associated with maximum sustainable yield. The timing of catch reductions and increases during rebuilding and the specific management tools used to achieve those catch targets may have substantially different impacts on the net benefits generated by the fishery during rebuilding and beyond. We discuss some key economic considerations for evaluating rebuilding strategies including how they may affect gross value and harvest costs over time. We discuss a variety of factors that often are not, but perhaps should be, considered when determining rebuilding targets and deadlines including: issues with multispecies fisheries and changes in fishery productivity that may relate to climate cycles or climate change. Finally we discuss how management strategy evaluations can be used to design rebuilding strategies that are robust to uncertainty and address economic and social, as well as biological objectives.

Introduction

The Food and Agriculture Organization (FAO) estimates that globally between 25 and 30% of fish stocks that are assessed are overfished (FAO, 2008). In the US the National Marine Fisheries Service estimated that 24% of assessed fish stocks were in an overfished state in 2007 (NMFS, 2008). Since the economically optimal biomass levels for many if not most fisheries are likely to be higher than those that define fish stocks as overfished, it seems likely that there is much to be gained, from both a biological and an economic perspective, by rebuilding many of the world's fisheries. However, this leaves open many questions that require a combination of biological and economic advice to answer. How fast should we try to rebuild these stocks? To what level should we try to rebuild them, and what management methods should we use to control catches to achieve the desired rebuilding.

In this chapter we discuss a number of factors that can affect the economically optimal rebuilding schedules and biomass targets for fisheries. These include economic, technical, social and biological characteristics of the fishery and variability and uncertainty in the state and productivity of the fishery. We present a simple model to demonstrate how some key economic and technical variables affect optimal rebuilding schedules and targets. We discuss how common legal constraints on the rebuilding schedule can impact the benefits and costs of rebuilding approaches. We then discuss a number of other factors that may also be important in determining the optimal rebuilding plan but are more complex and are sometimes hard to quantify. Finally we discuss a framework for integrating economic considerations and objectives into a model-based approach for evaluating alternative rebuilding strategies.

Defining the problem, the objective and the constraints

The United Nations Convention on the Law of the Sea (UNCLOS) provides a basis in international law for the common definitions that have been adopted by a number of countries to designate fish stocks as “overfished” or depleted and for requirements to rebuild those fish stocks. Referring to ongoing management as well as rebuilding of depleted fish stocks, Article 61.3 of UNCLOS states that “such measures shall also be designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing communities and the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether sub regional, regional or global.”

In some countries the definitions and requirements relating to rebuilding overfished stocks have become stricter than the UNCLOS mandate in the sense that only upward adjustments of the biomass limit or target for economic and social factors are considered. For example, in the US, the governing legislation is the Magnuson-Stevens Fisheries Management and Conservation Act (2007) which specifies: Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery where optimum is prescribed “on the basis of the maximum sustainable yield from the fishery, as reduced [inferring target biomass is increased] by any relevant economic, social, or ecological factor; and (C) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the

maximum sustainable yield in such fishery.” NOAA National Standard One Guidelines specify one-half of the biomass level associated with maximum sustainable yield (B_{msy}) as a default for the level that constitutes overfished (though the term “overfished” has been replaced with “depleted” to acknowledge that there are other factors that may have led to the depletion). The legislation and related NOAA guidelines require that an overfished fish stock be rebuilt in a time that is “as short as possible, taking into account the status and biology of any overfished stocks of fish, the needs of fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock of fish within the marine ecosystem. However, the flexibility associated with these factor is limited as the legislation says the rebuilding time should “not exceed 10 years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise” (16 U.S.C. 1802 MSA § 3).

For many commercial fisheries, particularly those in OECD countries, a set of biological reference points have been developed that are used to determine whether a fishery is “overfished” or whether “overfishing” is occurring. Overfishing is typically defined in legislation and regulations as an exploitation rate that exceeds the fishing mortality rate that generates maximum sustainable yield (F_{msy}) in a deterministic equilibrium setting. Definitions of “overfished”, in contrast, refer to biomass levels relative to a biomass target or limit. They do not necessarily infer that overfishing is occurring or even that it has occurred in the past as a fish stock might have declined to the level considered overfished for environmental reasons. Legal definitions of overfishing and overfished are typically static, that is they do not vary with environmental or economic conditions. However they may be adjusted if the estimates of F_{msy} and B_{msy} change when stock assessments are updated or the models used to determine them are changed.

Legal definitions and rebuilding requirements can be thought of and treated as constraints that trigger rebuilding requirement and limit the allowable harvest strategies for rebuilding. While applying these definitions of overfished and associated rebuilding requirements is likely to increase the long term value generated from many and perhaps most depleted fisheries, this will not always be the case and also does not provide sufficient guidance to determine the best legal rebuilding strategy. Economics can provide additional (though in some cases contrary) guidance in identifying optimal rebuilding strategies and targets. From an economic perspective, a fishery might be defined as overfished (or depleted) if allowing the biomass to grow would increase the present value of the future net benefit stream that can be derived from it. To operationalize this definition and use it to provide specific advice we must, among other things, define benefits. Arguably these should include consumer surplus (benefits to consumers) as well as harvesters’ profits, and, in many cases, should also include the in-situ value of the resource (e.g. as a food source for other species). However, to simplify the discussion in this chapter we primarily focus on producer surplus when defining and evaluating optimal rebuilding targets and schedules. Producer surplus is roughly synonymous with harvester profits; it is the difference between the landed value of the harvested fish and the full cost of harvesting it including opportunity costs of capital and labour.

The optimal rebuilding strategy, one that maximizes the expected present value of the stream on net benefits from the fishery, will depend on the expected response of the fish stock to reductions in exploitation but also on a variety of technical and economic factors

that affect the benefits derived from the rebuilding and rebuilt fishery. In many and perhaps most cases, the optimal fish stock level (i.e. the level below which the stock is economically overfished) will be higher than the legal definition of overfished, and the optimal rebuilding path may well be faster than required by law (e.g. 10 years in the US). Even where this is not the case, there will typically be economic gains from optimizing the rebuilding strategy within these constraints. The quickest rebuilding strategy is often not the economically optimal one but the longest allowable may not be either. Many or all of the factors that impact the optimal rebuilding schedule and target may change over time so the optimal rebuilding schedule from a given biomass starting point is inherently dynamic, and its determination at any point in time requires making assumptions about whether and how these parameters may change in the future.

A simple bioeconomic model of optimal rebuilding

To illustrate how some of the more basic economic and technical characteristics of fisheries can affect optimal rebuilding schedules and targets we present a simple bioeconomic model based on a Gordon-Schaefer fishery model. This model ignores many of the complexities of actual fisheries management, but it serves to demonstrate qualitatively how these economic and technical factors affect how fast and to what level it is optimal to rebuild.

Net growth of the fish stock, X , is determined by:

$$(1) \quad \frac{dX}{dt} = rX\left(1 - \frac{X}{K}\right) - H$$

Where r is the intrinsic growth rate, K is the carrying capacity, and H is harvest. For the scenarios discussed below we set r at 0.2 and K at 1 million. Harvest is a function of effort, E , a catchability coefficient, q , and the size of the fish stock:

$$(2) \quad H = qEX \rightarrow E = \frac{H}{qX}$$

We consider cases where q is a constant so that catch per unit effort (CPUE) is proportional to the size of the fish stock and also cases where q is a decreasing function of the fish stock such that CPUE for both alternatives is the same at B_{msy} but declines less than fishery biomass as the fish stock is fished down

$$(3) \quad q = .0001 \text{ or } q = \frac{.0003}{\left(1 + \frac{4X}{K}\right)}$$

Producer surplus, π , each time period is determined by prices, P , harvest, and harvest cost, C , where cost is a function of effort:

$$(4) \quad \pi = P(H) * H - C(E)$$

We consider constant prices where P is a constant, and also a constant elasticity demand specification for price with an elasticity of -0.2.

$$(5) \quad P = 1 \quad \text{or} \quad P = \exp(2 - .2H)$$

We consider both constant marginal costs and increasing marginal costs:

$$(6) \ C = 25E \quad \text{or} \quad C = 10000 + 5E + .01E^2$$

For each scenario, we optimize the net present value of future producer surplus over a 100 year period.

$$(7) \ Max \sum_{t=0}^{100} e^{-\delta t} (P_t H_t - C_t) \quad s.t. \ H_t \leq x^* F_{msy} \text{ and } x_{10} \geq B_{msy}$$

where δ is the discount rate.

The impacts of economic parameters on optimal rebuilding strategies

We now consider how the optimal rebuilding schedule for this simple deterministic fishery model is affected by various assumptions about catchability, cost and price (Table 4.1). We model optimal rebuilding trajectories subject to constraints that fishing mortality cannot exceed F_{msy} and biomass must be rebuilt to B_{msy} by year 10. These are standard constraints for rebuilding fisheries in the US. They are binding only for scenario 5 and we discuss the value of relaxing the constraint on the rebuilding time frame in that case. For each of these scenarios we assume the starting biomass is at one-half B_{msy} and determine the set of annual harvests for year 0 through year 100 that maximize present value of net revenues (revenues minus harvest costs) given the specified discount rate and assumptions about catchability, costs and prices laid out in Table 4.1. The biomass rebuilding paths and harvest trajectories through year 30 are shown for each of the scenarios (Figure 4.1).

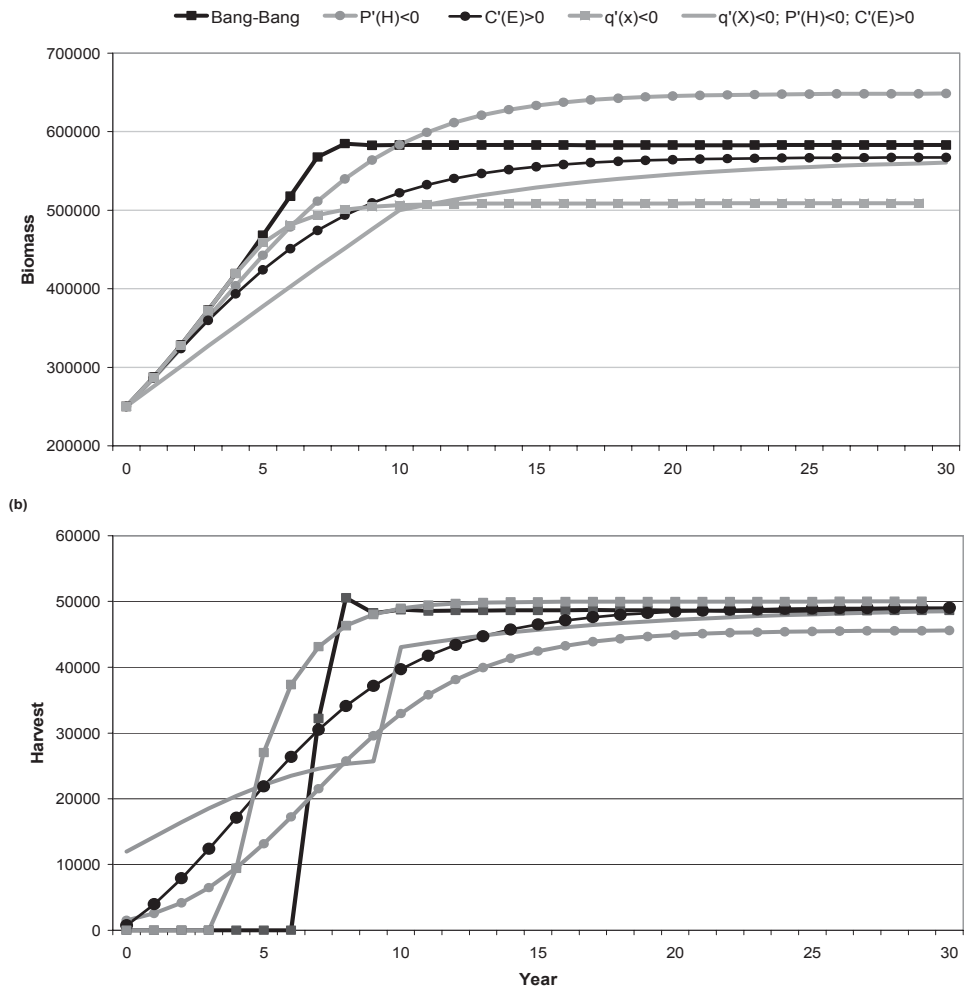
As is well known (e.g. Clark 1990), when prices and marginal cost are constant so that the profit function is linear, the optimal rebuilding approach is the fastest possible, often referred to as the bang-bang solution. Harvest is set at zero until the fish stock has risen to the optimal level which may be higher or lower than B_{msy} depending on the marginal cost and discount rate. With our model assuming constant price and constant marginal costs and a discount rate of 0.03 (Scenario 1 in Table 4.1), the fishery is closed for seven years, is partially opened in the eighth year, and is then fished with a harvest of around 48 000 per year thereafter. Note that the fishery biomass reaches B_{msy} after 6 years but is built to and maintained at an optimal level of around 580 000 which yields an equilibrium annual catch of 48 700. It is optimal to build biomass above B_{msy} because the lower harvest costs associated with higher biomass outweigh the slightly lower harvest level (Figure 4.1).

Table 4.1. Optimal rebuilding scenarios

Scenario	1: Bang-Bang low r	2: $q'(X)<0$	3: $P'(H)<0$	4: $C'(E)>0$	5: $q'(X)<0$; $P'(H)<0$; $C'(E)>0$
Discount Rate	0.03	0.03	0.03	0.03	0.03
		$\frac{.0003}{(1+\frac{4X}{K})}$			$\frac{.0003}{(1+\frac{4X}{K})}$
Catchability	0.0001		0.0001	0.0001	
Price	1.00	1.00	$\exp(2-.2H)$	1.00	$\exp(2-.2H)$
Total Cost	$25 * E$	$25 * E$	$25 * E$	$10000 + 5E + .01E^2$	$10000 + 5E + .01E^2$
Year Rebuilt ($X \geq B_{msy}$)	6	8	7	9	10
Target Equilibrium Biomass	582,000	509,000	649,000	567,000	567,000
Target Equilibrium Harvest	48,700	50,000	45,600	49,100	49,200

Scenarios subject to constraints that stock is rebuilt to B_{msy} by year 10 and fishing mortality cannot exceed F_{msy}

Figure 4.1: Optimal biomass and harvest trajectories under alternative economic and technical assumptions.



For the scenarios we model, we use a relatively low discount rate of 3%. However, higher discount rates can affect optimal rebuilding timeframes and biomass targets substantially (Larkin *et al.* 2006). With the same model parameters above but any discount rate higher than 10%, the optimal equilibrium biomass would be below B_{msy} . If managers were legally constrained to rebuild the fishery to B_{msy} , it would be optimal to delay doing so as long as possible.

The base model assumes that catchability is constant so that catch per unit effort changes proportionately with biomass. In many fisheries catchability does not fall as quickly as biomass when a fish stock declines (or increase proportionately when biomass increases) because fish stocks are unevenly distributed and fishermen can keep catch rates high by concentrating effort where fish stocks are aggregated. Scenario 2 alters the base case scenario to allow for catchability to decrease with increasing biomass. This lowers the optimal target biomass to 509 000 which raises the equilibrium harvest rate to just under the MSY level of 50 000. The fishery is closed for only 4 years but then harvest is progressively increased until the fishery reaches optimal biomass. The fish stock is rebuilt to B_{msy} after eight years.

Scenario 3 considers the case where price is inversely related to the catch. For this scenario all the model parameters are the same as Scenario 1 except that price is a function of harvest such that a 1% increase in harvest results in a 0.2% decrease in price (i.e. a constant elasticity demand curve with elasticity of -0.2). Relative to scenario 1, this increases the optimal equilibrium biomass (to 649 000) and decreases equilibrium harvest (to 45 600). The fishery is also never completely shut down. Small harvests are allowed from the beginning of the rebuilding program and increased as the fishery rebuilds. The stock reaches B_{msy} in year 7 (only a year later than scenario 1), but does not reach optimal biomass until around year 30.

Rising marginal cost is another factor that can change both the optimal rebuilding schedule and the optimal target biomass. Relative to the base case scenario the target biomass is decreased to 567 000 and the fishery is not rebuilt to B_{msy} until year 9. As with Scenario 3, the fishery is never completely closed and harvests are progressively increased as the fishery rebuilds.

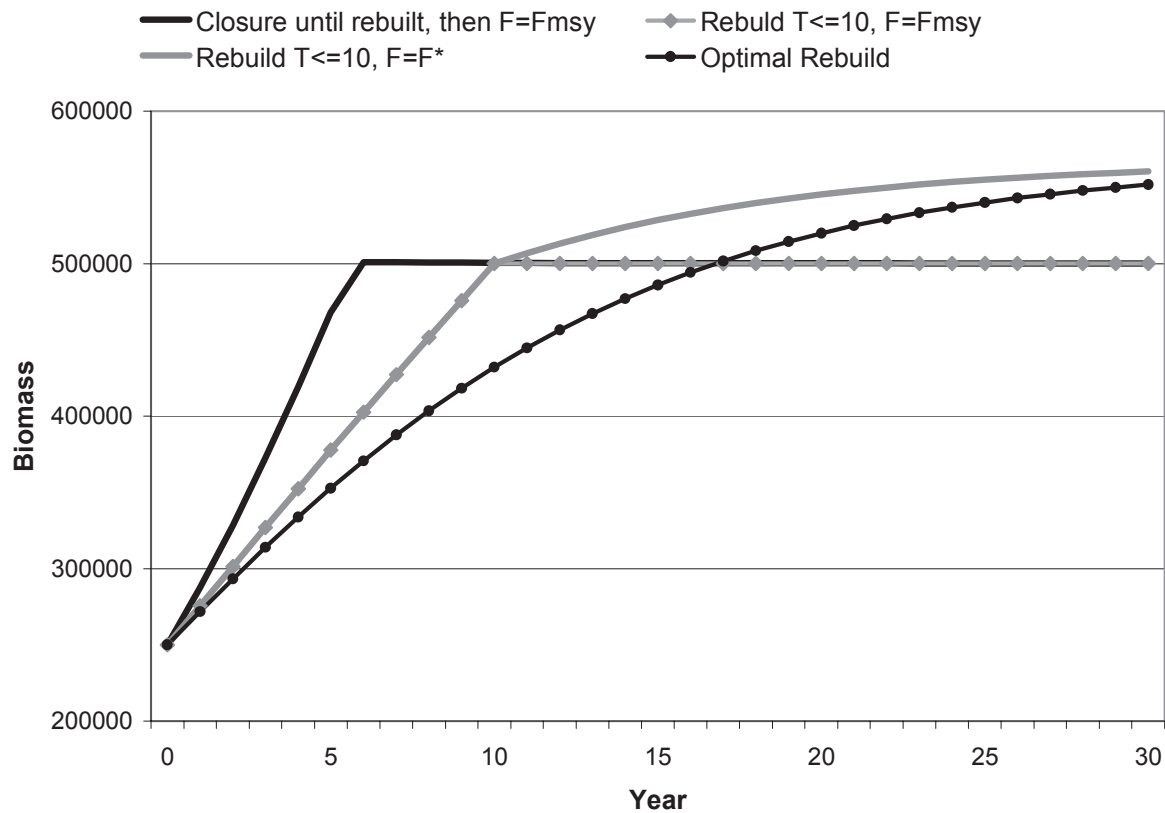
Scenario 5 combines the various assumptions explored in scenarios 2-4 allowing for decreasing catchability, downward sloping demand and increasing marginal cost. The net effect of these assumptions (relative to the base case) is to reduce the target biomass slightly to 567 000 and increase the equilibrium harvest slightly to 49 200. This scenario maintains somewhat higher harvests during the rebuilding than any of the other scenarios which slows rebuilding. The fishery is not rebuilt until year 10 which is the maximum allowed. If the rebuilding plan were not constrained by the 10 year maximum it would in fact be optimal to further slow the rebuilding such that the biomass would not reach B_{msy} until year 17 (Figure 4.2).

The economic gains from pursuing an optimal rebuilding strategy relative to simply closing the fishery until it is rebuilt will of course vary from fishery to fishery and will depend on a number of factors besides those explored above as will be discussed in the next section. For our simple model under scenario 5, there is a 10% increase in present value achieved by allowing the fishery to take ten years to rebuild to B_{msy} and then fishing at F_{msy} thereafter (Figure 4.2, Table 4.2). There is a further 1% increase from setting the post rebuilding harvest at the optimal level which allows the biomass to rebuild to 567 000. Beyond that there is a 2% further increase for relaxing the constraint on the rebuilding time frame and allowing 17 years for the fishery to rebuild.

Table 4.2. Present value of profits under alternative constrained and unconstrained rebuilding paths for scenario 5.

Scenario	1: Closure $X \leq B_{msy}$, $F = F_{msy}$	2: T rebuild ≤ 10 , $F = F_{msy}$	3: T rebuild ≤ 10 , $F = F^*$	4: Optimal Rebuild $F = F^*$
Net Present Value	421,750	462,090	469,107	474,869
Percent Increase fr	0%	10%	11%	13%

Figure 4.2: Fastest optimal (constrained and unconstrained) biomass rebuilding trajectories for Scenario 5 model assumptions.



Other factors that affect optimal rebuilding strategies

As the model discussed above demonstrates demand elasticity, the discount rate and technical-economic characteristics of the fishery that determine catchability and cost structure can significantly influence the optimal rebuilding path and biomass targets. Taking these factors into consideration in designing a rebuilding plan can yield increase in benefits. There are a number of other factors that may be more difficult to evaluate and model that are equally or perhaps more important.

Many fisheries are capital intensive requiring large investments in vessels and fishing gear that are specialized for the fishery and may have limited value for other fisheries.

These investments may be lost if the fishery is closed or catches drastically reduced, and it may be require substantial investment to rebuild infrastructure when the fishery is reopened. Markets may be lost if a fishery is closed or catches dramatically cut during rebuilding, and it may require considerable time and resources to rebuild these markets. People involved in fishing and processing may also have few other economic opportunities, and some fishery dependent communities may suffer serious harm from a sustained fishery closure. Standard economic analyses may fail to capture the full social costs of problems associated with high unemployment and emigration from the community. These impacts may be ameliorated by a somewhat slower rebuilding strategy, but quantifying these costs and weighing them against the benefits of having a rebuilt fishery more quickly can be difficult due to a lack of good information on the industry cost structure, costs of market development, and alternative uses of labour and capital.

Multispecies fisheries

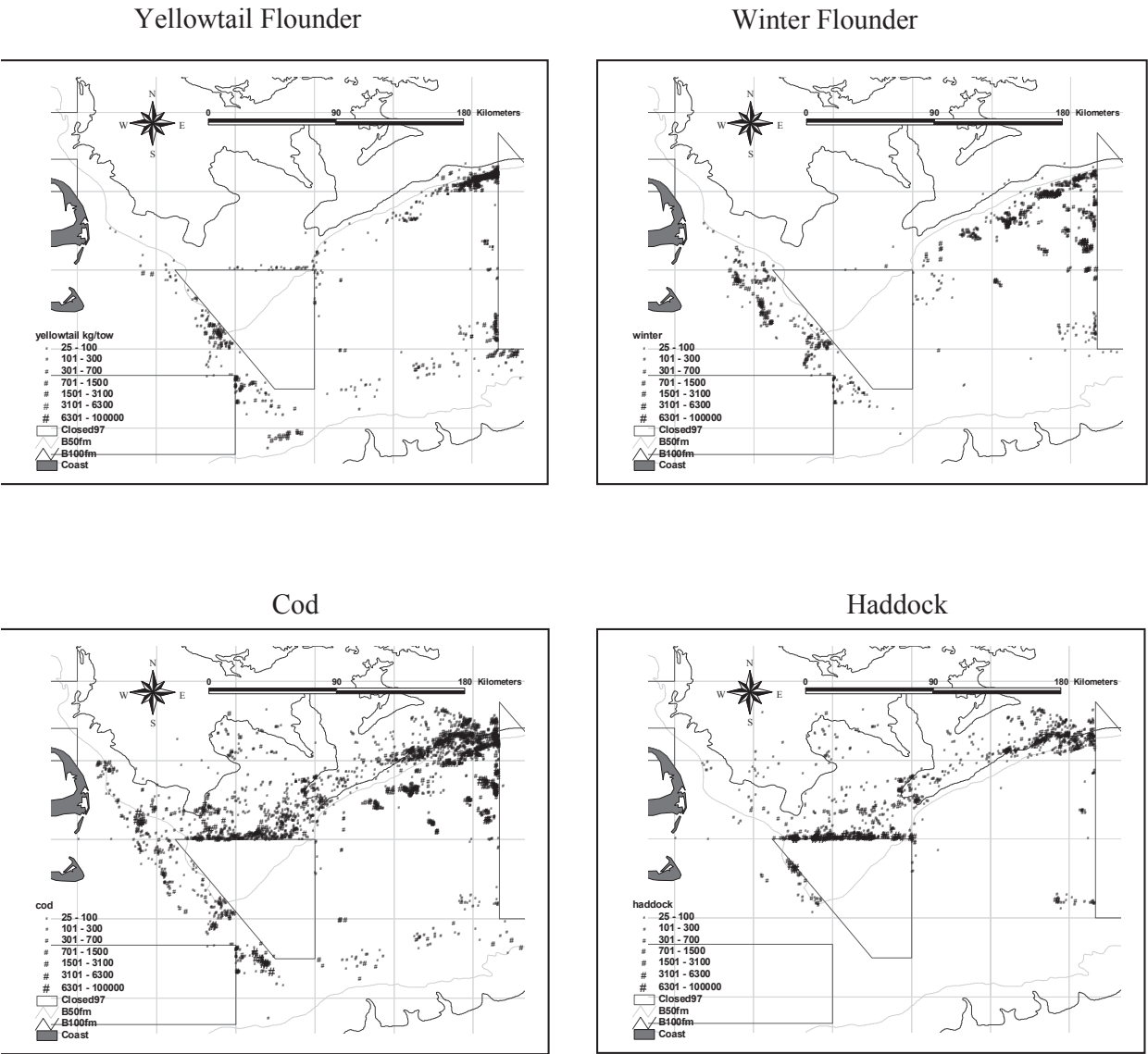
Many, if not most commercially harvest fish species are caught in conjunction with other species. This may be deliberate because those other species are valuable, and there are economies of scope in joint harvesting (i.e., it is less costly to harvest them together than separately). Or it may be that the other species have little or no value, but avoiding catching them would be costly requiring changes in harvesting methods that would reduce catch rates of the target species or drive up costs in some other way. In such cases, reductions in the allowable harvest level of one species are likely to affect the feasible harvest levels of jointly cost species or drive up the cost of catching them if it becomes necessary to actively avoid catching the depleted species.

When a fish stock that is part of a multispecies fishery is determined to be depleted and rebuilding is required, determining the optimal rate of rebuilding requires taking into account the effect on the net benefit stream for the overall multispecies complex. This does not necessarily mean that it will not be optimal to rebuild the depleted stock quickly, but it likely that the quickest rebuilding scenarios that require zero or very low catch may be costly to the larger fishery, and a somewhat slower rebuilding scenario might be economically superior. The degree to which a slower rebuilding schedule, and perhaps a lower rebuilding target, may be preferable will depend on how feasible and costly it is to reduce the relative catch rates of the depleted species and the value of the depleted species relative to the other species in the multispecies fishery.

The cost of reducing the catch of the depleted species will generally be heavily influenced by the management measures used to achieve the catch reductions. For example, with no change in target behaviour, a 30% reduction in catch of depleted species X may require a 30% reduction in catch of species Y. However, if there are areas of fishing methods that can reduce the catch rate of species X relative to species Y, it may be possible to achieve a 30% reduction in species X catch with less or even no reduction in species Y catch. Different species that are part of the same fishery and may often be caught together may have different, though overlapping, spatial distributions that make it possible at least partially target one species and actively reduce catch rates of another (Figure 4.3). With knowledge of these distributions it may be possible to design area closures, seasonal or year-round where species X catch rates (relative to species Y) are highest. But this may not always be feasible. As Figure 4.3 illustrates reductions in haddock might be achieved with limited impact on catches of flounder and vice versa; but

cod tends to overlap with haddock and flounders so that reductions of cod catch might increase costs of catching those species and vice versa.

Figure 4.3: Spatial distribution of catch per tow by species for four primary groundfish species. .



Data reflect catches from individual tows recorded by a study fleet of trawlers based in New Bedford, Massachusetts.

Source: Data collected by the RFAC program, School of Marine Science, University of Massachusetts Dartmouth.

In most cases, large scale area closures are unlikely to be the most efficient way of achieving the desired changes in relative species catch rates. Finer scale targeting behaviour based on current information generated by fishing may enable reductions in species X catch rates with less reduction in catch rates of species Y. Fishermen may also be able to alter gear or other fishing practices (e.g., towing speed and direction and season or time of day they fish) to alter catch mix. It may not be feasible or practical to design

command-and-control style regulations to require this behaviour because regulators do not have the necessary information or the ability to monitor behaviour. However, management systems that allocate species specific quotas to individual fishermen or groups of fishermen can create incentives for fishermen to utilize their own knowledge to adjust relative catch rates since doing so will enable them to utilize a higher percentage of their quota allocations of other species (Holland 2007). While they are rarely used to manage fisheries, landing taxes that reduce the net value of a species might also be an effective way to incentivize fishermen to reduce catches of that species.

While it may be possible to alter relative catch rates to reduce or perhaps eliminate catch of a rebuilding fish stock, it will generally be costly to do so. In determining the optimal rebuilding plan, this should be factored in. It may be that allowing a longer rebuilding schedule with lower initial reductions in catch may be able to meet legal rebuilding requirements while minimizing the cost to the large multispecies fishery.

Uncertainty

Fishery managers typically face a high level of uncertainty about the current state of fish stocks and how fast they will grow in the future. The models used to predict the response of a fish stock to a specified harvest strategy, while typically more sophisticated than the one discussed above, rarely account for environmental and ecological factors that can substantially alter average growth rates and natural mortality. Accounting for this uncertainty and variability in growth can substantially change the optimal harvest schedule. This is particularly likely when there are cyclic or secular changes in the productivity of the fish stock that are at least partially understood.

Parma (1990) showed that with cyclic productivity optimal escapement (i.e., target biomass) is lower and harvest rate increased when recruitment conditions are poor, and optimal escapement is increased when recruitment conditions are good. Similarly, Costello *et al.* (2001) show that it is optimal to reduce escapement and increase harvest when future expected growth is lower than average and to reduce harvest and increase escapement when expected growth in future is higher. While these analyses were not focused specifically on rebuilding depleted fish stocks, they suggest that an optimal rebuilding strategy should account for expectations of future productivity. A less conservative rebuilding strategy may be called for when the fishery is in a sustained period of low productivity, and a more conservative strategy may be called for when future expected growth conditions are good. These conclusions, however, may not hold if there is an increased probability of fishery collapse when the fish stock falls to low levels. Spencer (1997) constructed a surplus production model incorporating a nonlinear rate of predation which results in multiple, stable equilibriums. When variability in growth is correlated through time (i.e., auto-correlated variation), it can result in rapid flips in marine fish abundances between high and low biomass states. Spencer shows that the optimal policy, given these assumptions, requires conservative harvest strategy during poor environmental conditions. This would suggest that rapid rebuilding of depleted stocks would be desirable. Johnston and Sutinen (2001) explore optimal management with an uncertain biomass shift that results in collapse of the target species and replacement by another species. If the probability of the shift is affected by stock size, more conservative management is called for when stocks are depleted unless the replacement species is more valuable.

The analyses discussed above make simplifying economic assumptions about price and cost structure to make the models tractable - i.e., they assume constant price and

constant marginal cost. As the discussion in the previous section illustrated, relaxing these assumptions can have important impacts on an optimal rebuilding strategy. Singh *et al.* (2006) develop a dynamic model, calibrated to the Alaskan Pacific halibut fishery, which simultaneously incorporates random stock growth with a quadratic cost function, costly capital adjustment and downward sloping demand. Under these assumptions, they show it is optimal to build up the fleet when growth is good (with positive serial correlation), in anticipation of higher future catch levels, and decrease fleet size when growth is poor. For low and high stock sizes, the optimal harvest rate is lower than the best constant harvest rate; it is only slightly higher at intermediate stock levels.

Many important fisheries are subject to changes in productivity over time relating to environmental cycles. These may be short term cycles such as the El Niño-Southern Oscillation (ENSO) or longer term cycles such as the Pacific decadal oscillation (PDO) which has been linked to change in productivity of salmon fisheries in the Pacific (Mantua *et al.* 1997) and may affect productivity of many of the key fisheries in the North Pacific (Hollowed *et al.* 2001, Mantua and Hare 2002). Many, if not most fisheries will be affected by climate change which is likely to cause species to shift spatial ranges but is also likely to change the relative productivity of different species in ways that are not yet well understood. There is growing concern that many marine ecosystems and important fisheries may be impacted by ocean acidification which could undermine productivity and perhaps viability of some shellfish species as well as other species that prey on calcifying zooplankton such as pteropods or depend on calcifying organisms such as corals for habitat (Royal Society 2005).

It would be desirable to adjust the reference points that determine whether fisheries are depleted and to what levels they should be rebuilt to account for these climate-induced changes. However, these reference points are generally designed to estimate maximum sustainable growth and associated biomass based on long time series of data that reflect past conditions. Reference points calculated in this way are likely to overestimate productivity and target biomass for some species that are negatively affected by climate change and set unrealistic rebuilding requirements. The reverse may be true for other fish stocks that are positively impacted by climate change. In both cases, the benefits from the fishery will be reduced if reference points are not adjusted to reflect changes in productivity of fisheries.

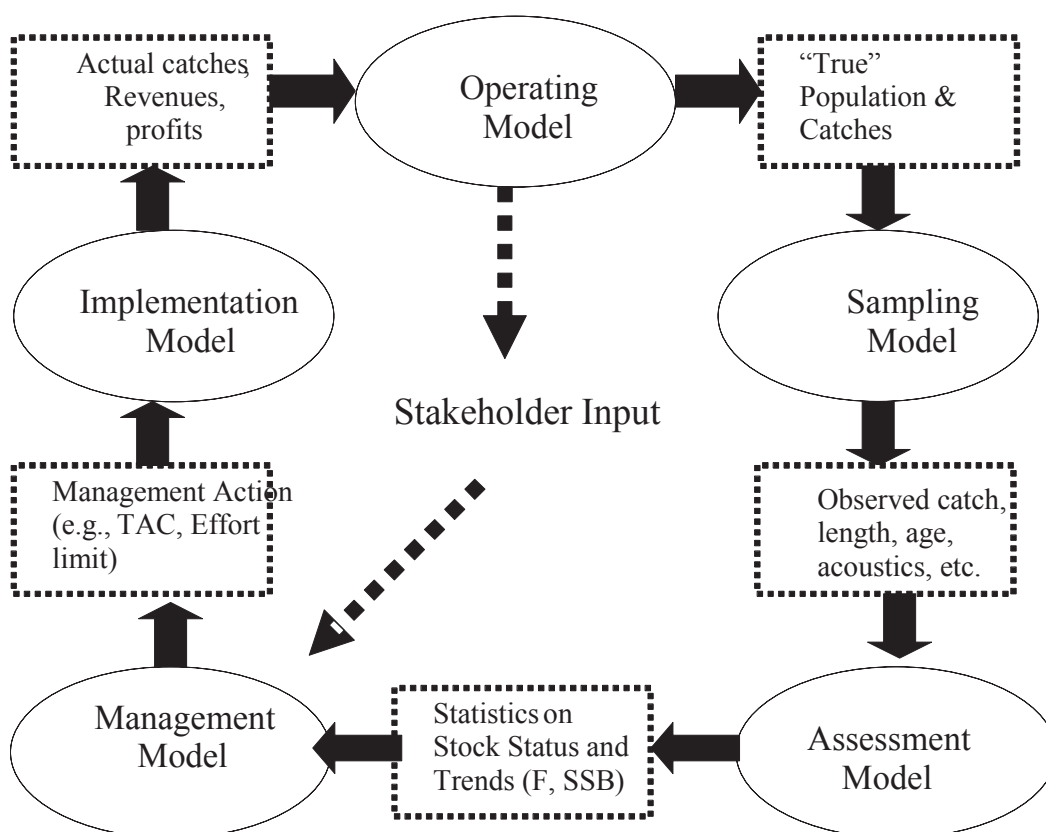
Finding and testing “optimal” rebuilding strategies

The discussion in the previous two sections illustrates that prescriptions for rebuilding fisheries optimally are dependent on a variety of factors that will vary from one fishery to the next. A tailored modelling approach that accounts for specific biological and economic characteristics of the fishery, different objectives of stakeholders, regulatory constraints, and various types and levels of uncertainty is generally needed to provide useful advice to fishery managers and stakeholders. An approach for designing and testing harvest strategies, known as management strategy evaluation (MSE), can meet these requirements and provide a means for stakeholders to evaluate the tradeoffs between various objectives that are often conflicting.

MSE is a general methodology aimed at designing and testing decision rules (i.e., heuristics) for setting and adjusting total allowable catch (TAC) or effort levels. MSE is explicitly aimed at finding decision rules that are robust to natural variation in the system as well as uncertainty and error in both stock assessments and implementation. An MSE

is generally not designed to find “optimal” strategies in terms of a single metric such as net present value, but rather to identify and compare harvest strategies with “adequate, albeit potentially suboptimal, management performance with respect to multiple criteria over a wide range of model assumptions about the dynamics of the resource” (Cooke 1999). The approach was first developed by the Scientific Committee of the International Whaling Commission (IWC) during the 1980s (Punt and Donovan 2007) and has been applied to a number of fisheries since, mostly in the southern hemisphere (see Butterworth and Punt 1999 for an evaluation of several MPs in Australia and South Africa). Decision rules specify actions contingent upon the values of a set of indicators from the fishery. Such indicators may be output from a formal stock assessment, or something simpler such as commercial CPUE. The decision rule may use a combination of indicators and could use results from a formal assessment only occasionally (e.g. every second or third year). Decision rules may combine current states and trends of indicators with seemingly ad hoc rules, such as not allowing changes in the TAC in consecutive years. Managers and stakeholders agree *a priori* about the indicator data, the decision rules, and the period over which the rule will be used.

Figure 4.4: Schematic of a management strategy evaluation model.



A typical MSE incorporates a number of interlinked model structures: population dynamics; data collection; data analysis and stock assessment; the setting of the harvest control rule; the harvest decision process; and imperfect implementation (McAllister *et al.* 1999). An operating model is typically used to generate ‘true’ ecosystem dynamics including the natural variations in the system (Figure 4.4). Data are sampled from the operating model to mimic collection of fishery dependent data and research surveys (and their inherent variability). These data are passed to the assessment model, which estimates parameters such as indicators of current abundance. The assessment model can explicitly calculate stock abundance, or may focus on a simple indicator such as standardized CPUE – whatever will actually be used in the decision rule. Based on this assessment and the decision rule, a management decision is made (e.g., annual or multi-year TACs). Fleet effort and catch are then modelled, potentially allowing for error in implementation, and resulting catches are fed into the operating model. By repeating this cycle the full management cycle is modelled. Alternative decision rules can be compared by running many stochastic simulations for several years to identify the performance of a decision rule according to different metrics under the likely range of conditions. The objective is to identify decision rules that perform “well” under the range of conditions based on the pre-determined objectives and constraints. For example, we might be looking for a rule that results in a low probability of stock collapse, a low annual variability in total catch, and relatively high average catch and stock size. A decision rule that provides for the highest net present value of profits on average might be rejected if it does not perform well on other objectives or performs poorly in a substantial proportion of model runs.

Conclusion

Many fish stocks around the world are depleted and rebuilding them can create substantial economic value. Many countries, including the US have laws that require that these fish stocks be rebuilt to and maintained above levels that support maximum sustainable yield. In the US, law requires fishery managers to rebuild depleted fish stocks within ten years if possible. These legislative mandates may constrain the rebuilding strategies available to fishery managers and stakeholders, but there still may be substantial gains from careful design of rebuilding plans that better meet stakeholder objectives and reduce the costs of rebuilding a depleted fishery. More gradual rebuilding strategies are likely to generate greater economic benefits if demand is inelastic and marginal costs increase with the level of fishing activity. In many cases it will be desirable to rebuild fish stocks to well above B_{msy} , but this will not always be the case and again depends on a combination of biological and technical-economic factors that will vary from fishery to fishery.

Designing an optimal rebuilding strategy for a fish stock that is part of a multispecies fishery can be particularly complex as it requires understanding how it will affect the harvests and harvest costs of other species. The management system and tools used in a multispecies fishery can have large impacts on the cost of rebuilding. Using economic incentives such as those created by individual or group quota systems can reduce rebuilding costs by harnessing the knowledge and skills of fishermen to the task of reducing catch rates of a rebuilding stock.

The variation in the characteristics of fisheries and the objectives of fishery stakeholders and the uncertainty associated with almost all fisheries requires a tailored approach to designing rebuilding and ongoing harvest strategies for fisheries.

Management strategy evaluate provides a general framework for evaluating fishery rebuilding plans that is flexible, rigorous and robust, It can accommodate the multiple and often conflicting objectives of stakeholders, the idiosyncrasies of particularly fisheries and the regulatory constraints managers face.

A primary challenge to designing rebuilding strategies for depleted fisheries is to account for how the environment and ecosystem affect the productivity of fish stocks and their ability to rebuild. Most fish stocks are still managed as if their productivity is static and unaffected by the dynamic ecosystems of which they are a part. The drawbacks of this single-species management approach have led to calls for an ecosystem based approach to fishery management, but, for most fisheries, this has yet to be operationalized in terms of setting the fishery reference points that dictate rebuilding requirements. Our current reliance on single-species population models and equilibrium reference points will become even more problematic as climate change alters the spatial ranges and productivity of fish stocks. A forward looking approach that attempts to anticipate future changes in ecosystems is necessary but presents a difficult challenge for fishery scientists and may require changes in legislation that currently requires managers to adhere to reference points based on single-species maximum sustainable yield.

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Chapter 5.

Harvest strategy policy and stock rebuilding for commonwealth fisheries in Australia

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Abstract

In response to sustainability concerns the then Australian Government Minister for Fisheries, Forestry and Conservation issued a Ministerial Direction to the Australian Fisheries Management Authority to recover overfished stocks, develop a world's best practice harvest strategy policy for Commonwealth fisheries, and investigate the use of individual transferable quotas. To meet the requirements of the Ministerial Direction it was recognised that changes to management arrangements would be significant and that the benefits arising from these changes would need to be long lasting. To adjust to this new operating environment, the Australian Government announced the 'Securing our Fishing Future' package at the end of 2005. The package comprised a one-off structural adjustment package and a series of new management measures.

In response to sustainability concerns the then Australian Government Minister for Fisheries, Forestry and Conservation issued a Ministerial Direction to the Australian Fisheries Management Authority to recover overfished stocks, develop a world's best practice harvest strategy policy for Commonwealth fisheries, and investigate the use of individual transferable quotas. To meet the requirements of the Ministerial Direction it was recognised that changes to management arrangements would be significant and that the benefits arising from these changes would need to be long lasting. To adjust to this new operating environment, the Australian Government announced the 'Securing our Fishing Future' package at the end of 2005. The package comprised a one-off structural adjustment package and a series of new management measures.

These measures have the potential to improve the economic returns from management of Commonwealth fisheries. The harvest strategies developed under the 'Harvest Strategy Policy' require that fish stocks be maintained at sustainable levels while targeting maximum economic yield (MEY). However, it is recognised that achieving the MEY target in fisheries that require rebuilding involves trading off short term economic gains for longer term fishery profitability. This chapter explores the potential benefits from recent changes in the fisheries management and operating environment in Commonwealth managed fisheries and issues associated with implementing an MEY target.

Introduction

Fisheries resources have the potential to generate net benefits for the community. However, this potential is only realised with effective management of fishing effort. Without effective management, fisheries tend to an equilibrium where too many resources are devoted to fishing and the potential returns to society from fishing are dissipated over the longer term. At a fishery level, effective management implies that fisheries managers control fishing effort — either in the form of input controls or output controls — at levels that ensure the stock biomass remains at a sustainable level, and at a level which ensures that the maximum economic yield is able to be extracted from the fishery over the longer term. This yield will be one that provides the maximum possible returns to fishers from their effort, given the biological characteristics of the fishery. In addition to an MEY target, ensuring that the net returns to the community from fisheries management are realised also requires that fishing management instruments that provide incentives for fishing costs to be minimised and returns to be maximised are employed (see Grafton, Kirkly, Kompas and Squires 2006).

Under the Australian Constitution, jurisdiction over Australia's fisheries resources is a mix of Australian government, State government and Territory government responsibilities. Under Australian law the sovereignty of the states ends at the low-water mark but negotiated Offshore Constitutional Settlement (OCS) arrangements between many States and the Australian Government means that the jurisdiction of State fisheries extends to the first three nautical miles from shore. Under these arrangements, many fisheries are managed cooperatively by the governments, especially where fish stocks straddle jurisdictional boundaries. In general, State and Territory governments manage inshore fishing (to 3 nautical miles from shore), aquaculture, and recreational and charter fisheries. State fisheries account for around 85% of the total gross value of Australian fisheries production. The Australian Government jurisdictional power over Commonwealth fisheries generally extends from three to 200 nautical miles from shore, an area known as the Australian Fishing Zone (AFZ).

Commonwealth fisheries are managed under the Fisheries Administration Act 1991 and the Fisheries Management Act 1991. The Australian Fisheries Management Authority (AFMA) is established under those Acts as the Australian Government body empowered to manage fisheries, a task that it has been undertaking since February 1992. AFMA is responsible for the sustainable use and efficient management of fishery resources on behalf of the Australian community and stakeholders. Its management is accountable to both the Australian Government minister with portfolio responsibility for fisheries matters and to the Commonwealth Parliament. The minister has a responsibility to oversee the authority's activities, but at 'arm's length', and only in exceptional circumstances is the minister empowered to give AFMA directions on the performance of its functions and the exercise of its powers.

The Fisheries Management Act 1991 binds AFMA to pursue a number of objectives (AFMA, 2006):

- implementing efficient and cost-effective fisheries management on behalf of the Commonwealth;
- ensuring that the harvesting of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (which include the exercise of the precautionary principle), in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment;
- maximising net economic returns to the Australian community from the management of Australian fisheries;
- ensuring accountability to the fishing industry and to the Australian community in AFMA's management of fisheries resources; and,
- achieving government targets in relation to the recovery of the costs of AFMA.

Assessments by the Bureau of Rural Sciences indicate that there has been a trend toward overfishing in the period 1992 to 2005. Twenty four fish stocks in 2005 — of the eighty three assessed — were classified as 'overfished and/or subject to overfishing' (Larcombe and McLoughlin, 2007). AFMA also noted that in 2005, the ecological sustainability, economics and management of the Commonwealth's fisheries were being affected by, amongst other things, excess fishing capacity and effort and economic and market pressures such as, rising operating costs and unfavourable exchange rates for export (AMFA, 2005).

In December 2005, the then Australian Government Minister for Fisheries, Forestry and Conservation issued a Ministerial Direction to AFMA under section 91 of the *Fisheries Administration Act 1991* to recover overfished stocks, develop a world's best practice harvest strategy policy for Commonwealth fisheries, and investigate the use of individual transferable quotas in the management of all fish stocks in Commonwealth fisheries. To meet the requirements of the Ministerial Direction it was recognised that changes to management arrangements would be significant and that the benefits arising from these changes would need to be long lasting. To adjust to this new operating environment, the Australian Government announced the *Securing our Fishing Future* package at the end of 2005. The package comprised a one-off structural adjustment package and a series of new management measures. The then government had instigated the package because it had determined that in many Commonwealth fisheries it was necessary to reduce fishing capacity, in association with catch reductions that had been announced by AFMA, to better position the industry to be profitable and autonomously adjust in the future.

The *Securing our Fishing Future* package included three elements, including requirements that AFMA put in place management actions that ensure that Commonwealth fisheries remain sustainable, the facilitation of the creation of Marine Protected Areas in the South East Marine Region, and the provision of a 220 million USD structural adjustment package. The 220 million USD structural adjustment package was to:

- buy back up to 149 million USD in fishing concessions within and across Commonwealth managed fisheries;
- to provide 50 million USD of grant assistance to individuals, businesses and companies that had been affected by the impacts of the buyback and/or the new management measures;
- reduce the amount that AFMA would need to recover through fishing concession holders to implement the new management measures (15 million USD); and,
- improve AFMA's science, compliance and data collection (6 million USD).

The buyback targeted concessions in the following four fisheries where stocks were considered as overfished or at risk of being overfished:

- Bass Strait central zone scallop fishery (BSCZSF);
- eastern tuna and billfish fishery (ETBF);
- northern prawn fishery (NPF); and,
- southern and eastern scalefish and shark fishery (SESSF).

Concessions were also sought from 'non target' fisheries.

In line with the 2005 Ministerial Direction, and complementary to the implementation of the *Securing our Fishing Future* package has been the release by the Australian Government of the *Commonwealth Fisheries Harvest Strategy Policy*. This policy aims to improve the effectiveness of management of fish resources in the Australian fishing zone by providing a framework within which Commonwealth fisheries can be managed sustainably and achieve maximum net economic returns to the community from their management. The harvest strategies developed within this policy framework require that fish stocks be maintained at sustainable levels while targeting maximum economic yield (MEY). A target of achieving the maximum economic yield from Australian fisheries has been accepted as an appropriate target for fisheries management. However, achieving the MEY target in fisheries that require rebuilding involves trading off short term economic gains for longer term fishery profitability. This chapter explores the potential benefits from recent changes in the fisheries management and operating environment in Commonwealth managed fisheries and issues associated with implementing an MEY target. A number of case studies are used to illustrate the changes that have occurred and the potential benefits.

Harvest strategy policy

In response to the 2005 Ministerial Direction, the *Commonwealth Fisheries Harvest Strategy Policy* was developed and released by the Department of Agriculture Fisheries & Forestry in September 2007. The Harvest Strategy Policy is designed to restore confidence in the Australian community that commercial fish species are being managed for long term biological sustainability and economic profitability. It provides a framework for managing Commonwealth fisheries into the future, with the aims being the maximisation of net economic returns and the maintenance of stocks at biologically safe

and productive levels. The application of the policy requires all Commonwealth fisheries to have a harvest strategy in place that is consistent with the policy.

To achieve the aims of the policy, AFMA requires harvest strategies that seek to maintain fish stocks, on average, at a target biomass point equal to the stock size required to produce maximum economic yield. Various other government policy statements have affirmed the importance of managing for economic considerations (see DAFF 2003 and DPIE 1989), as have key pieces of fisheries management legislation such as the Fisheries Management Act 1991 and the Fisheries Administration Act 1991. The current wording of the economic objective in the Fisheries Management Act states that AFMA must “pursue the maximisation of net economic returns to the Australian community from the management of Commonwealth fishery resources”. Consistent with the objective of achieving maximum economic yield from managing fish stocks, harvest strategies need to also be framed such that they maintain fish stocks, on average, above a limit biomass level, where the risk to the stock of biological collapse is regarded as too high; at least 90 % of the time.

The *Harvest Strategy Policy* establishes clearly defined reference points for both biomass levels and fishing intensity, at which changes to the management of fish stocks are warranted (figure 5.1). These reference points are to be built into harvest strategies. The reference points include the limit reference point, B_{LIM} and F_{LIM} , below which fish stocks are considered to be in an overfished state or where overfishing is considered to be occurring respectively, and target reference points to which fish stocks are sought to be re-established (B_{TARG}) or the desired fishing intensity rate to be achieved (F_{TARG}).

The *Harvest Strategy Policy* recognises that economic constraints are important in determining appropriate targets for a harvest strategy. As such, target biomass and fishing intensity levels need to be consistent with achieving maximum economic yield for the management of fishery resources. The concept of MEY is defined in the *Harvest Strategy Policy* as a sustainable catch or effort level that maximises net economic returns in the fishery. It is also recognised that economic efficiency requires the implementation of a management regime that allows costs to be minimised and revenues to be maximised.

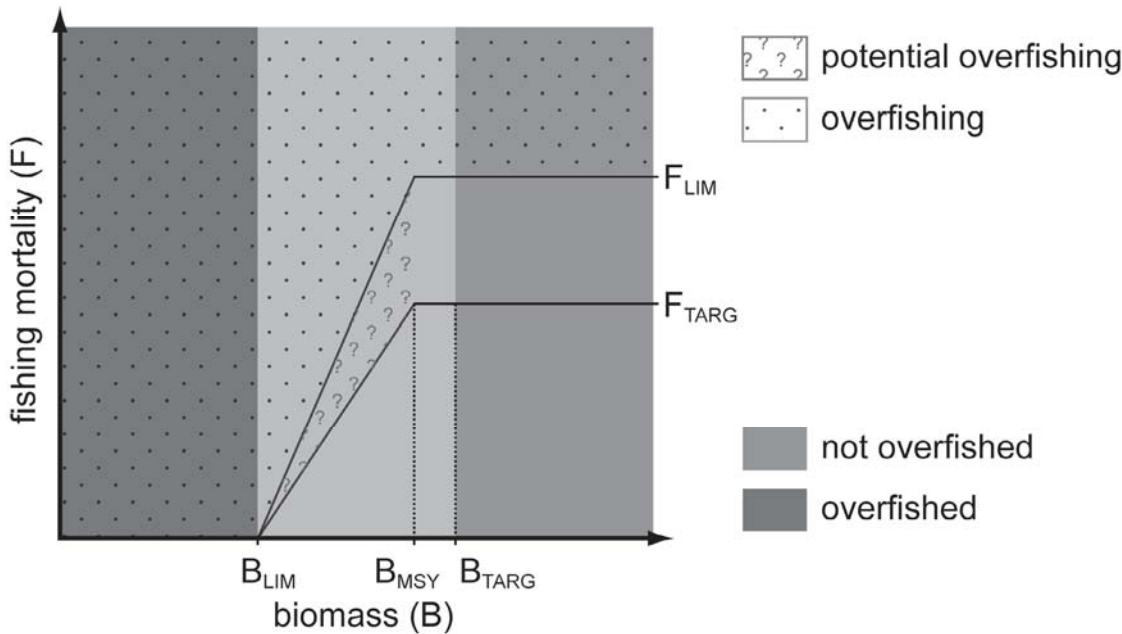
In cases of stock rebuilding, that is where stock levels are at or below levels considered to be dangerous to the stock in terms of its viability (B_{LIM}), harvest strategies need to adopt the strategy of rebuilding stocks to the level required to achieve maximum sustainable yield (B_{MSY}) as an intermediate target. It is important to note that the requirement to rebuild to B_{MSY} ensures that the risk to the fish stock of ecological collapse is minimised, and is not driven by the need to enhance economic efficiency over the longer term. However, it is recognised that moving to B_{MSY} is a move toward a biomass point that is consistent with maximum economic yield. Hence, after achieving the B_{MSY} reference point, harvest strategies need to pursue B_{MEY} , which is typically associated with thicker fish stocks than B_{MSY} .

During the rebuild phase, no fishing effort is allowed until the biomass of the affected stock is brought above its limit reference point. Limited fishing effort is allowed between the limit reference point and target reference point, but this fishing effort needs to be at a level that allows a continued rebuild of the stock up to B_{MSY} . The rate of rebuild will be defined within the harvest strategy and will vary from species to species depending on their unique biological characteristics.

A further consideration for stocks below their limit reference points is the possible application of the Environmental Protection and Biodiversity Act. Fish stocks with a

rebuilding plan in place may be considered under the Act as conservation dependent species, if the removal of the rebuilding strategy would adversely affect the stock. For more severe breaches of the B_{LIM} target reference point fish species may be placed under the Act under higher threatened species categories, including vulnerable, endangered or critically endangered. A listing under any of these categories would trigger the requirement under the Act to establish a formal recovery plan.

Figure 5.1. Reference points for harvest strategies.



An example of a harvest strategy (or harvest control rule) that is consistent with the Commonwealth Fisheries Harvest Strategy Policy—stock status is indicated by hatching and colours, relative to biomass on the horizontal axis and to fishing mortality on the vertical axis.

Issues in implementing MEY

While harvest strategies have been put in place for a number of Commonwealth fisheries and applied in 2008, the use of MEY as a target for these fisheries is yet to be fully incorporated. AFMA has found the application of MEY a difficult concept to integrate into many of its harvest strategies, owing to lack of information on the biological and economic characteristics of fisheries (Raynes and Read 2007). To date only the northern prawn fishery is managed in a way that directly targets the maintenance of the stock biomass at a level consistent with maximum economic yield.

In cases where the stock recruitment relationship and economic parameters can be estimated with a reasonable degree of certainty, a bio-economic model can be used to help determine MEY (see the northern prawn example in Box 5.1). Bio-economic models are usually optimisation models. That is, they are used to estimate a set of control variables, such as fleet size or aggregate catch, that maximise a given variable, such as aggregated profit over a period of time.

Box 5.1. Estimating MEY — an example from the northern prawn fishery

Maximum economic yield (MEY) estimates for the Northern Prawn Fishery (NPF) are obtained from a bioeconomic model that combines stock assessment parameters with a profit function (see Kompas and Che 2004 for details). The profit function measures the difference between the discounted total revenue and the total costs of fishing. The revenue function contains a harvest relationship that accounts for the effect of different stocks of prawns, given changes in fishing effort, on harvest. Key economic parameter values have defined mean values, drawn from ABARE survey data, as well as standard deviations to partially account for the effect of uncertainty.

In the NPF, MEY estimates are obtained for both brown and grooved tiger prawns. Endeavour prawns are treated as an 'economic bycatch', adding to revenues but not the costs of fishing. Banana prawns are not accounted for in the model. Model output generates measures of the stock of prawns at MEY to the stock of prawns at maximum sustainable yield, along with measures of optimal effort and catch at MEY. An updated version of the model developed by ABARE and CSIRO now calculates the dynamic MEY value, that is, the economically optimal pathway to reach the MEY value. Results are presented at NORMAC each year. The model is calibrated for the current price of prawns, the cost of fuel and all other major input expenditures. Model results are also generated based on 3 to 5 year forecasts of the price of prawns and the cost of fuel, with annual updates.

ABARE's bioeconomic model of the tiger prawn component of the northern prawn fishery indicates that the current (2006) biomass of brown tiger prawn stocks is below the level associated with MSY. The ratio of biomass size at MEY (B_{MEY}) to biomass size at MSY (B_{MSY}) for brown tiger prawns is estimated to be 1.54. Also the calculated optimal number of days fished per boat is 110 days, which results in an MEY target of approximately 50 boats.

Proxies for MEY

In the absence of a formal estimation of MEY, the harvest strategy guidelines direct fisheries managers to choose a proxy for the biomass consistent with MEY. A proxy for this biomass is any reasonable variable that has some correlation with where the biomass associated with MEY lies for a particular fishery. For example, the biomass associated with MEY has been shown to be in general greater than the biomass needed to achieve the maximum sustainable yield or harvest from a fishery at reasonable discount rates and fishing costs. Consistent with this view, the harvest strategy guidelines direct that where B_{MEY} for a particular fishery is unknown, the proxy given in equation (1) can be used as a proxy for B_{MEY} .

$$B_{MEY} = 1.2 \times B_{MSY} \quad (1)$$

The guidelines also instruct that where B_{MSY} is unknown then the proxy given in equation (2) can be used.

$$B_{MSY} = 0.4 \times B_0 \quad (2)$$

where:

B_0 is the estimated virgin biomass for a fishery in its unfished state.

This implies that where B_{MSY} is unknown but B_0 is, a proxy B_{MEY} can be calculated through substituting equation (2) into (1) with the equivalent proxy to equation (1) given by equation (3)

$$B_{MEY} = 0.48 \times B_0 \quad (3)$$

The proxies for B_{MEY} suggested for use by the harvest strategy guidelines should only be used where B_{MEY} or B_{MSY} are unknown. Also, these proxies may not correlate very closely with the actual B_{MEY} that would be estimated from an empirical study of the fishery. For example, the estimated value for B_{MEY} in empirical studies has been shown to be sensitive to a range of variables, including the biological characteristics of fish species, fishing costs and discount rates. (Box 5.2 contains estimates from a bioeconomic model of the southern and eastern scalefish and shark fishery. Estimates for the northern prawn fishery are contained in Box 5.1). The guidelines recognise this weakness in the use of proxies, and direct that where a more suitable proxy for B_{MEY} can be found, then this should be used. For example, while most fish species in the southern and eastern scalefish and shark fishery (SESS) use a target biomass proxy for B_{MEY} of $0.48 \times B_0$ as is mandated by the Harvest Strategy Policy. However, for tiger flathead a proxy for B_{MEY} of $0.42 \times B_0$ is used to be consistent with a bioeconomic model built for the SESS.

In some cases, future catches at MEY will be higher than current levels. For example, the bioeconomic work conducted for the SESS indicates that long run MEY harvest of flathead is around 3800 tonnes per year, which is higher than the current TAC and catches (Box 5.2). While it might be the case that long run optimal catches are higher than current levels, it will be the case that catches will need to be reduced for a period to allow stocks to rebuild in order to achieve those levels. This will impact negatively on fishing revenue and profits during this period, but the higher future profits will more than offset this short term loss.

Commonwealth of Australia (2007) provides the following example of the implication for catches of moving from a B_{MSY} target to a target of $1.2 B_{MSY}$ (Table 5.1). Empirical results based on recent stock assessments for 5 SESSF quota species (Table below) show the expected reduction in long term replacement yield in moving from B_{MSY} to B_{MEY} ($0.4 B_0$ to $0.48 B_0$, the latter approximating $1.2 B_{MSY}$) for several key shelf, upper slope and mid slope species (Commonwealth of Australia 2007).

These results show that, in the long term, the reduction in catch (sustainable yield) is around 10 %. If it is assumed that CPUE increases in proportion to biomass, then it is shown in Commonwealth of Australia (2007) that by moving to the MEY proxy of $1.2 B_{MSY}$ that 90 % of the MSY catch can be achieved with only 75 % of the effort.

Table 5.1. Reduction in catch required for $1.2 B_{MSY}$ target

SPECIES/STOCK	% REDUCTION IN CATCH
Blue grenadier	11
Pink ling	10
Eastern Zone orange roughy	11
Flathead	9
Morwong	9

Box 5.2. Calculating MEY— an example from the Commonwealth trawl fishery

Kompas and Che (2008) have constructed a bioeconomic model of selected stocks for the Commonwealth trawl sector of the southern and eastern scalefish and shark fishery. Solutions to the bioeconomic model are obtained by maximising the aggregated discounted profits over time subject to a specification for harvest functions — the production function mapping fishing inputs to the harvest of fish — and the appropriate stock-recruitment relationship. All initial conditions for biomass are taken from virgin biomass measures provided by CSIRO or estimated from information supplied by CSIRO.

The results of the model are preliminary and the model likely requires further calibration based on biological studies and economic data. The results of the model are in two forms:

- harvests and stocks in steady state (that is optimal harvests after stock rebuild);
- harvests during the rebuild phase.

The preliminary results indicate that for four of the major stocks (orange roughy, pink ling, spotted warehou and tiger flathead) considerable stock rebuilding is required to maximise profits (Table 5.2). That is, historical levels of harvest and fishing effort have resulted in current stock sizes that are below the stock level B_{MEY} . Also in Table 5.1 the stock level associated with MEY relative to MSY is shown and for each species B_{MEY} is above B_{MSY} . The optimal harvests at the steady state are also shown in Table 5.1. However, during the rebuild phase, harvests need to be set lower than 2004 catch levels to allow the stock to rebuild to B_{MEY} .

The path to MEY

That it can be shown that there are long term benefits from adopting an MEY target is not surprising. By definition, such a target is superior to other targets in terms of long run economic returns. As described above, the transition to MEY will involve operating the fishery at below the MEY catch level for a period of time. The Harvest Strategy Policy does not specify how quickly a fishery should move from the ‘interim’ target of B_{MSY} to the B_{MEY} . One obvious possibility would be a path that maximises economic returns. The *Harvest Strategy Policy* states that the rate of rebuilding from B_{MSY} to B_{MEY} may be slower than from B_{LIM} to B_{MSY} and “shall be determined in a way that considers the appropriate balance between short term losses and longer term economic gains” (Commonwealth of Australia 2007).

How often should MEY be updated?

It is noted in Commonwealth of Australia (2007) that MEY is a dynamic concept — changes to fishing costs and fish prices will result in MEY changing both within and between seasons — and that it is not likely to be feasible or worthwhile to adjust MEY with respect to short term or temporary fluctuations in factors affecting MEY. It is suggested that ‘basing MEY around expectations of future values of key factors (fish prices and fishing costs) over the medium term (3-5 years) would seem appropriate for most fish stocks’ (Commonwealth of Australia 2007). If major changes occur to factors affecting MEY in the interim, such as a significant change in fishing costs, then a review could be conducted and MEY adjusted if necessary.

Table 5.2. Results of bioeconomic model of the Commonwealth trawl sector of the southern and eastern scalefish and shark fishery.

Species	BMEY/BCUR	BMEY/BMSY	Optimal harvest at steady state (MEY) tonnes	Initial harvest TAC during rebuild * tonnes	Harvest (2004) tonnes
Orange roughy – Cascade	1.64	1.47	995	665	1600
Spotted warehou	1.30	1.08	4117	3114	4100
Pink ling (trawl)	1.80	1.29	1397	914	1073
Tiger flathead	1.05	1.03	3830	2980	3200

* This is the initial TAC during the rebuild phase. The TAC will increase through time over the rebuild period up to the optimal TAC at steady state.

MEY in multi-species/multi-method fisheries

In multispecies fisheries it is important that consideration of the concept of MEY is at a fishery level, not an individual species level. This is recognised in the *Harvest Strategy Policy*. It is noted that ‘By optimising MEY across the fishery, some individual stocks may be below B_{TARG} . That is, in order to maximise the overall profits of a fishery, it may be necessary to forego some profits of one species in order to generate higher profits from another’ (Commonwealth of Australia 2007). The *Harvest Strategy Policy* requires that the estimated biomass of all species must be maintained above their limit reference point, B_{LIM} .

Ideally catch levels across species would be set to maximise the aggregated profit over the long term from the combined catch (subject to environmental concerns). It is possible to construct bioeconomic models that solve this problem (Box 5.2). However, a substantial limitation in many fisheries is adequate biological knowledge of all target species.

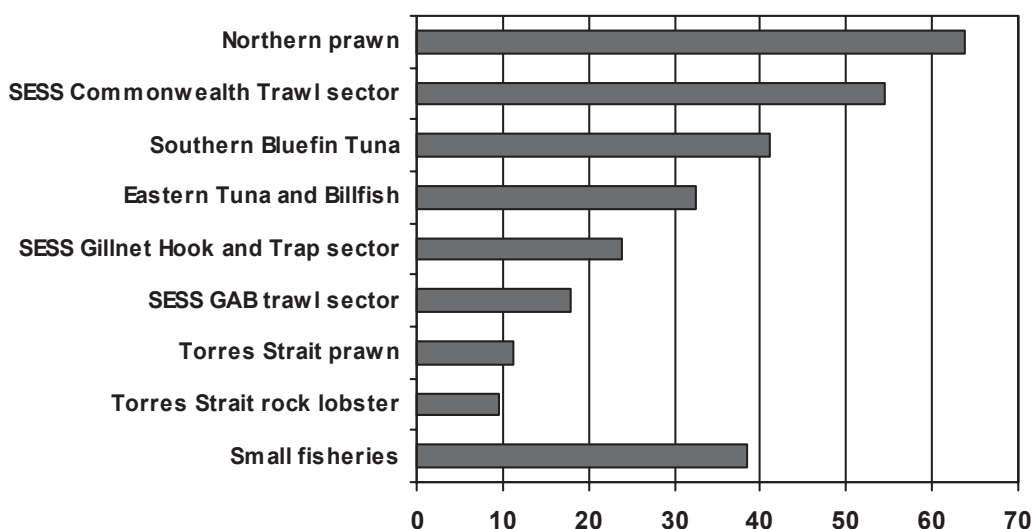
MEY in low value fisheries

Eleven of the 17 Commonwealth fisheries in Australia are low value, earning less than USD 3 million of gross value of production a year. However, these fisheries combined generated around USD 38 million in 2006-07, or 13 % of total Commonwealth GVP — which was around USD 293 million in 2006-07 (figure 5.2). The low value of production in these fisheries makes the construction of formal bio-economic models prohibitive, as the cost of model development would in many cases exceed the gross value of production of these fisheries, and the cost of implementation would far outweigh the benefit of managing the fishery at MEY. For these fisheries the *Harvest Strategy Policy* calls for a precautionary stance by fisheries managers. In practice, this implies that fisheries are managed with limited biological or economic information but formal rules

are imposed that call for more information to be obtained as the fishery develops. Such rules are imposed in harvest strategies through the incorporation of trigger points. These trigger points are typically linked to catch levels, and as progressive triggers are reached, formal processes are established to limit catch and collect more information before catch rates are allowed to breach the trigger point.

While the trigger points built into the harvest strategies of small fisheries will help manage these fisheries sustainably, fisheries managers will still increasingly need to monitor how their fishery is tracking against the objective of achieving economic efficiency. Performance indicators, encompassing a range of quantitative and qualitative metrics, have an important role to play in fisheries management.

Figure 5.2. GVP of Commonwealth fisheries in 2006-07 (USD A million) .



Performance indicators

A range of indicators are available for use by fisheries managers to assess how close they are to achieving their stated goal of maximising net economic returns to the community and to assess the effectiveness of stock rebuilding strategies. Kompas *et al.* (2009) found that along with MEY measures there are a number of other useful indicators of the economic performance of fisheries, such as direct efficiency measures (*e.g.*, stochastic frontiers), productivity indicators and profit decompositions.

- Stochastic frontiers measure vessel level efficiency to determine whether harvest is at its maximum level, given inputs, or whether the cost of fishing at a given harvest level is minimized.
- Productivity measures are a basic indicator of the ratio of output to inputs. Often this measure is stock adjusted in a fishery to account for changes in abundance. Holding stock and inputs constant, an increase in output indicates an increase in productivity. If output falls under the same conditions, productivity falls.

- Profit decompositions decompose profits into various components: for example, output, inputs and productivity. Profit decompositions allow the effects of changes in, for example, fuel prices, on profits to be determined. In this report, profit decompositions are applied to both the SETF and the eastern tuna and billfish fishery.

Kompas *et al.* (2009) discuss these methods and illustrate their use.

One of the most effective ways to assess fishery profitability is to conduct periodic surveys of the fishery. For example, ABARE undertakes an economic survey of some large Commonwealth fisheries, including the northern prawn, Torres Strait prawn, and eastern tuna and billfish fisheries and the Commonwealth trawl and gillnet hook and trap sectors of the south east scale fish and shark fishery biennially. These surveys provide a measure of the economic performance of the fishery, both for the average boat, and the fishery as a whole, by estimating net economic returns.

Other indicators that are indirectly related to fishery level profitability — but typically require less information to estimate — include fishery level latency, quota lease values, and gross value of production.

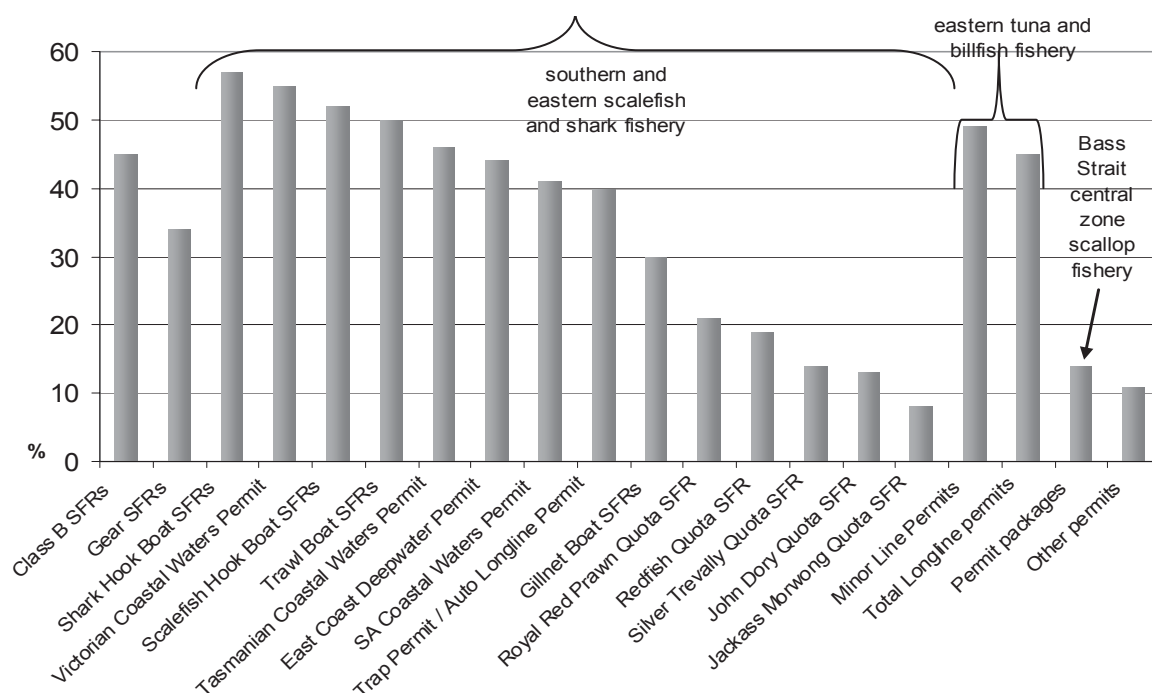
Economic performance of Commonwealth managed fisheries

In this section the results of the fishing concession buyback are summarised and the economic performance of the fisheries most affected by the buyback are reviewed. Where information is available, the potential benefits of the removal of effort through the buyback, recent changes in management arrangements and the implementation of the *Harvest Strategy Policy* are highlighted.

Impact of the Commonwealth fisheries “buy back”

The buyback of fishery concessions was undertaken in two rounds, the first finalised in September 2006, and the second in December 2006. The main fisheries targeted were the northern prawn fishery, the southern and eastern scale fish and shark fishery (SESS), the eastern tuna and billfish fishery, and the Bass Strait central zone scallop fishery. A substantial proportion of entitlements were purchased in three of the target fisheries (figure 5.3).

The success of the buyback and the new management measures implemented by AFMA in meeting the objectives of allowing stocks to rebuild and to better position the industry to be profitable and autonomously adjust in the future is still under assessment. Results of preliminary analysis of the impact of the buyback on fishing revenues and costs for the main fisheries affected by the buyback are outlined below. ABARE is currently conducting fishery surveys of the NPF to determine economic returns both at a boat and fishery level for 2006-07 and 2007-08, which will provide a strong indicator of post buyback trends in economic performance in this fishery. In 2010, ABARE will conduct similar surveys of key sectors of the SESS and eastern tuna and billfish fishery (ETBF) which will provide further evidence for an assessment of the impact of the buyback and recent management changes.

Figure 5.3. Target fisheries % reduction in concessions.

Economic performance of the northern prawn fishery

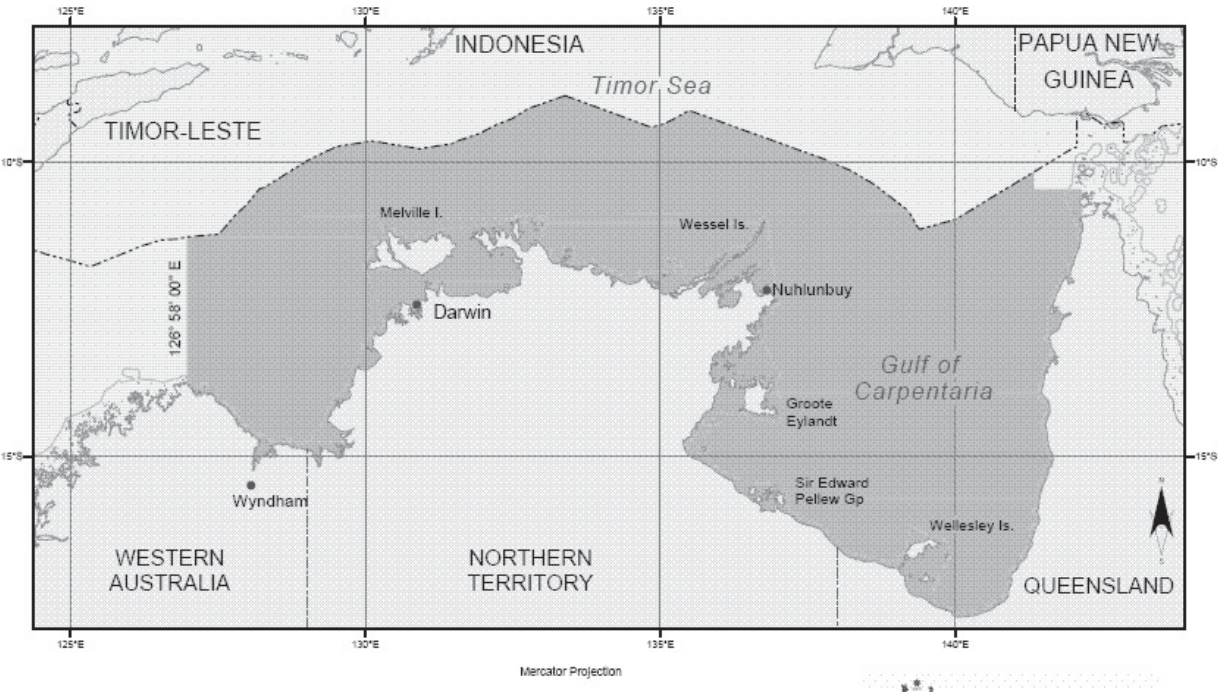
The northern prawn fishery (NPF) is the largest and one of Australia's most valuable Commonwealth fisheries occupying an area of 771 000 square kilometres off Australia's northern coast (see map 5.4.A). The white banana prawn, the brown tiger prawn, and the grooved tiger prawn account for almost 95 % of the total annual landed catch weight from the fishery (ABARE 2008). The gross value of prawn production in the NPF in 2006-2007 was AD 64 million with a total harvest of about 5 100 tonnes (ABARE 2008).

AFMA and its predecessors have managed the fishery with input controls since the fishery began in the mid-1960s. However, the adoption of new fishing techniques has forced management authorities to continually adjust restrictions on gear length and vessel size. For this and other reasons, industry and AFMA have recently adopted a harvest strategy of explicitly targeting MEY, and are currently developing the transition to an ITQ system.

Economic performance

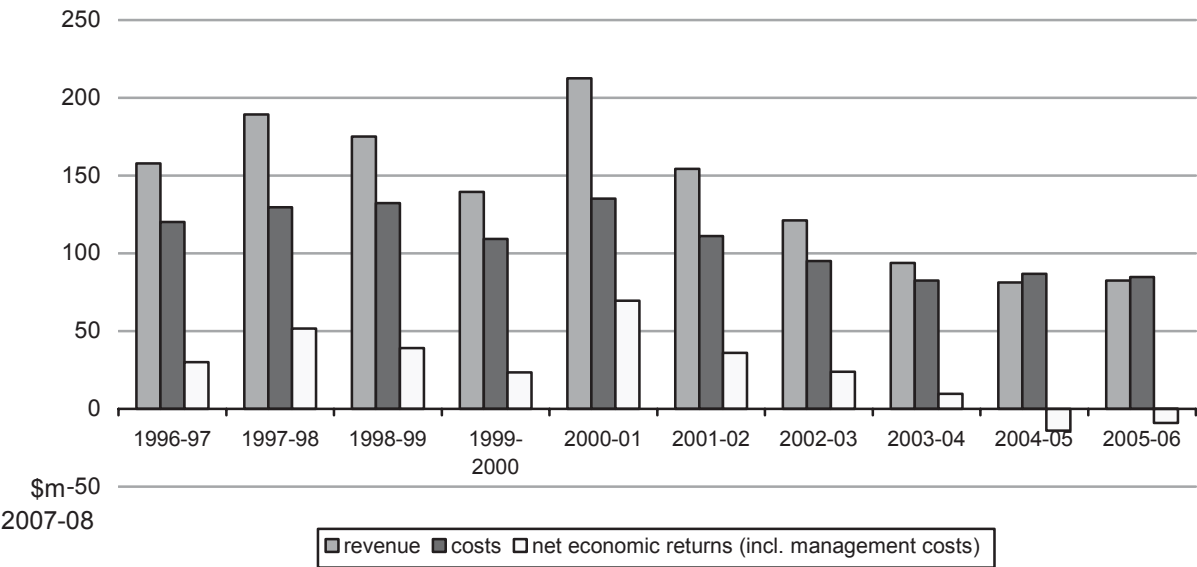
Prior to 2004-05, the northern prawn fishery was one of only a few Commonwealth fisheries that regularly earned positive net economic returns. Net economic returns peaked at USD 69 million in 2000-01 after a number of years of high returns. Following this period, net economic returns were negative in both 2004-05 and 2005-06 (figure 5.5). While in the past decade net economic returns have been high, Rose and Kompas (2004) suggested that some of the returns may have come at the cost of future stocks. It is important to note that in recent years increased fuel prices and lower prawn prices have had a substantial impact, reducing profits in the fishery.

Figure 5.4. Map A. Area of the Northern Prawn Fishery .



Source: Australian Fishery Management Agency 2008. www.afma.gov.au/.

Figure 5.5. Net economic returns northern prawn fishery.



A bioeconomic model of the tiger prawn component of the northern prawn fishery has been developed. The bioeconomic model is updated regularly to feed into NORMAC decisions. The 2006 assessment which included updated fishing cost data as well as the

2006 tiger prawn biological assessment indicated that the fishery's current economic yield is 74 % of its maximum potential economic yield. Estimates of the optimal number of vessels are also provided by the model and the current optimal number of boats is estimated to be around 45 (compared to around 85 boats operating in the fishery in 2005).

Fishing concession buyback

The northern prawn fishery was a target fishery in the *Securing our Fishing Future* adjustment package. In total 43 class B SFRs and 18 365 gear SFRs were purchased from the fishery, representing a 45% and 34% reduction of the pre-buyback number of permits respectively. Given that latency is generally low in the fishery, this will mean a significant reduction in effort in the fishery initially. However, an increase in efficiency of those remaining in the industry may peg back some of the effort reduction over time.

Future management arrangements

The input control system used in the northern prawn fishery has been recognised as problematic and constraining economic returns from the fishery (Rose and Kompas 2004). As a condition of being a 'target' fishery in the buyback, it was agreed between industry and the Government that the northern prawn fishery would move to implement a management system based on output controls. NORMAC advises AFMA on management issues in the northern prawn fishery and reports that industry is aiming to have the fishery managed by ITQs (at least for some species) in the near future. A cost benefit analysis of management scenarios in the fishery is currently underway. The analysis will help determine a preferred management option that would optimise net economic returns to the Australian community from the fishery, cost-effective management of the fishery and contribute to the ecologically sustainable development of the fishery.

Southern and eastern scalefish and shark fishery

The southern and eastern scalefish and shark (SESS) fishery was created in 2003 through the merger of four fisheries. Each of the former fisheries remains as a sector of the new fishery. They are:

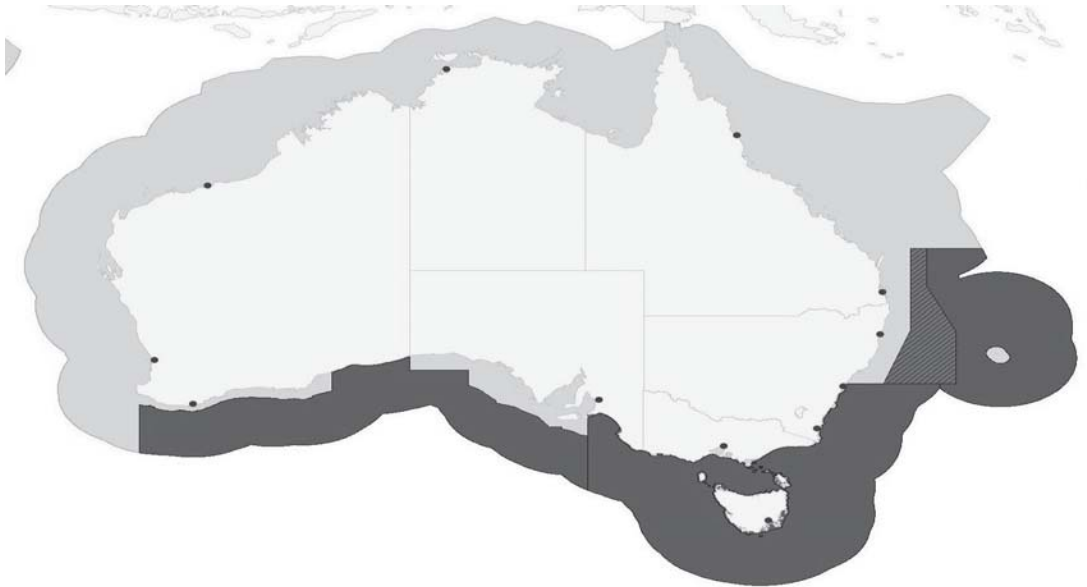
- Commonwealth trawl sector (previously the south east trawl fishery)
- Great Australian Bight trawl (GAB) sector
- east coast deepwater trawl (ECDWT) sector
- gillnet, hook and trap (GHT) sector.

The fishery covers almost half of the AFZ, from Sandy Cape in Queensland southward to Cape Leeuwin in Western Australia, and includes waters around Tasmania (Map 5.6.B). Each sector has a management area within the boundaries of the fishery.

The fishery is managed principally by output controls under the *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003*. Total allowable catches (TACs) are set for 34 species groups. In most cases these are allocated to fishers as statutory fishing rights in the form of individual transferable quotas (ITQs). Despite being the Commonwealth's most valuable fishery, management historically has not been optimal

from an economic or biological point of view, with many species being overfished and catches well below TACs (Hohnen *et al.* 2008).

Figure 5.6. Map B. Southern and eastern scalefish and shark fishery.



Economic performance

Net economic returns in the Commonwealth trawl sector are very low given the size of the sector. The highest estimate for the past ten years is USD 5.9 million (in 2007-08 dollars), recorded in 1997-98 (figure 5.7). Net economic returns were negative between 2002-03 and 2004-05.

Relative to the trawl sector, the gillnet, hook and trap sector has generally been profitable. Since 1998-99, net economic returns have averaged USD 1.3 million in real terms (2007-08 dollars) (Figure 5.8).

There has been significant latent effort in the southern and eastern scalefish and shark fishery. FERM (2004) reports that soon after their introduction, TACs and catch for many species had increased by nearly 50 %. Prior to 2004, fishing effort in the Commonwealth trawl sector, measured in hours trawled, was increasing over time (figure 5.9). Following the introduction of ITQs in 1992, the number of hours trawled in the sector increased from 58 000 to 117 000 in 2004. At the same time, both the volume and value of catch declined. As a result, catch — in both weight and value terms — per hour trawled declined. Since 2004 however, total trawl hours in the fishery have declined substantially and in 2007 were at the same level as in 1992 at approximately 58 000 hours.

Figure 5.7. Boat cash profit and net economic returns total for Commonwealth trawl sector, USD 2007-08.

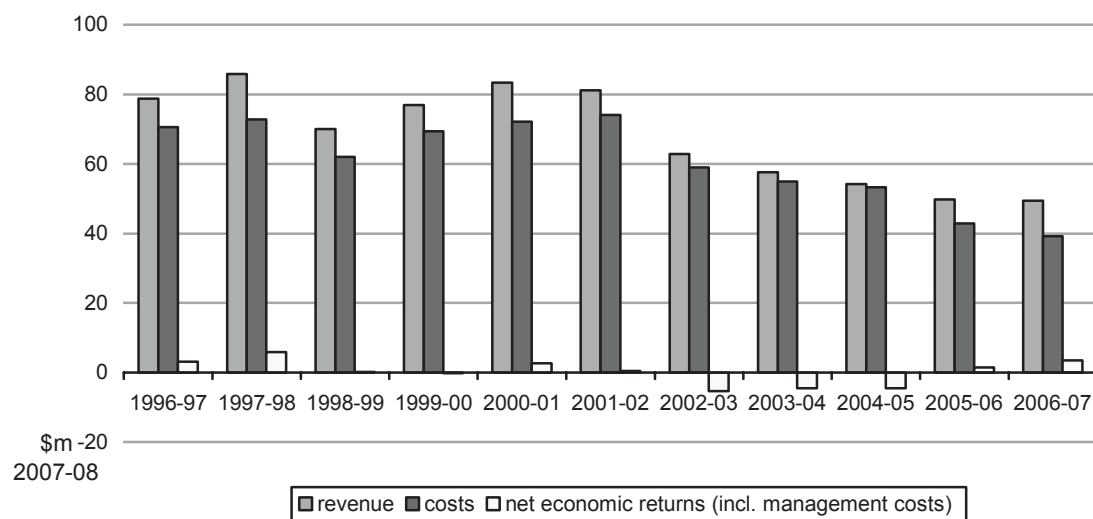


Figure 5.8. Boat cash profit and net economic returns total for gillnet hook and trap sector, USD 2007-08.

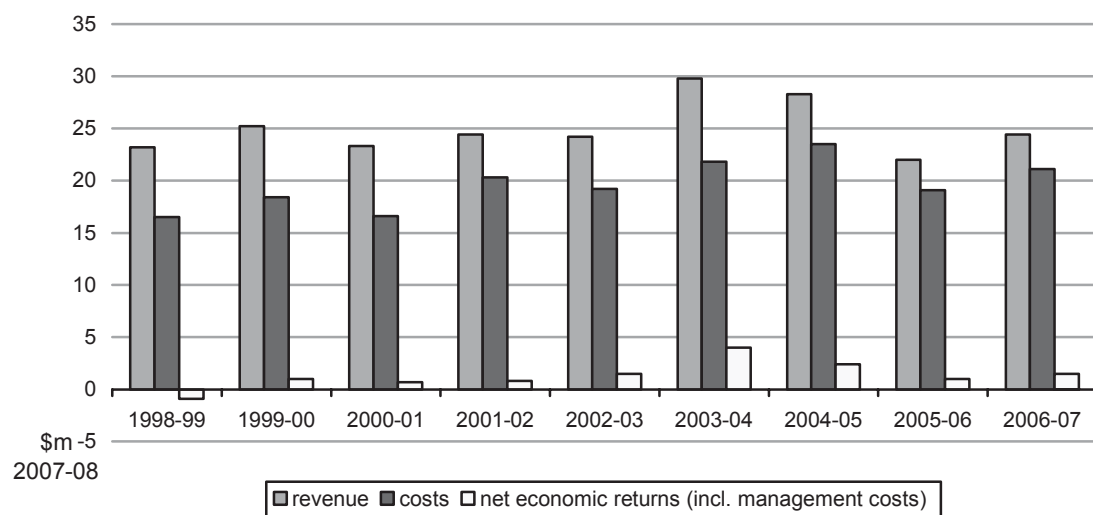
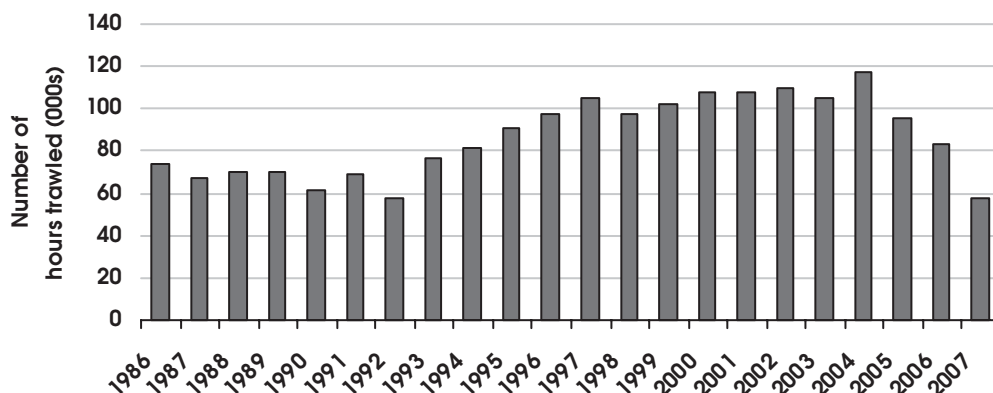


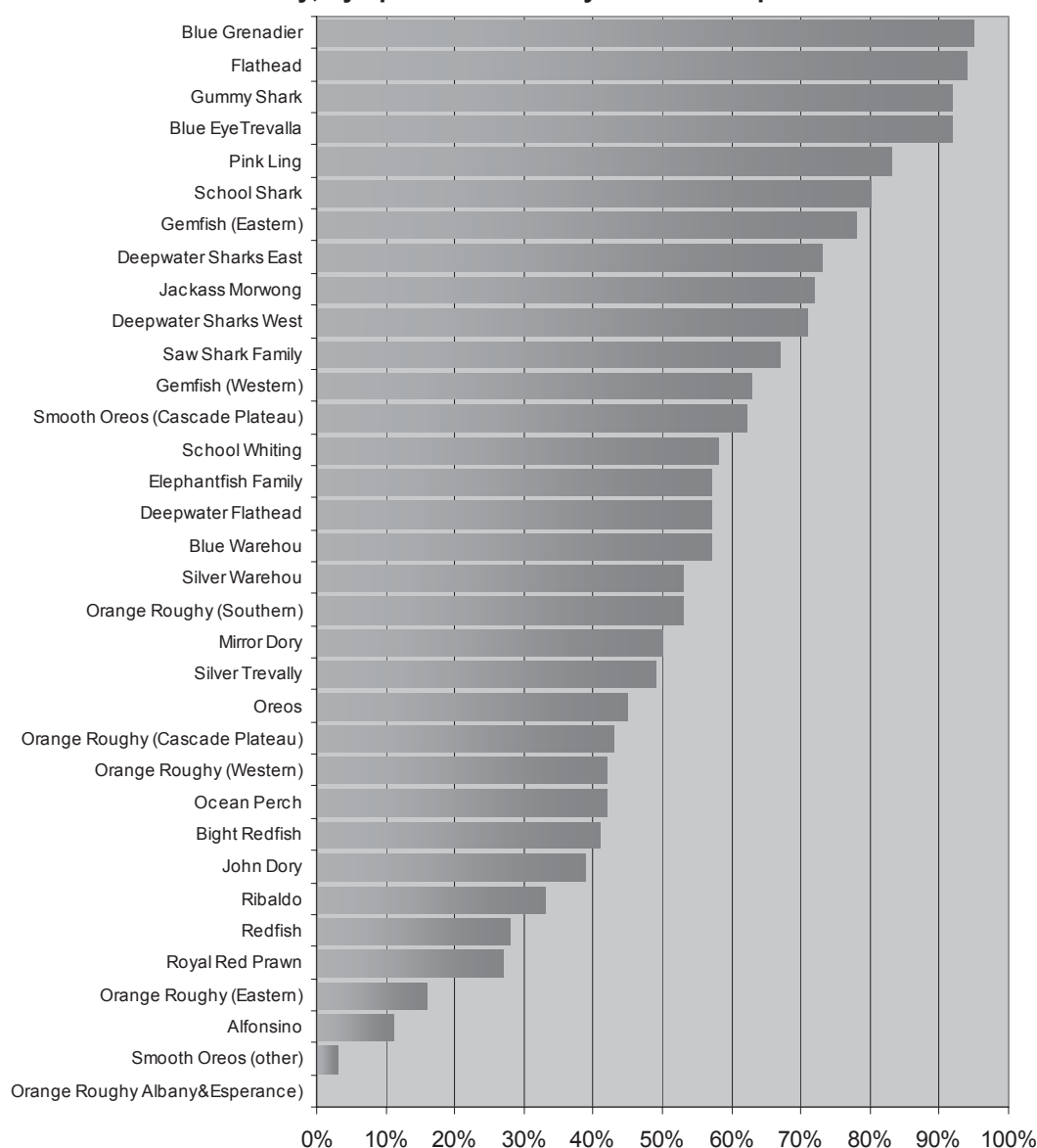
Figure 5.9. Number of hours trawled in the Commonwealth trawl sector.

While it is not expected that all quotas bind every season in a multi-species fishery, no species' quota was met in 2007, and only four species had 95% or more of the available quota used. Overall, almost a third of available TAC remained uncaught in 2007. Of more concern is that the TACs for many species that are classified as overfished or uncertain were not close to being filled (figure 5.10). For example, in 2007, 28% of available redfish quota, 49% of silver trevally quota, and 45 % of oreo quota were caught. Effort in the fishery will gravitate to the open access equilibrium when TACs are set too high (and hence are nonbinding).

Nonbinding TACs also affect the rate of autonomous adjustment in the fishery. Autonomous adjustment is the process of effort gravitating to the most efficient operators. One reason that it has not been observed on a large scale in the fishery is that controls on catch are rarely binding. This makes the quota price for many species relatively low and unlikely to offset the transaction costs of trading. Another hurdle to autonomous adjustment is that the market value of many vessels in the fishery is probably very low, so operators have an incentive to continue fishing until their vessel is due for a major overhaul.

As described in Box 5.2, Kompas *et al.* (2006) report preliminary results from a bioeconomic model for the Commonwealth trawl sector. The bioeconomic model provides estimates of steady state MEY harvests and optimal initial harvests to allow for stocks to rebuild while maximising long term profits. In all cases the model indicates that TACs need to be reduced from 2004 catch levels to maximise net economic returns. In some cases the necessary reductions in catch are large [almost 60 % for orange roughy (Cascade Plateau)] but for others the reductions are relatively small (only 7% for flathead). The benefits of restricting catches now are realised in the future when for almost all species a TAC could be set that results in larger catches than were being made in 2004. For example, implementing a TAC of 2980 tonnes now for flathead allows a TAC of 3850 tonnes to be set in the future when the stock has recovered to a long run equilibrium biomass.

Figure 5.10. Catch as a percentage of average TAC in the Southern and Eastern scalefish and shark fishery, by species: 1 January 2007 to 30 April 2008 .



Species Smooth oreo, Smooth oreo cascade and Oreo include Spikey, Warty, Black and Rough Oreo

Source: AFMA (2008c).

Fishing concession buyback

The southern and eastern scalefish and shark fishery was a target fishery for the *Securing our Fishing Future* structural adjustment package. Various permits and boat SFRs were purchased, as well as some quota SFRs (Table 5.3). Given the magnitude of the reduction in permits, the operating environment of the fishery is likely to be different in future. In addition, many of the TACs were reduced for the 2007 and 2008 fishing seasons which is likely to restrict catches of key species to a greater degree. For these reasons the southern and eastern scalefish and shark fishery is likely to be more profitable

in the future relative to previous years. While some time lag would normally be expected for higher profits to eventuate from these changes (due to the time taken for stocks to rebuild so that the cost per unit of catch falls), ABARE's most recent survey results suggest that profits have already improved in the Commonwealth trawl sector and remain positive in the gillnet, hook and trap sector. However, no work has been undertaken to assess the cause of this improvement.

Table 5.3. Endorsements surrendered under concession buyback southern and eastern scalefish and shark fishery.

Type of concession	Number of concessions in fishery prior to buyback	Total number of concessions purchased (Rounds 1 and 2)	% reduction
Gillnet Boat SFR	88	26	30
Scalefish Hook Boat SFR	122	63	52
Shark Hook Boat SFR	30	17	57
Trawl Boat SFR	118	59	50
Trap Permit / Auto Longline Permit	20	8	40
East Coast Deepwater Permit	18	8	44
SA Coastal Waters Permit	41	17	41
Tasmanian Coastal Waters Permit	82	38	46
Victorian Coastal Waters Permit	51	28	55
Redfish Quota SFR	586 720	112 822	19
John Dory Quota SFR	235 784	30 889	13
Silver Trevally Quota SFR	538 740	74 912	14
Jackass Morwong Quota SFR	1 480 633	114 872	8
Royal Red Prawn Quota SFR	485 394	103 296	21

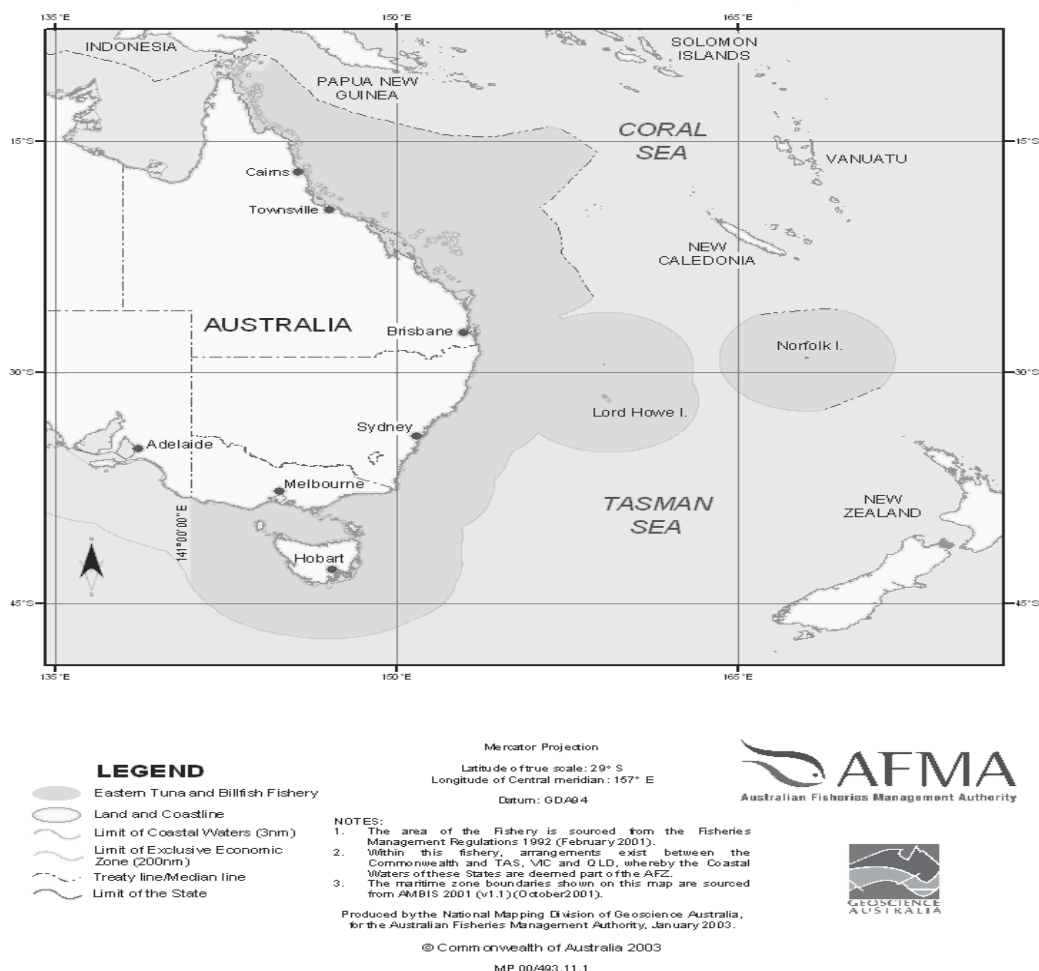
Source: Abetz (2006).

Eastern tuna and billfish fishery

The eastern tuna and billfish fishery is a complex fishery system involving multiple species and fishing methods. There is also a significant recreational sector targeting the same stocks. The commercial fishery includes longline and minor line fishing methods, and the non-longline sector, which uses purse seine and pole fishing methods.

The ETBF extends along Australia's entire eastern seaboard from the tip of Cape York to the southernmost point of the Australian Fishing Zones. It includes Commonwealth waters off Queensland, New South Wales, Victoria and Tasmania out to the 200 nautical mile limit of the Australian Fishing Zone, and also includes waters around Norfolk Island (Map C). The fishery has been commercially exploited since the early 1950s when the Japanese began pelagic longlining off the east coast of Australia. Major ports used by the fleet include Cairns, Mooloolaba, Coffs Harbour and Hobart (AFMA 2008b). In 2006-07 the gross value of production of the entire fishery was around USD 32 million, of which the longline sector accounted for over 99 % (ABARE 2008).

Figure 5.11. Map C. Map of the eastern tuna and billfish fishery.



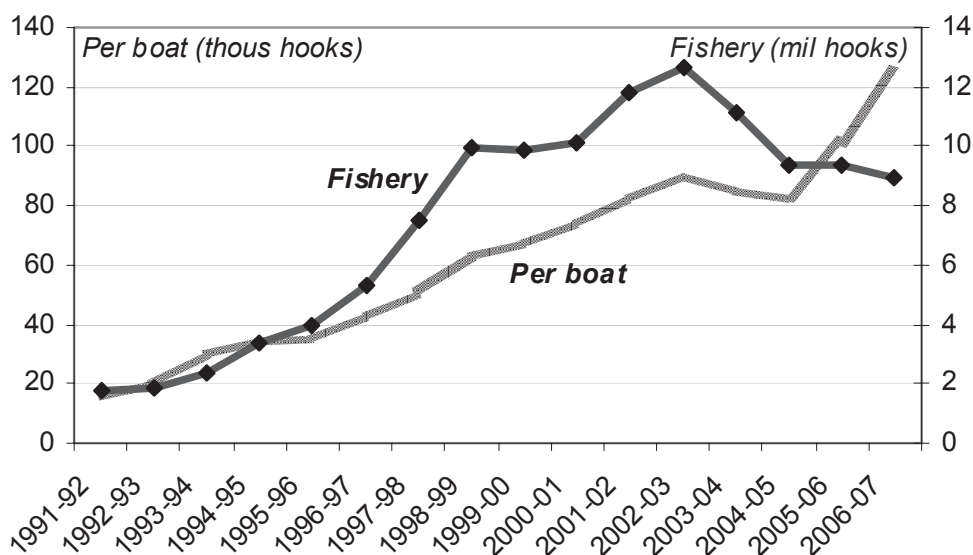
Commercial fishing for major tuna and billfish species in the ETBF is regulated by the Commonwealth government through the *Eastern Tuna and Billfish Fishery Management Plan 2005*, which was adopted in October 2005. Under the plan, annual fishing permits are to be replaced by statutory fishing rights (SFRs) (AFMA 2005). Longline SFRs will restrict the number of branchline clips (hooks) available to operators using longline methods on a yearly basis and minor line SFRs will define the maximum number of lines that may be used at any one time by minor line operators. Operators in both sectors will also need an additional permit to operate in the Coral Sea Zone, formerly referred to as Zone E. All other management zones in the fishery have been removed under the new management plan.

Until SFRs are granted, the fishery continues to be managed by annual fishing permits (through transitional arrangements under the Management Plan). Species specific arrangements are also in place for operators targeting southern bluefin tuna, broadbill swordfish and albacore (Kompas *et al.* 2009).

During the 1990s the ETBF expanded rapidly, particularly in northern Queensland waters where catch rates of yellowfin and bigeye were high. In late 1997, many longliners began to fish out of southern Queensland ports, such as Mooloolaba, to target both bigeye tuna for sashimi markets and swordfish for markets in the United States (AFMA 2004).

Effort in the ETBF increased steadily throughout the 1990s before peaking at 12.7 million hooks in 2002-03. Since then effort has decreased significantly to 8.9 million hooks in 2006-07 (figure 5.12). The number of active vessels had also decreased from roughly 143 in 2001-02 to 113 vessels in 2004-05 and 71 vessels in 2006-07 (Kompas *et al.* 2009).

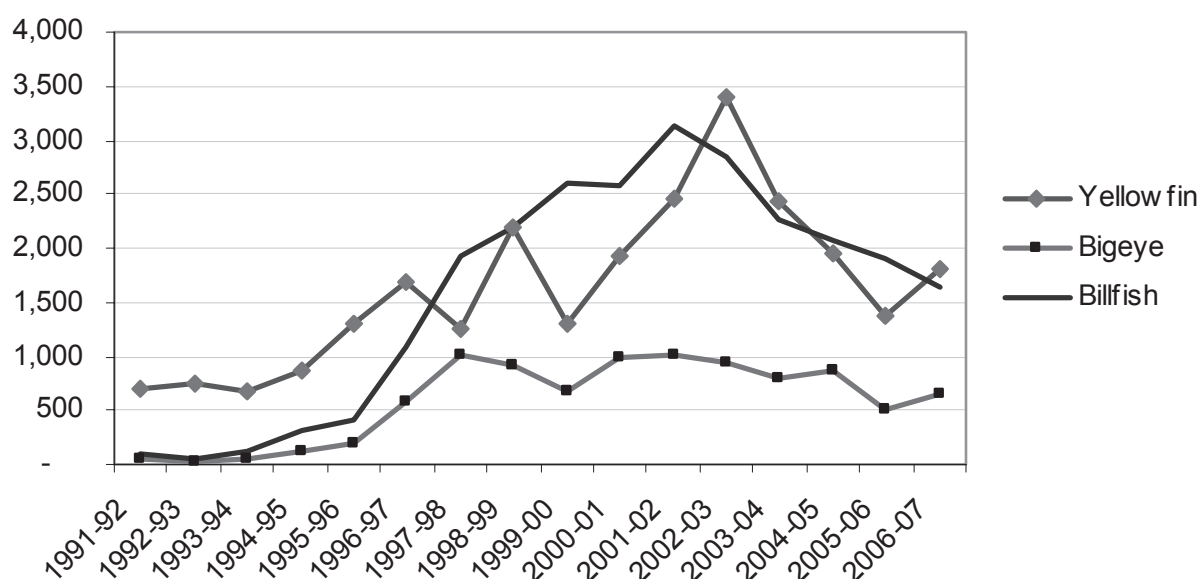
Figure 5.12. Effort of the fishery, 1992-2007.



Source: Australian Fisheries Management Authority (2008a).

In contrast, average effort per vessel has increased sharply (figure 5.13) from 90 thousand hooks in 2001-02 to 101 thousand hooks in 2005-06 and 125 thousand hooks in 2006-07. The number of hooks per set has also increased, from around 900 hooks per set during in 1998-99 to 2001-02 to around 1 200 hooks in 2006-07 (Kompas *et al.* 2009).

Catches of yellowfin, bigeye and broadbill swordfish are shown in figure 5.3. Swordfish catches grew strongly until 2001-02 when they peaked at 3129 tonnes before falling to 1633 tonnes in 2006-07. Similarly, catches of yellowfin peaked at 3394 tonnes in 2002-03, and fell to 1385 tonnes in 2005-06, before recovering slightly to 1800 tonnes in 2006-07. In contrast, catches of albacore have increased from 632 tonnes in 2004-05 to 2814 tonnes in 2006-07 (ABARE 2008).

Figure 5.13. Harvest (longline and minor line) by major species, 1991-92 to 2006-07 (tonnes) .

Source: ABARE 2008a.

Economic performance

There is substantial evidence that the eastern tuna and billfish fishery has been operating as an unmanaged, open access fishery despite it being a controlled fishery (Hohnen *et al.* 2008). In particular, there has been a substantial degree of latent effort in the fishery.

Over the period 1994-95 to 2006-07, a positive net economic return was estimated on only 3 occasions (figure 5.14). While revenues increased throughout the 1990s, this was almost always accompanied by proportional increases in costs, leaving the net return of the fishery largely unchanged. Fishers targeting swordfish off Mooloolaba (Queensland) in the late 1990s led to modest net returns being generated, but these had been dissipated by 2001-02 as interest in this species increased. Since then, substantial net economic losses have been made in the fishery.

In addition to excess levels of effort in the fishery, swordfish catches and catch per unit of effort have declined substantially in recent years. These declines are a concern to both fishers and managers and have raised doubts as to whether current catches are sustainable. Kompas *et al.* (2009) have estimated that swordfish stock depletion has reduced average catch per boat by around 15 % a year and profit by about 14 % a year. Swordfish stock depletion is estimated to have reduced net income across the fishery by 5.1 million USD a year, on average (figure 5.15).

Figure 5.14. Boat cash profit and net economic returns total for fishery, USD 2007-08 .

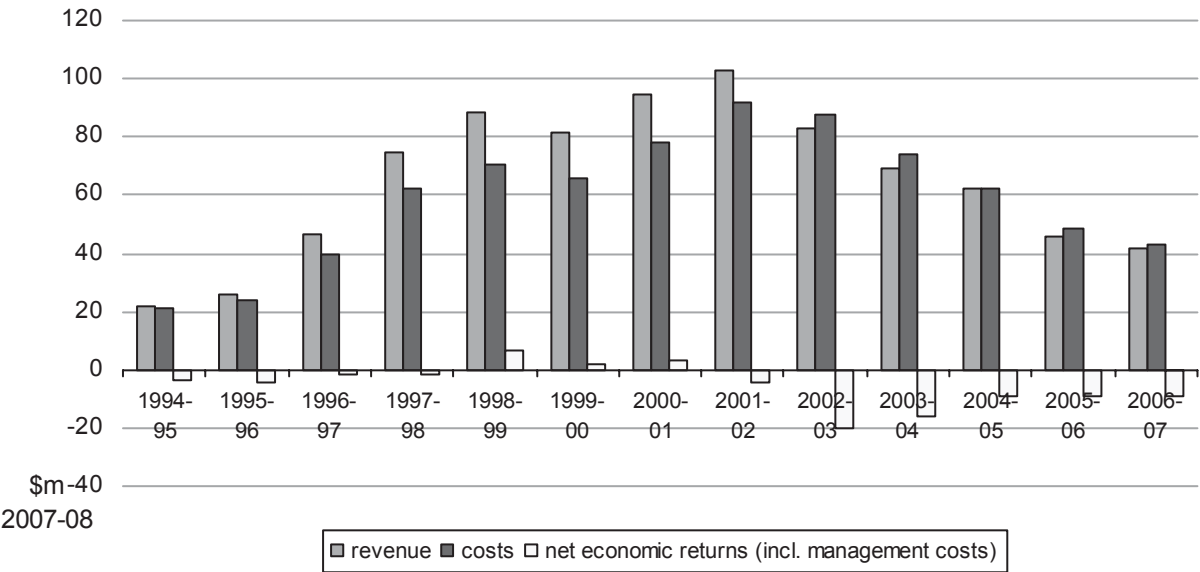
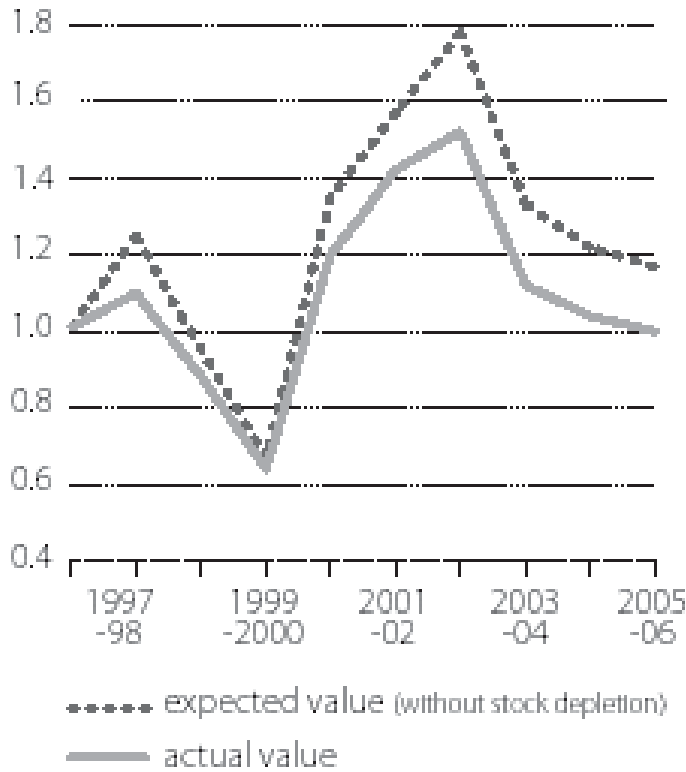


Figure 5.15. Impacts of swordfish depletion on average income index per vessel.



Fishing concession buyback

The fishery was classified as a target fishery for the purposes of the Securing our Fishing Future business exit assistance package. The buyback resulted in 99 longline permits and 112 minor line permits being surrendered from the ETBF (Abetz 2006). Following the buyback there were 119 longline permits and 118 minor line permits remaining in the fishery.

The 2006 Ministerial Direction requires that AFMA implement output controls in the form of individual transferable quotas (ITQs) in all Commonwealth fisheries by 2010 unless there are significant impediments to their introduction in specific fisheries. AFMA subsequently commissioned a report to examine the feasibility of ITQs in the ETBF. Discussions are currently underway on the possible implementation of a quota system in the ETBF.

Conclusion

The release of the Ministerial Direction in 2005 and the concurrent establishment of the *Securing Our Fishing Future* package have changed the structure of Australia's Commonwealth fisheries and have led to significant opportunities for stock rebuilding. Following the completion of the buyback significant effort has been removed from affected fisheries. In addition, the release of the *Harvest Strategy Policy* in September 2007 has provided the Australian Fisheries Management Authority with the framework to establish rules based management regimes that are effective from both a biological and economic perspective. Having predefined rules, whether through limit reference points or trigger points, has improved transparency in management and given fishers improved certainty over their fishing activity. In addition, these rules help protect fish stocks from over exploitation.

Under the *Harvest Strategy Policy*, strategies are required to first rebuild stocks and then pursue the achievement of maximum economic yield, and where this is not formally calculated, to be framed in a way that enhances economic efficiency in the fishery. Modelling results indicate significant benefits associated with the move to MEY in the northern prawn fishery and southern and eastern scalefish and shark fishery. In addition, analysis of the impact of swordfish stock depletion in the eastern tuna and billfish Fishery indicate that the benefits of stock rebuilding can be substantial.

Anecdotal evidence suggests that the change in fleet structure arising from the Securing Our Fishing Future package has already provided some benefits. Monitoring of the program that is currently in place will enable the assessment of the longer term benefits. Importantly, changes to management have occurred in conjunction with restructuring policy. It is also important to ensure that the move toward the implementation of ITQs in the northern prawn fishery and the eastern tuna and billfish fishery is sustained, to ensure that the benefits achieved by the package are not dissipated through effort creep.

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Chapter 6.

Managing the transition:

Distributional issues of fish stock rebuilding

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Abstract

Rebuilding overfished fish stocks is a challenging task with which governments have had mixed success. The time between “overfished” to “rebuilt” is a transition period managed by a rebuilding plan whose effectiveness is strongly influenced by distributional issues. Stock rebuilding is a targeted biological objective, but the process of rebuilding is an economic one that embodies allocation and distribution. Just as distributional issues influence the policy choices that lead to overfishing, they also shape the strategies employed to rebuild overfished stocks. Distributional issues are embedded in the management context, history, structures and processes of a fishery and through these, influence the identification and implementation of a rebuilding strategy.

This chapter provides an overview of distributional issues in fisheries and examines the role they play in the stock rebuilding strategies of three U.S. fisheries. It first reviews the economic case for rebuilding, describes the U.S. legal requirements to rebuild overfished fisheries, and provides a brief summary of U.S. rebuilding progress. Next, it discusses the economic context for stock rebuilding, focusing on the incentive properties of the transition that affect distributional outcomes. Incentives shape and are shaped by competition, transactions costs, uncertainty and expectations. These are in turn influenced by the path of management history, management structure, the intervention point, and stakeholder involvement. The chapter uses three case-study fisheries to examine how distributional factors influence the strategy taken to stock rebuilding: Bering Sea snow crab; Pacific canary rockfish; and Gulf of Maine cod. These fisheries represent different management regions, scales and styles of operation. For each fishery it describes the management plan, management approach, rebuilding history, rebuilding strategy, stakeholder involvement, distributional issues identified by fishery stakeholders, and complementary fishery management actions. It draws conclusions about the influence of distributional factors on the choice and success of the rebuilding strategy. It identifies insights offered by the three case studies on the interplay among incentives, distribution, and stock rebuilding.

Introduction

The cliché that fishery management is about managing people not fish contains central truths that are well illustrated by the challenge of rebuilding overfished stocks. Successful rebuilding is a process of engaging people in a productive way to limit the distributional impacts of rebuilding. This is a challenging task with which governments have had mixed success. There have been both high-profile successes and notable failures in designing and implementing stock rebuilding programs. Caddy and Agnew (2003) report that most of the small number of recoveries has occurred in the U.S. under the jurisdiction of the Magnuson-Stevens Fishery Conservation and Management Act.

The approach to stock rebuilding problems is often to focus on strengthening modeling approaches or regulatory controls (cf. Wiedenmann and Mangel, 2005). These are technical approaches targeted at a biological endpoint. However, the root causes of rebuilding problems are more distributional than technical. The clearest cause of rebuilding failure is management's inability to reduce exploitation enough to end overfishing (Rosenberg *et al.*, 2006). In managing exploitation, rebuilding becomes an economic process defined by a distribution of costs and benefits.

Fish stocks are capital assets with stock and flow values. Structuring incentives to encourage the long-term protection of asset value is fishery management's most important and challenging task. Fishery management has over time been quite successful in designing incentives to capture the flow of goods and services from fish populations, but far less successful designing incentives to sustain their stocks (Hanna, 2006). Since future expected benefits from any resource have less value to users and managers than do known current benefits, the future is naturally discounted relative to the present. Rates of fishery exploitation have in some cases reflected a high level of discounting of future flow values and a preference for short-term utilization of the stock. In contrast, stock rebuilding requires adopting a planning horizon far longer than the one that led to overfishing. It also requires the remedial reduction of exploitation to rates even lower than those previously appropriate for sustaining stock size. We invest in rebuilding the stock value of fishery assets because we recognize the long-term biological and economic benefit of doing so. In the U.S., this recognition is now reflected in law. But even with a legal requirement to rebuild the key question remains how we manage the transition from "overfished" to "rebuilt." What are the distributional components of rebuilding? How do they shape the strategies to rebuild?

Caddy and Agnew (2003) note that experience with stock rebuilding indicates that success depends heavily on the management and socio-economic contexts. Despite agreement that rebuilding is a worthwhile goal, there are still different perspectives over the distribution of benefits and costs on the way to achieving this goal. Who bears the costs and who reaps the benefits of rebuilding?

Distributional effects are both a cause and a consequence of fish stock rebuilding strategies. Distributional issues play a central role in determining the type of management strategy that is adopted and implemented (Cunningham, 1994) and that often leads to overfishing. The rational shortsightedness of people who face high levels of uncertainty and hold insecure claims over the resource, and the decoupling of benefits from costs both operate in the "political marketplace" to favor certain types of fishery outcomes and disfavor others (Sutinen and Upton, 2000). Under these conditions long-term policies like stock rebuilding are disfavored by industry because they concentrate costs in the short to

medium term in exchange for an expectation of long-term gain that may be challenged by uncertainties in markets and environmental factors (Pascoe and Burnett, 2007).

Similarly, distributional issues influence the strategies employed to rebuild overfished stocks. Distributional issues are embedded in the management context, history, structures and processes, and through these, influence the identification and implementation of rebuilding strategies or even people's willingness to engage in rebuilding.

Distributional issues are reflected in many different spheres. They exist between sectors within a single fishery, for example commercial and recreational, gear types or functional groups such as harvesters, processors and communities. They exist in space between geographic subsectors such as fishing areas, ports and regions. They exist across time between present and future fishery interests. Management typically addresses distribution among industry sectors and functional groups. Strategies to rebuild overfished stocks expand the consideration of distributional effects beyond its traditional scope. Rebuilding affects a broader set of stakeholder than industry, and includes seafood consumers, the interested public, elected officials, environmental organizations and the research community.

This chapter provides an overview of the distributional issues surrounding stock rebuilding in fisheries. It examines the role of distribution in the stock rebuilding strategies employed in three U.S. fisheries: Gulf of Maine cod, managed through the New England Fishery Management Council; canary rockfish, managed through the Pacific Fishery Management Council; and Bering Sea snow crab, managed through the North Pacific Fishery Management Council. On the basis of the three case study fisheries the chapter reaches some conclusions about the interaction among incentives, distribution, and stock rebuilding.

The economic case and legal requirements for rebuilding

The economic case for rebuilding

There is general agreement that many fisheries as currently managed are achieving only a portion of their potential value, and about the need for and benefits from rebuilt stocks. The underlying economic problem is the failure to fully appreciate the wealth-producing potential of fisheries as public assets and to manage for long-term asset value.

The most recent FAO report indicates that for those stocks for which information is available the proportions of overexploited, depleted and recovering stocks have remained relatively stable in the last 10–15 years, following an earlier period of increases. In 2007 FAO estimated that of the stock groups they monitored, 2% were underexploited and 18% were moderately exploited. Slightly more than half of the stocks (52%) were fully exploited, with no room for further expansion. The remaining 28% were producing less than their maximum potential because they were overexploited (19%), depleted (8%) or recovering from depletion (1%) with an increased risk of further declines and a need for rebuilding (FAO, 2009).

Overexploitation and depletion of stocks violates the conservation principles of the 1982 UN Convention on the Law of the Sea and the 1995 FAO Code of Conduct for Responsible Fisheries. These agreements reflect the international consensus that overfishing diminishes ecosystem productivity, food security, economic prosperity, and social welfare. The Plan of Implementation of the World Summit on Sustainable

Development notes that a requirement of sustainable fisheries is that stocks be maintained or restored “to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015” (Garcia *et al.*, 2003).

Worldwide, the recent “rent drain” study by the World Bank and FAO (World Bank, 2009) estimates the difference between the potential and actual net economic benefits from marine fisheries is in the order of USD 50 billion per year. This estimated economic loss to the global economy from marine fisheries is partly attributable to lost biological productivity from overfished stocks and partly attributable to fisheries subsidies. The study authors argue that a focus on the declining biological health of the world’s fisheries has obscured issues of economic health of the fisheries which are fundamental to achieving fish stock rebuilding as well as other fishery objectives.

Sumaila and Suatoni (2006) estimated the net present value of 17 overfished stocks in the US and the net present value of those same stocks after rebuilding. They compared the direct use value of those fish stocks by the commercial and recreational sectors. The total estimated net present direct-use value of the 17 stocks before rebuilding is USD 197M, compared to a NPV of USD 567M for rebuilt stocks, a factor of almost 3. Because the estimation was conducted on a portion of the 76 overfished stocks in 2003, it represents a fraction of the potential increases in value from rebuilding all overfished stocks.

U.S. legal requirements for rebuilding

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) provides the statutory authority for fisheries management in the U.S. Exclusive Economic Zone (EEZ). The Act includes ten national standards for fishery conservation and management with which fishery management plans must comply. It also requires that the Secretary of Commerce establish advisory guidelines for the implementation of these national standards. National Standard 1 requires that conservation and management measures “shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.”

After a two-decade expansion of U.S. fisheries, concern about overfished stocks led to amendments to US law emphasizing sustainable fisheries and requiring that stocks be maintained at levels of maximum productivity. The 1996 Sustainable Fisheries Act, amending the MSA, contained a number of strong conservation measures, among them the requirements that overfishing be ended and rebuilding plans for overfished stocks be implemented. Ten years later the 2006 Magnuson-Stevens Reauthorization Act (MSRA) introduced even stricter requirements for ending overfishing and rebuilding stocks. The MSRA included new requirements for annual catch limits (ACLs), accountability measures (AMs) and other provisions regarding preventing and ending overfishing and rebuilding fisheries. Overfishing is defined as a fishing mortality rate (F) in excess of the stock’s maximum fishing mortality threshold (MFMT). An overfished stock is at less than a minimum stock size threshold (MSST), the biomass that would support the maximum sustainable yield. A specific rebuilding target is required, as is a rebuilding timeframe of not more than 10 years in most cases. Rebuilding plans are to allow some fishing if possible, but must attempt to minimize bycatch, protect essential fish habitat and improve monitoring (Swasey and Rosenberg, 2006; Department of Commerce, 2009a).

One area of controversy has been the interpretation of the “mixed stock exception” which allows overfishing to occur on stocks within a complex at a level that will not lead to the stock becoming overfished in the long term. These exceptions apply only when the stock is not in an overfished condition, fishing will generate long-term net benefits to the Nation, mitigating measures have been considered, and fishing will not cause a stock or its complex to fall below its MSST more than 50% of the time in the long term (Department of Commerce, 2009a).

U.S. rebuilding progress

The MSRA requires that the National Marine Fisheries Service report annually to Congress and to the regional fishery management councils on the status of U.S. fisheries. The latest report is based on the 2008 review of 531 individual stocks and stock complexes. Of these, 41 are subject to overfishing (16%) and 46 (23%) are overfished. These numbers represent slight positive progress in rebuilding compared to 2007 (NMFS, 2009).

The incentive context of rebuilding

The legal requirement for rebuilding overfished U.S. stocks is clear. The economic benefits to be realized from rebuilt stocks are also obvious. What remains at issue is the distribution of these economic benefits and the distribution of the costs of achieving them. Stock rebuilding presents a classic case of externalities with decoupled benefits and costs. Those who pay the costs of rebuilding are not necessarily those who will reap the benefits. The benefits of stock rebuilding are realized in the long term, while the costs of stock rebuilding accrue in the short term. The costs of rebuilding are both private and public. Private costs are primarily foregone income, while public costs include the transactions costs of analysis, allocation, monitoring and enforcement.

The separation of benefits and costs over time and across interests is an externality that generates distributional effects for the transition to rebuilt stocks. The management question becomes one of managing the transition by containing the magnitude and distribution of costs, while creating some assurance about sharing in the benefits.

Distribution is at the core of fishery policy. Policy creates winners and losers regardless of how resource allocation is accomplished. Distributional considerations underlie management objectives and pertain to benefits, costs and time frames. Distributional issues also shape the path of policy implementation and can hinder its effectiveness if left unaddressed (Hirschman, 1970; Hanna, 1997). In thinking about distributional aspects of fishery rebuilding, it helps to remember the incentive properties of the decision environment in which this transition takes place. These properties embody many elements affecting distributional outcomes. They include the important areas of competition, transactions costs and uncertainty.

Competition

Two forms of competitive behavior are common to the fishery management context: scramble competition and interference competition (Hirshleifer, 1978). In scramble competition each user behaves autonomously to capture resources in a race against other users. The absence of property rights to fisheries promotes this type of competition, illustrated by the classic “race for fish.” Interference competition, in contrast, is based on

strategies that interfere with users' abilities to compete; for example manipulating a management process to create rules that work to one's advantage and others' disadvantage. Increasingly stringent regulatory controls in fisheries have limited the scope for scramble competition but have given rise to more interference competition, as groups attempt to garner political support for favorable management outcomes or derail management processes. The deliberative decision processes of fishery management structure provide opportunities for strategies of interference competition (Hanna, 1999).

Transactions costs

Fisheries inevitably evolve from specialized commodity extraction systems to ecologically linked natural production systems, an evolution that has been characterized as the life cycle of fisheries (Smith, 1986). Management coevolves with the fishery, changing from a rudimentary to a complex system. The reason for the evolution is the effect of scarcity on the transactions costs of gathering information, coordinating users, organizing decision making and enforcing rules (Eggertsson, 1990). In the early stages of a fishery when resources are in surplus the transactions costs of a competitive *laissez-faire* style are low. When resources become scarce, the transactions costs of managing this competition rise, leading, through efforts to reduce those costs, to new management configurations that exert more extensive control.

The importance of transaction costs lies in their potential to shape management strategies toward cost-lowering approaches. Fishery management influences the magnitude type and distribution of transactions costs by structuring how participants are coordinated, information is generated, decisions are made, and monitoring and enforcement take place. The biological scarcity associated requiring rebuilding also influences costs, as management must account for more tradeoffs between direct and indirect uses, between present and future uses, and between user groups. Under these conditions, the rules that govern resource distribution and use become correspondingly more complex and costly. The structure of management influences the distribution of transactions costs, with centralized structures associated with low transaction costs *ex ante* to implementation (fishery description and regulation design), but higher *ex-post* costs for implementation, monitoring and enforcement. A decentralized management structure involving more stakeholders in decision making tends to have higher *ex ante* costs created by coordination and information gathering, and lower *ex post* costs, created by higher levels of compliance. Each distribution of transactions costs will exert stresses on different points of the management system. The magnitude and types of transaction costs will influence the type and design of policy instruments employed (Williamson, 1994; 1996 Eggertsson, 1990; Raakjær Nielsen and Vedsman, 1995; Hanna, 1998; 2002; McCann *et al.*, 2005).

Uncertainty

Uncertainty pervades fishery management and creates a powerful behavioral incentive that directly contradicts the precautionary approach. Uncertainty shortens time horizons and creates incentives on the part of fishing industry and managers to intensify rates of use and avoid investing in the future. Uncertainty is a major reason why implementing long-term rebuilding schedules for overfished stocks is so difficult. It can take the form of fact uncertainty, tenure uncertainty, or procedural uncertainty.

Fact uncertainty results from incomplete knowledge ecological, economic or social systems; their driving variables and binding constraints. The scientific information on which fishery management decisions are based is incomplete, and will always be so. The management charge is to make decisions based on the best scientific information available. The existence of fact uncertainty means that decisions intended to be rational are in fact bounded by limited information. High levels of uncertainty limit the degree to which fishery management can be rationally foresighted, and leaves management actions vulnerable to opportunistic attempts to undermine the validity of the science (Williamson, 1985).

Tenure uncertainty results from lack of security about fishery access, created by poorly specified property rights or abrupt changes in management. Resource managers may experience similar uncertainties about their political tenure. Uncertainty about future claims to the resource underpins the destructive race for fish. Only after the issue of tenure uncertainty is addressed, when claims to future share of resources are protected and free riding minimized, will the race for fish end and an incentive to invest in long-term stock-rebuilding behaviors exist.

Procedural uncertainty can exist when the managers and stakeholders have incomplete information about legal requirements or when decision making power is ambiguous. This kind of uncertainty can prevent the formation of patterns of co-operation. It can preclude the making of credible commitments or credible threats, where what is promised is reliably delivered. It can also lead to questioning and undermining of authorities and encourage patterns of interference competition (Runge, 1984; Williamson, 1985). When fishery management decisions involve long-term endeavors like stock rebuilding, having established patterns of co-operation can improve the effectiveness of development and implementation.

The influence of distribution on rebuilding strategy

Rebuilding plans in U.S. fisheries offer case studies of the role played by distributional issues in stock rebuilding. U.S. federal fisheries are managed through a system of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act in 1976. Council membership includes representatives of commercial and recreational fisheries, non-governmental organizations, state and federal agencies, and treaty Indian tribes. The councils recommend management plans and regulations to the Secretary of Commerce for fisheries 3-200 miles offshore. Fisheries in the eight regions vary widely in their species, history, culture and management approach. Stock rebuilding plans in three of council regions – New England, Pacific, and North Pacific – illustrate the diversity. These rebuilding plans reflect different species characteristics, management cultures and distributional issues.

New England Fishery Management Council: Gulf of Maine cod

The New England Fishery Management Council (NEFMC) is responsible for fisheries off the coasts of Connecticut, Rhode Island, Massachusetts, New Hampshire and Maine.

Management plan

Atlantic cod (*Gadus morhu*) is managed under the Northeast Multispecies Fishery Management Plan (FMP), implemented in 1986. The FMP applies to a complex of 15 groundfish species. Atlantic cod is managed as two stocks: Georges Bank cod and Gulf of Maine cod (NEFMC, 2003). Gulf of Maine cod is one of twelve species managed as “large mesh” species, based on fish size and type of gear used to harvest the fish. Three species are managed under a separate “small mesh” multispecies program.

Management approach

The Northeast Multispecies FMP was implemented to reduce fishing mortality of heavily fished groundfish stocks and to promote rebuilding to sustainable biomass levels. The groundfish complex is managed by seasonal and year-round area closures, gear restrictions and minimum fish size limits. Since 1994 the complex has been managed using direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5, 7, and 13 to the FMP. Trip limits are also in effect for both Gulf of Maine and Georges Bank cod (NEFMC, 2003; Mayo and O’Brien, 2006).

Affected interests

The interests affected by the groundfish rebuilding plans are described in the 1996 Amendment 7 to the FMP. Gulf of Maine cod is caught by a variety of gear types. Large mesh trawling occurs both inshore and in deeper water, catching cod with other associated species. Other Gulf of Maine mixed fisheries that include cod include sink gillnet and shrimp trawling (NEFMC, 1996).

Gulf of Maine cod is part of the larger Northeast groundfish fishery, which is the predominant fishery in the region in terms of landed pounds and number of vessels. The groundfish fishery is diverse in fishing operations, gear types, vessel sizes, business structures and target species. Many vessels fish in multiple fisheries. A significant percentage of participants are seasonal or part-time. The fishery is centered predominantly in Massachusetts, with a large group in Maine (NEFMC, 1996).

The fishing industry almost exclusively comprises small enterprises owned by individuals or families. Much of the processing and distribution of fresh fish is also conducted by small enterprises (Doeringer, Moss & Terkla, 1986). The total number of vessels permitted under the Northeast Multispecies FMP in 1995, just before the implementation of the Amendment 7 rebuilding strategy, was 4,891. Of these, 1,712 were limited access permits and 3,179 were open access permits. The largest number of limited access vessels fell into the <45 ft. category (NEFMC, 1996).

Cod is also caught by recreational fisheries through three principal modes. Fishing from shore and on private or rental boats is predominantly conducted by coastal residents, while slightly more party/charter trips are taken by non-coastal and out of state residents. Between 1990 and 1995, recreational catch of Gulf of Maine cod averaged 20% of the commercial catch, although there is significant variation from year to year (NEFMC, 1996).

New England fishing ports are economically and culturally diverse, with individual identities that are reflected in the ethnic, cultural and philosophical differences that exist among fishermen. Ports are relatively stable in terms of the composition of species landed. Almost all domestic landings of Atlantic groundfish are processed into fresh

fillets and sold into the domestic market. Groundfish processing plants almost always specialize in groundfish production; few process other species and even fewer produce both fresh and frozen product. Almost all groundfish processing plants are located in the major ports of Massachusetts, with a few plants in Rhode Island and Portland, Maine (NEFMC, 1996).

Rebuilding history

GOM cod experienced high levels of fishing mortality and a depleted biomass for many years. The rebuilding history of GOM cod has been fraught with controversy since 1992, when Amendment 4 to the Northeast Multispecies FMP established the first rebuilding target. The approach to rebuilding has evolved through a series of subsequent plan amendments. Amendment 5 (1994) implemented a moratorium on access as well as effort reductions through allocated days at sea (DAS). Effort reductions were intended to eliminate the overfished condition of the principal groundfish stocks (cod, haddock, and yellowtail flounder) and to strengthening rebuilding by reducing fishing mortality by 50% (Wang and Rosenberg, 1997).

Amendment 7 (1996) revised overfishing definitions, extended time and area closures, set target TACs for species, established a multispecies monitoring committee and increased fishing effort reduction goals, but did not specify a time schedule for rebuilding. Amendment 9 (1998) further revised the overfishing and rebuilding definitions to comply with the reauthorized Magnuson-Stevens Fishery Conservation and Management Act. Amendment 9 established initial biomass rebuilding targets and defined control rules specifying target fishing mortality rates and a rebuilding time horizon of ten years. Management controls to reduce GOM cod harvest included a reduction in allowable days at sea (DAS), incentives to increase mesh size, and seasonal spawning closures. The target fishing mortality rates were intended to reduce catch of GOM cod by 23% (NEFMC, 1998a; 1998b; Wang and Rosenberg, 1997; Mayo and O'Brian, 2006; Swasey and Rosenberg, 2006; Brodziak *et al.*, 2008).

In 2001 the NEFMC was found by the courts to be out of compliance with rebuilding requirements. This litigation led to revised biomass and fishing mortality targets derived by a working group at the Northeast Fisheries Science Center. These targets formed the basis of Amendment 13 (2004), which established individual rebuilding plans for each stock, with specified time periods for GOM cod and other groundfish species. It also included area management and sector allocation alternatives. The goal of the rebuilding plan was to allow stocks to ultimately rebuild to target biomass levels. (NMFS NEFSC, 2002; NEFMC, 2003; Mayo and O'Brian, 2006; Swasey and Rosenberg, 2006).

The 10-year rebuilding plan for the GOM cod stock has a target completion date of 2014. The plan was implemented using a suite of regulations, including minimum mesh size, gear limits, trip limits, recreational bag limits and seasonal spawning closures (NMFS NEFMC, 2003; Swasey and Rosenberg, 2006). Reducing fishing mortality to desired levels has been problematic. The 2007 fishing mortality was higher than the fishing mortality estimated to ensure recovery to BMSY by the end of the rebuilding period (NMFS NEFSC 2008). Nevertheless, GOM cod stock status improved between 2004 and 2007. It is still experiencing overfishing but is no longer overfished (NMFS NEFSC 2008).

The rebuilding plan for Gulf of Maine cod continues to be contested. The 2006 implementation of Framework 42 (FW42), designed as an interim bridge measure to

further reduce fishing mortality until the implementation of Amendment 16 to the FMP in 2010, generated a great deal of controversy. Objections to the effort reduction measures contained in FW42 led to litigation and an eventual modification of the rules (NOAA, 2009).

In 2006, the Commonwealth of Massachusetts and the State of New Hampshire filed a legal challenge of FW42 and requested that it be vacated. The plaintiffs alleged that the NMFS did not adequately consider the applicability of the mixed-stock exception and that the reductions in DAS were overly strict. The Court temporarily suspended FW42 and required NMFS to perform a review of the mixed stock exception. In April 2009 the Court found that NMFS had appropriately analysed the mixed-stock exception and, in light of the development of an interim rule containing new management measures and replacing FW42, found the earlier action to be moot (U.S. District Court, 2009).

Distributional issues

Public comments made during development of Amendment 7 and the first rebuilding targets illustrate the many distributional issues involved in the rebuilding of Gulf of Maine cod. Amendment 7 identifies three main areas of controversy: inadequate fishery data, the lack of an ecosystems perspective, and the magnitude of impacts of effort displacement. Data inadequacy was cited as generating the greatest controversy (NEFMC, 1996).

A standard "Notice of Intent to Prepare a Supplemental Environmental Impact Statement for Amendment 7" formally initiated a scoping process to identify the significant issues related to the proposed amendment affecting the human environment. During this process the Council received public comment identifying issues for consideration. These issues were used to develop management alternatives and were factored into the Council's choice of alternative to submit as a plan amendment (NEFMC, 1996).

Based on public comment the Council defined 10 distributional issues that needed to be resolved or mitigated. The Amendment 7 document notes the Council's awareness of the allocation impacts of its decisions and its intent to seeking additional public input on the future allocation of available resources (NEFMC, 1996).

- effort displacement: competition among user groups for available resources or bottom, especially between "traditional" users and new, displaced vessels; gear conflicts arising from a greatly increased level and variety of fishing activity in a reduced area; habitat impacts of greatly increased fishing activity in open areas;
- lack of control over Canadian catch;
- potential for unrestrained recreational catch to impede rebuilding;
- impact of predator species;
- high marginal cost of approaching zero mortality levels through restrictions on "bycatch fisheries;"
- socio-economic impact of severely restricting small-scale fisheries or those with selective gear;

- ability to monitor stock status and rebuilding progress under a zero or near-zero mortality scenario;
- ability to administer and enforce regulations under industry conditions of desperation and conflict;
- restriction of public access to the resource for recreational use;
- need for effort consolidation for financial survival.

Restructuring actions

Amendment 5 contained the beginning of access limitation for the groundfish fisheries by placing a moratorium on the issuance of additional vessel permits during the rebuilding period of 5–7 years, with exceptions for smaller and lower power vessels (Wang and Rosenberg, 1997).

Amendments 5 and 7 were accompanied by two economic assistance programs. The goal of the first program was to mitigate the impact of Amendment 5 on fishing industries and communities. The program consisted of a 30 million USD grant designed to assist fishing industries and communities to develop alternative fisheries, improve fishery infrastructure, provide job training for fishermen and promote community development. The goal of the second program was to reduce capacity in the groundfish fleet through a voluntary vessel buyback program. The program consisted of a USD 2 million pilot program followed by a USD 23million full-scale project (Wang and Rosenberg, 1997). This program was criticized for being ineffective in achieving permanent reductions in capacity.

Amendment 13 contained the beginning of a move away from dependence on input controls through the enablement of sector allocations, in which a group of vessel permit holders voluntarily agree to restrictions and procedures in exchange for a share of the total catch. Sectors underlie a share-based groundfish allocation system that for sector members will replace the DAS restrictions on fishing effort. In 2009 there are two New England groundfish sectors and 17 more proposed that could encompass the majority of Northeast groundfish vessels (NOAA, 2009).

In 2009 NOAA announced it would allocate USD 16 million to assist the Northeast fishing industry with the transition to management of the fishery by sectors and catch shares. Six million will be allocated to cooperative research between fishermen and scientists on projects related to stock surveys and selective gear development. Ten million will be used to develop data reporting and fishery monitoring systems for improved in-season management (NOAA, 2009).

Pacific Fishery Management Council: Canary Rockfish

The Pacific Fishery Management Council (PFMC) is responsible for fisheries off the coasts of California, Oregon, and Washington.

Management plan

Canary rockfish (*Sebastes pinniger*) are managed under the Pacific Coast Groundfish Fishery Management Plan (FMP), implemented in 1982. The FMP applies to more than 90 different species of rockfish, flatfish, roundfish, sharks and skates, and other species. Sixty-four species of rockfish are managed under the FMP (PFMC 2008).

Management approach

The PFMC uses a variety of management tools to control rockfish fishing mortality. A license limitation program for trawl, longline and pot gear has been in place since 1994. As part of that program an open access fishery was maintained to accommodate the low level of landings of small vessels, state-managed fisheries and incidental catch. In addition, quotas, trip (size and frequency) limits, area restrictions, seasonal closures, and gear restrictions are used. An IFQ program for the shoreside groundfish fishery and co-ops for the whiting mothership and catcher-processor sectors will be implemented in 2009.

Rockfish Conservation Areas (RCAs) designed to protect overfished shelf rockfish species are large area closures that vary in location seasonally, bounded by latitude and longitude coordinates that approximate depth contours. Different RCAs apply to trawl, non-trawl and recreational fisheries (NMFS, 2009b).

Affected interests

Canary rockfish is widely distributed across the continental shelf, exposing it to a number of commercial and recreational fisheries. Harvest reductions to achieve rebuilding most severely affect groundfish fleets with few alternative fisheries or locations to shift effort. A large proportion of the catch is bycatch to targeted flatfish trawl fishing. Smaller amounts are caught in the whiting and “DTS” (Dover sole, short-spine thornyhead and sablefish) trawl fisheries, and by longline vessels targeting groundfish. Four Washington tribes with treaty rights to catch up to one half of the harvest in their “usual and accustomed places.” participate in the whiting fishery with canary rockfish bycatch. Shrimp trawlers are required to use excluders to minimize canary rockfish bycatch. Charter vessels fishing off Northern California and Oregon account for most of the recreationally-caught canary rockfish (PFMC 2003; PFMC 2008).

All groundfish-dependent fishing communities and many non-groundfish dependent fishing communities of the U.S. West Coast are affected by canary rockfish rebuilding measures, with Oregon and Washington ports realizing the greatest impacts in reduced landings. Many small buyers and processors in these ports have limited scope to reduce operations or change product mix to remain solvent. Charter fleets with support services (bait and tackle) are also affected (PFMC, 2003; PFMC, 2008).

Rebuilding history

Canary rockfish were declared overfished in 1999 and a rebuilding plan was immediately initiated through adjustments in annual management measures. The 2000 OY was reduced by over 70% and limited to canary rockfish bycatch, limited the amount of other target species that could be harvested. The OY was subsequently reduced by the same margin over the next three years. In 2002 a number of management tools were used to constrain catches to the lower targets, including Rockfish Conservation Areas (RCA),

which vary in location within a fishing year according to fish location. Gear restrictions to prevent trawling in canary rockfish habitat and to lower bycatch in flatfish and shrimp trawls were also implemented, as were reductions in commercial trip limits and recreational bag limits for canary rockfish and co-occurring species. In 2003, results of a new stock assessment led to a further 50% reduction in total OY, establishment of small trip limits for trawl bycatch, and the extension of RCAs to recreational fisheries (Stewart, 2007b).

Four FMP amendments address stock rebuilding. Amendment 16-1 (2003) established a rebuilding framework that included guidelines for developing and adopting rebuilding plans. Amendment 16-2, adopted by the Council in 2003, set the rebuilding parameters for canary rockfish and three other overfished species. A range of management measures developed through the annual/biennial harvest specification process was used to constrain total fishing mortality within levels identified by the rebuilding parameters. New measures were not developed but were held out as a potential part of some future action. The range of management measures did not vary among the alternatives (PFMC, 2003). Amendment 16-3, approved in 2004, incorporated key elements of rebuilding plans (PFMC, 2006).

In 2005, a Court of Appeals ruling refined the legal interpretation of the Magnuson-Stevens Act rebuilding period requirements (U.S. 9th Circuit Court, 2005), clarifying that stocks were to be rebuilt as quickly as possible. Updating and revision of rebuilding plans followed this ruling. Amendment 16-4, approved in 2006, revised the FMP to specify that rebuilding periods will be as short as possible, taking into account the status and biology of the stocks, the needs of fishing communities, and interactions of overfished stocks with the marine ecosystem. As a result of this ruling, Amendment 16-4 also revised the rebuilding periods for six other overfished stocks (PFMC, 2006). The rebuilding parameters for canary rockfish were revised based on an analysis that had determined the canary rockfish stock to be at 9.4% of its unfished level in 2005 (Methot, 2005).

Distributional impacts of the rebuilding alternatives were analysed for all sectors. Impacts on the commercial sector were measured as the effect on ex-vessel revenue of limits on harvest. Tribal sector impacts were measured as the degree of change in groundfish landings relative to historical levels. Recreational impacts were calculated as changes in fishing opportunity measured in the number of trips. Impacts on buyers, processors and markets were estimated as changes in landings and ex-vessel revenues and the degree of substitutability in markets. Fishing community impacts were considered to be an aggregate of all the above impacts. Geographic differences in community impacts were estimated through changes in personal income impacts (Stewart, 2007a).

Distributional issues

Before the implementation of the first rebuilding plan (Amendment 16-2) the Council and its advisory bodies took public comments at seven meetings. The Council also held a scoping meeting to elicit comments on the proposed rebuilding alternatives. Most comments were received from the commercial sector, environmental organizations, processors and tribes (PFMC 2003). A wide range of distributional issues was analysed in the canary rockfish rebuilding plan based on scoping processes that included stakeholder comments. These issues illustrate that distributional effects of canary rockfish rebuilding were of concern to environmental interests, communities, and tribes, as well as to industry.

- Information adequacy: data are inadequate to develop a rebuilding plan;
- Data continuity: placing restrictions on fishermen will mean fewer data
- Precaution: use an ecologically conservative approach; commit to not exceeding the OY.
- Rebuilding time period: Explore a range of rebuilding time periods
- Management's role in overfishing: analyse impact of past management practices
- Communities: Consider impact on coastal community infrastructure. Concern about job loss.
- Consider the human impact of large fishery reductions;
- Tribal fisheries: Ensure treaty rights are protected and that treaty fishing is not affected;
- Protected Species: Consider effect of marine mammals on fish populations
- Bycatch: evaluate all alternatives for reducing bycatch
- Mixed Stock Exception:
 - Do not use for any species;
 - Use it – it's impossible to rebuild all stocks at once

Restructuring actions

In addition to management actions taken under the rebuilding plan, a number of actions and events shaped the fishery following the first large reductions in canary rockfish catch in 1998. A federally supported trawl vessel buyback program removed 92 (34%) of the 274 vessels with groundfish permits from the fishery in 2004. A 2005 lawsuit by environmental organizations resulted in a ruling by a federal appeals court requiring stronger protections for rebuilding overfished Pacific groundfish (PFMC, 2006). In 2008, the Council recommended an IFQ program for the shoreside groundfish fishery and co-ops for the whiting mothership and catcher-processor sectors (PFMC 2008). In 2009 the Council took action to limit effort in the open access fishery.

North Pacific Fishery Management Council: Bering Sea Snow Crab

The North Pacific Fishery Management Council (NPFMC) is responsible for fisheries off the coast of Alaska.

Management plan

Bering Sea Snow Crab (*Chionocetes opilio*) were first managed under the Fishery Management Plan for the Commercial King and Tanner Crab Fisheries of the Bering Sea/Aleutian Islands, implemented in 1989 (NPFMC, 1989). The FMP was updated in

1998 and renamed as the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs. The FMP applies to eight species of crab (NPFMC, 1998).

Management approach

Under the FMP crab fishery management is delegated to the State of Alaska, including opening and closing fisheries and setting total allowable catches or guideline harvest levels. NMFS and the NPFMC retain the authority to prevent overfishing, rebuild overfished fisheries, determine Essential Fish Habitat and administer the Crab Rationalization Program. The Crab Rationalization Program allocates BSAI crab resources among harvesters, processors, and coastal communities. It includes share allocations to harvesters and processors and incentives to participate in fishery cooperatives. Community interests are protected by Community Development Quota (CDQ) allocations of 10% of the total allowable catch, and by regional landing and processing requirements (Fina, 2005). NMFS and the Council also establish closed areas and take action to reduce crab bycatch in the trawl fisheries. The NPFMC Crab Plan Team coordinates crab management between NMFS and the State. It also provides Federal oversight of State crab management, develops FMP amendments to comply with the Magnuson-Stevens Act and other applicable federal law, and prepares the annual Stock Assessment and Fishery Evaluation Report (NPFMC, 2008a).

The status of the snow crab stock is calculated annually within the context of a five-tier system that reflects varying levels of uncertainty of information. The tier system allows new scientific information to adjust the status determination of a stock, if appropriate. A stock is assigned to one of the five tiers based on the availability of information. Snow crab is considered a Tier 3 stock. Tier 3 stocks are those for which reliable estimates of the spawner/recruit relationship are not available, but proxies for FMSY and BMSY can be estimated (NPFMC, 2008b).

Overfishing and overfished criteria are formulated annually and assessed to determine whether overfishing is occurring or a stock is overfished. Overfishing is determined by comparing the overfishing level (OFL), as calculated in the five-tier system for the crab fishing year, with the catch estimates for that crab fishing year. Results are regularly reported in Stock Assessment and Fishery Evaluation (SAFE) reports (NPFMC, 2008a; NPFMC 2008b).

Regulatory enforcement in the fishery is strict, with observers required on all Bering Sea crab vessels. At-sea enforcement also includes boarding to check pots and gear and air monitoring of area closures (Swasey and Rosenberg, 2006).

Affected interests

Snow crabs are distributed throughout the continental shelf of the Bering and Chukchi Seas, but are not present in the Gulf of Alaska. In the Bering Sea they are commonly found at depths less than 200 meters. The Eastern Bering Sea population inside U.S. waters is managed as a single stock (NPFMC, 2000a).

When the snow crab rebuilding plan was developed in 2000, the directed fishery fleet size ranged from 226 to 253 vessels, including up to 19 catcher processors and a varying number of floating processors. Vessels ranged in size from 58-120 ft., with the majority under 125 ft. (NPFMC, 2000b).

In addition to the directed fishery, snow crab was also caught as bycatch by groundfish trawl, longline and pot gear, and in small amounts by scallop gear. As snow crab abundance declined, bycatch was also significantly reduced. Bycatch limits were established in 1997. In addition, the flatfish trawl fleet implemented a voluntary bycatch reduction program in the Bering Sea that monitored bycatch by area and directed vessels away from crab hotspots (Gauvin *et al.*, 1995). Bycatch in the cod and Pollock trawl fleets was reduced through improved retention requirements that increased trawl mesh size. Bycatch limits for snow crab in trawl fisheries were implemented in 1998, under Amendment 40 to the groundfish FMP. This Amendment was preceded by a negotiated agreement with the trawl industry on prohibited species caps (PSCs) for snow crabs in the Bering Sea trawl fisheries (NPFMC, 2000b).

Coastal communities participate in the snow crab fishery in a number of ways. Communities as distant as Seattle are home ports to vessels and fishermen, processing and support businesses. Shore-based processing plants are located throughout the Bering Sea. Other more distant Alaska ports also process snow crab. In the years leading up to the adoption of the rebuilding plan, the largest proportion of the snow crab harvest was processed by the floating processor fleet (NPFMC, 2000b).

In 1996, the reauthorized Magnuson-Stevens Fishery Conservation and Management Act required the establishment of the Western Alaska Community Development Quota Program for Bering Sea Crab Fisheries to promote economic revitalization of rural communities. Under criteria established in the Act, 65 communities formed 6 groups to produce Community Development Plans and manage the CDQ harvest. Under the Program communities received a fixed percentage of Bering Sea crab quotas, beginning at 3.5% in 1998 and increasing to 7.5% from 2000 onward (NPFMC, 2008a). The Crab CDQ Program was adopted as Amendment 5 to the FMP and was implemented in 1999 (NPFMC, 2000b).

Communities also benefit from a 50% share of the 3% state tax on all fish landed and processed in Alaska. This fish tax is an important source of funds for local governments of the Eastern Bering Sea communities. In addition to revenues associated with the fish tax, Bering Sea communities receive a large proportion of their revenue from crab-related processing through employment, support services, harbor facilities, and fuel tax. In 2000 the Secretary of Commerce issued a determination of a commercial fishery failure in the Bering Sea snow crab fishery. This determination was accompanied by federal relief money for Alaska coastal communities (NPFMC, 2000b).

Rebuilding history

The Bering Sea (BS) snow crab fishery is a high value fishery. Fluctuating stock status resulted in a classification of the snow crab as “fully exploited to depleted” by the UNFAO in 1997, with the fishery operating at or close to optimum yield with no room for further expansion (FAO, 1997; Swasey and Rosenberg, 2006).

The NMFS declared Bering Sea snow crab overfished in 1999. In 2000 the BSAI snow crab rebuilding plan was adopted by the Council as Amendment 14 to the FMP. Rebuilding measures included a low exploitation rate based on spawning biomass; a minimum threshold for establishing guideline harvest levels (GHLs); pot gear modifications to provide escapement of female and juvenile crabs; and a fishery closure when the stock falls below 50% of the minimum stock size threshold (MSST; one half the BMSY stock size) (NPFMC 2008a; Dept. Commerce, 2000a; 2000b).

Under the rebuilding plan, the snow crab stock had a 50% probability of rebuilding to the BMSY level of 921M pounds in 7 to 10 years. The stock will be considered “rebuilt” when it attains the maximum sustainable yield stock size level for 2 consecutive years.

Since the plan’s implementation, the estimated total mature biomass has oscillated slightly around the MSST threshold. Recruitment between 2003 and 2006 is estimated to be near or above average, while the estimated recruitments for 2007 and 2008 are below average (NPFMC, 2008a; NPFMC, 2008b).

In December 2007, the NPFMC took final action to revise overfishing definitions for all FMP crab stocks, which was implemented as Amendment 24 to the FMP. As part of Amendment 24 the NPFMC adopted a tier system based on the availability of information for a given stock. Once a stock is assigned to its appropriate tier, the tier determines how the OFL is calculated (NPFMC, 2008a).

The most recent Stock Assessment and Fishery Evaluation (SAFE) Report reported that 2008/09 mature male biomass (MMB) of snow crab was estimated to be 251.1 MP, which exceeds the proxy for the minimum spawning stock threshold (MSST) of 158.9 MP. This means that the stock is no longer overfished. The Crab Plan Team plans to evaluate whether overfishing occurred during 2008 when the catches for 2008/09 become available (NPFMC, 2008b).

Distributional issues

In its preparation of Amendment 14, the NPFMC consulted with a number of state and federal agency personnel, academics, interested public, and its usual set of advisory groups: the BSAI Crab Plan Team, Alaska Board of Fisheries, the NPFMC Scientific and Statistical Committee, and the NPFMC Advisory Panel (NPFMC, 2000b).

In response to a Federal Register notice of availability for the proposed Amendment 14 to the FMP, which described the Amendment and invited comments, only two comments were received, reflecting equally the need for precaution in setting rebuilding conditions and questioning the need for the rebuilding plan (Department of Commerce, 2001).

- The rebuilding plan does not contain meaningful bycatch reduction measures and habitat protection measures. The rebuilding plan should employ a large amount of precaution.
- Approval of Amendment 14 should be delayed until a thorough scientific analysis of the snow crab stock status and the rebuilding plan are complete. The rebuilding plan may be an over-reaction to a flawed definition of overfishing for snow crab.

The NPFMC environmental assessment of Amendment 14 acknowledged the distributional impacts of snow crab rebuilding on fishing communities but assessed them to be relatively short-lived, as some fishing was expected to take place during rebuilding. Community protections for small Western Alaska coastal communities were in place through the Community Development Quota program (NPFMC, 2008a).

Restructuring actions

In addition to management actions taken under the rebuilding plan, a number of associated actions were taken by the North Pacific Fishery Management Council that strengthened the snow crab rebuilding plan.

The NPFMC approved the License Limitation Program for the crab FMP in 1995. Implementation approval for the LLP was given by the Secretary of Commerce in 1997. In 1998 the crab LLP was further amended to add recent participation criteria for eligibility. These changes were adopted as Amendment 10 to the Crab FMP in 1998. The final LLP was implemented in 2000 (NPFMC, 2008a).

To reduce excess fishing capacity and slow the race for fish in the snow crab fishery, Congress approved a capacity reduction program in 2000. Bering Sea crab fishermen received a federal loan to buy competitors out of the industry, with the intent to pay back the loan through a tax on future crab landings (Department of Commerce, 2004b).

The Crab Rationalization Program was implemented in 2005 to address the problems of an overcapitalized derby fishery that continued to exist subsequent to the 2000 implementation of the License Limitation Program. Rationalization program components include quota share allocation, processor quota share allocation, individual fishing quota (IFQ) and individual processing quota (IPQ) issuance, quota transfers, use caps, crab harvesting cooperatives, community protections, protections for Gulf of Alaska groundfish fisheries, an arbitration system, monitoring, economic data collection, and cost recovery fee collection. The Program was approved by Congress in 2004 and implemented in 2005 as Amendments 18 and 19 to the crab FMP (Fina, 2005; NPFMC, 2008a).

Conclusion: Insights on distribution and rebuilding

The three case studies offer insights on the interplay among incentives, distribution, and stock rebuilding. They fall along a spectrum of effectiveness and of levels of acceptance by stakeholders of their distributional effects. At one extreme is Bering Sea snow crab where distributional effects were effectively addressed and stakeholder resistance minimized. In the middle is the Pacific canary rockfish, where distributional effects on harvesters, processors and communities were addressed to an intermediate degree. At the other extreme is Gulf of Maine cod, where distributional effects remain unaddressed and continue to lead to stakeholder contestation of the stock rebuilding plan.

Bering Sea snow crab is no longer overfished (NMFS, 2008). Distributional effects on processors and harvesters were addressed through a share-based program of rationalization that ends the race for fish and addresses overcapacity. Distributional effects on communities have also been mitigated through community development quota allocations and community landing and processing provisions.

Pacific canary rockfish is no longer overfished (NMFS, 2008). Distributional effects on harvesters were slowly addressed through a vessel buyback program and the parallel development of an individual transferable quota (ITQ) program. Distributional effects on processors were addressed to a limited extent through the ITQ program, but effects on communities were mitigated only to a limited degree through community access competition provisions within the ITQ program. Stakeholder resistance to the rebuilding plans was focused on the mixed stock nature of the fishery and the large-scale impacts of stock rebuilding on fisheries targeting associated stocks.

Gulf of Maine cod is the least successful and least well accepted rebuilding plan of the three. The stock continues to be subject to overfishing and remains overfished (NMFS, 2008). Attempts were made mitigate the distributional aspects of rebuilding through existing management approaches. These approaches included effort reductions within the context of tenure insecurity and a continuing race for fish, leading to strong stakeholder resistance to rebuilding and attempts to activate the mixed stock exception.

The interaction of distribution and rebuilding is affected by the incentives of the larger management context. The interaction also leads to derivative distributional effects, and it relates to the possibilities of mitigation.

Incentives of the larger management context

One of the key factors determining both the approach and the success of a rebuilding strategy appears to be expectations among stakeholders about their tenure in the fishery. Resolving access rights and ending the race for fish are critical necessary conditions for establishing the security of tenure necessary for stakeholders to take a long term perspective. Without some form of secure property rights that assure stakeholders they will share in the gains of rebuilding, stakeholders have little incentive to cooperate in long-term planning and will view the rebuilding process as one of transition costs without assurance of benefits (Grafton *et al.*, 2007). The lower the profitability of the fishery, the greater the tendency to emphasize the distributional aspects of management over potential efficiency gains (Armstrong and Clark, 1997). The incentives that property rights provide for stock rebuilding are particularly important because they shift the perspective of stakeholders to the long-term asset value of the stock (Hilborn, 2007).

The complexity of the management context also plays a role in how the distributional aspects of rebuilding are felt. Management that has become increasingly complex in an attempt to address distributional effects may find that complexity a limit on subsequent management flexibility and a hindrance to mitigating the distributional effects of rebuilding (Healey and Hennessey, 1998).

Another important incentive of the management context is the authority of the underlying control rules for rebuilding. In their review of rebuilding plans worldwide, Caddy and Agnew (2003) found that the existence of overriding non-discretionary legislation that incorporates overfishing definitions and reference points is of critical importance to rebuilding. Also important is the requirement that stocks be rebuilt to MSY conditions or their equivalent when limit reference points for biomass and fishing mortality are infringed. The authority embedded in provisions of the 1996 SFA which was further strengthened by the 2006 MSRA and subsequently clarified through the courts, kept stakeholder resistance to the idea of rebuilding in check, and instead redirected management focus to mitigating the distributional effects of rebuilding.

Derivative distributional effects of rebuilding

In addition to the distributional effects that rebuilding plans directly create, there may also be derivative distributional effects generated. The need to accomplish successful rebuilding may lead to strategies that also address the larger economic and social objectives of the fishery. It appears from the three case studies that where the negative distributional aspects of rebuilding loom the largest are where these larger objectives have remained unaddressed. The process of addressing these economic and social

objectives is the purview of the political marketplace characterized by special interest effects, time horizons, uncertainties, and bureaucracy (Sutinen, 2008).

One obvious contributor to the economic and social objectives of the fishery has been actions taken to reduce capacity in association with stock rebuilding. Of the three case studies, the two stocks that have been successfully rebuilt, snow crab and canary rockfish, were in fisheries that also developed meaningful capacity reduction programs. The removal of excess capacity from the fisheries served a larger long-term interest in the fishery than the rebuilding of a single stock. It has been noted that curbing fishing effort has often been difficult because of the excess levels of capacity in the fishery, leading to actions that are "too little and too late" (FAO, 2005).

Stakeholder involvement is another area that contributes to the larger goals of the fishery. Stakeholder involvement in rebuilding is fundamental to the acceptability and enforceability of rebuilding plans. The nature of this involvement may be either constructive or destructive, depending on the general approach to stakeholder co-operation taken by the management system as well as stakeholder expectations about their continuing tenure in the fishery. For stakeholders to engage effectively in rebuilding and accept a share of rebuilding costs, they must have some expectation of benefitting from rebuilding gains. For decision rules to be effective, stakeholders should contribute to their planning and development rather than to the decisions to modify these rules once rebuilding is in place. There is a need to establish procedures with clear decision rules in advance of the rebuilding process, before specific distributional effects are in play (Caddy and Agnew, 2003). This need is in common with the general rule of fishery management negotiations to decide procedures and indicators on the basis of general distributional effects, in advance of situations where specific effects are in play.

The most extreme example of destructive stakeholder involvement among the three case studies is in New England, where measures taken to implement stock rebuilding according to legal requirements were met with strong resistance among a wide range of industry, community, and political stakeholders (Department of Commerce, 2009b). Resistance by disaffected stakeholders took the form of the "end run" phenomenon, where assistance is asked of elected representatives in overturning the decisions of the management agency (Sissenwine and Mace, 2001).

Mitigating distributional effects

The ability of management to mitigate the distributional effects of rebuilding relates to its ability to articulate a full range of policy choices, a time path for rebuilding and clear decision rules for recovery. Stakeholder involvement in defining policy choices influences their acceptability, but this involvement rests in turn upon the tenure assurance that allows engagement in long-term planning. Communities are included in the group of stakeholders needing tenure assurance. Management plans that do not involve communities at some level of assurance for continuing participation in the fishery will likely be subjected to pressures to mitigate community impacts of rebuilding.

The time path for rebuilding is often a matter of contestation, especially with long lived species that are caught in a mixed-stock fishery. In these cases the distributional effects are compounded over time and over species, providing greater incentives for stakeholders to resist rebuilding. Possibilities for mitigation may rest on the existence of substitute fishing activities. Without substitution possibilities, a clearly defined time path

for rebuilding combined with tenure security for fishery participants may provide a long-term possibility for mitigation.

Clear decision rules mitigate the procedural uncertainty of rebuilding. A rule-based approach requires precautionary or limit reference points to be defined and a decision about non-discretionary action that will be taken if these limits are reached. Experience in stock rebuilding shows the importance of specifying the conditions under which rebuilding is obligatory and strict enforcement during the rebuilding process (Caddy and Agnew, 2003; FAO, 2005).

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Chapter 7.

Setting allowable catch levels within a stock rebuilding plan

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Abstract

The essence of a stock rebuilding plan can be summarized in a harvest control rule that specifies the level of harvest that is to be permitted at each stock size over the relevant range from the current size to the target stock size, X_{TAR} . The selection of an appropriate control rule is a policy decision based upon, among other things, tradeoffs between present and future benefits and the desired time in which to achieve X_{TAR} . While the selection of the control rule is a critical part of building a successful SRP, the analysis here will focus on the implementation of the control rule taking into account that the information used to generate the control rule may not accurately capture the population dynamics of the fish stock, due to the limited ability to describe stock characteristics and project stock conditions. The purpose is to develop an analytical probabilistic framework to consider how the control rule harvest level can be modified to address the possible weaknesses in the construction of use of harvest control rules.

Introduction

The essence of a stock rebuilding plan (SRP) can be summarized in a harvest control rule that specifies the level of harvest that is to be permitted at each stock size over the relevant range from the current size to the target stock size, X_{TAR} . The formal analysis of how an appropriate control rule can be selected is the subject of other papers in the forum. It is a policy decision based upon, among other things, tradeoffs between present and future benefits and the desired time in which to achieve X_{TAR} . While the selection of the control rule is a critical part of building a successful SRP, the analysis here will focus on the implementation of the control rule taking into account that the information used to generate the control rule may not accurately capture the population dynamics of the fish stock, due to the limited ability to describe stock characteristics and project stock conditions.

Control rules are developed using stock projection models and while there are many reasons for potential inaccuracies, the main ones include incomplete data, inaccurate data due to measurement and sampling error, errors in model specification, errors in estimating parameters, and stochastic and environmental variation. See the Lensfest Working Group Report (2007). The bottom line is that we do not know which, if any, model correctly captures the population dynamics of exploited fish stocks. Further we do not know the model parameters with certainty. In some cases there are estimates with a mean value and a probability distribution. As defined by Knight (1921), this is risk. And even in these cases issues of stochasticity and environmental variability are not fully considered. In other cases there is no information at all. This is what Knight would call uncertainty.

The purpose of this discussion is to develop an analytical probabilistic framework to consider how the control rule harvest level can be modified to address the possible weaknesses in the construction of use of harvest control rules. This means that it will be necessary to focus attention on relatively data rich situations involving risk. There will be no analysis of uncertainty although the procedure may provide some hints as to conceptualize the problem.

The following definitions and notation will be used in the probabilistic analysis. At any point in time there will be an estimate of the current stock size (X_t). The control rule will explicitly or implicitly specify a control fishing mortality rate (F_{Ct})² that can be used to calculate the proposed allowable level of harvest for the current year (Y_{Ct}). In addition, an estimate of the stock size in the coming year will be generated. Call it X_{Ct+1} .

Ideally it would be necessary to expand the probability analysis to consider multiple years, even if it is to be performed annually. To simplify the discussion at this point the focus here will be on a one year horizon but the concepts should be relatively easy to extrapolate.

The problem of how to modify the proposed allowable catch level can be formulated by introducing the concept of a buffer between the proposed allowable harvest level that follows from the control rule (Y_{Ct}) and the harvest level that is actually promulgated in the fishery management process, call it Y_{Pt} . Formally:

$$Y_{Pt} = Y_{Ct} - B \quad (1)$$

A semi-hypothetical stock projection model

The following is the minimum amount of information that is necessary to build a stock projection model that is capable of developing and interpreting a harvest control rule.

- A specification of a stock recruitment relationship with a PDF of the parameters and a procedure to choose central tendency measures to use as point estimates.
- The PDFs for age class specific parameters for natural mortality, fecundity, current age class size, and relative catchability coefficients and a procedure to choose central tendency measures to use as point estimates.

The author used point estimates for the above parameters (except for age class distribution) for the Gulf of Mexico Red Grouper to develop a stock projection model using EXCEL, with a Crystal Ball add on to perform Monte Carlo analysis. To avoid any misinterpretations with respect to actual Red Grouper management policy, the current age class size distribution was proportionately changed³. The F_{msy} control rule was developed using the point estimates of the parameters. The model was used to provide examples in the analysis below and it is available from the author. The results should not be interpreted to apply to any particular fishery. The purpose is to demonstrate that a useful model can be developed by information that is frequently available for many fisheries and to demonstrate what kinds of results can be produced.

Analysis

There are three issues that need to be addressed in order to introduce this probabilistic approach. First, what is the probability distribution that is of policy relevance? Second, how can the PDF be generated? And finally, how can the PDF be used to convey useful information about how to set buffers?

Consider the case of weather forecasting. Rain can be a good thing (up to a point) for farming but a bad thing for picnics. There are important definitional issues. In addition to details about time and location, the amount of rain is often of prime importance. Assume that anything greater than 0.2 inches of rain over a 12 hour period in the location where a picnic will occur will unduly affect the participation at and enjoyment of the picnic. In this case the policy relevant probability is the chance that rain fall will be greater than 0.2 inches. Using standard probability notation, this can be written as $P(\text{rain} > 0.2 \text{ inches})$. If the forecasts are given in terms of the probability (i.e., the probability of rain is 25%), people can then make up their own minds about whether to attend the picnic depending on the predicted probability. This is a matter of taste and willingness to accept risk. Call this a simple probability analysis.

But the estimated probability of rain can be used in a more analytical way with respect to certain types of decisions related to weather. Assume a trucking firm has to move material that will be damaged if rainfall is greater than 0.2 inches. Assume further that the damage from that amount of rain would be equal to L and the cost of covering the truck to prevent the damage is C .

In this simple case, the trucking firm can specify a procedure for determining whether it makes sense to protect the truck based on the expected costs. If the firm protects the

truck, the cost will be C no matter how much rain falls. If it does not protect, the expected loss is:

- $P(\text{rain} > 0.2 \text{ inches}) * C$. If the objective is to minimize long run expected cost, then the trucks should be protected when $P(\text{rain} > 0.2 \text{ inches}) * L > C$. This breaks down to the operational rule that the trucks should be protected on days when $P(\text{rain} > 0.2 \text{ inches}) > C/L$. Call this a formal risk analysis.

If a critical stock criterion that is analogous to a critical weather event can be specified, it is possible to perform both simple probability analyses and more formal risk analyses that may help to inform policy on the necessary size of the buffer. The problem of adjusting catch levels is not as simple as protecting trucks, but it is possible to use an analogous chain of logic. In the context of a SRP, the operational objective is to achieve catch levels so as to maintain the stock growth trajectory specified by the control rule. Therefore the probability of achieving the desired stock trajectory is the policy relevant variable.

In simple terms, the control rule, implicitly or explicitly, specifies a fishing mortality rate that when applied to the current stock size, X_t , produces the allowable harvest level. The calculation process that leads the allowable harvest level will also specify the stock size in the next year.

The control rule provides two choices for the critical stock criterion. First there is the probability that the actual fishing mortality that results from a specific allowable harvest level is greater than F_{Ct} . Alternatively there is the probability that the expected stock size next year is less than X_{Ct+1} . In an excellent paper Shertzer, Praeger, and Williams (2008) propose a procedure to consider the first one. As a basis for comparison, the current analysis will consider the second choice. There are several differences between the two but an important one the ease of computation. The Shertzer, Praeger, and Williams procedure requires a complex generation algorithm while the one to be described here only requires the addition of a Monte Carlo analysis to the stock projection model. There are likely other ways to stipulate the problem and it is hoped that this discussion will stimulate more research in this area.

The projected stock size that follows from the control rule can be used as the interim target stock size. There is an interesting subtlety here. X_{Ct+1} is a result of the stock projection model, and there are as many questions about its true value as there are about any other number in the whole exercise. However, it is necessary to specify something as the critical stock criterion.

The focus of attention will be the probability that the expected stock in the next year is less than X_{Ct+1} given that the proposed allowable harvest level (Y_{Ct}) that follows from the control rule is reduced by a buffer equal to B .

$$P(B) \equiv P(X_{t+1} < X_{Ct+1} \mid B) \quad (2)$$

For ease of exposition, this will be called the probability of failure with reference to the failure to meet the interim stock goal.

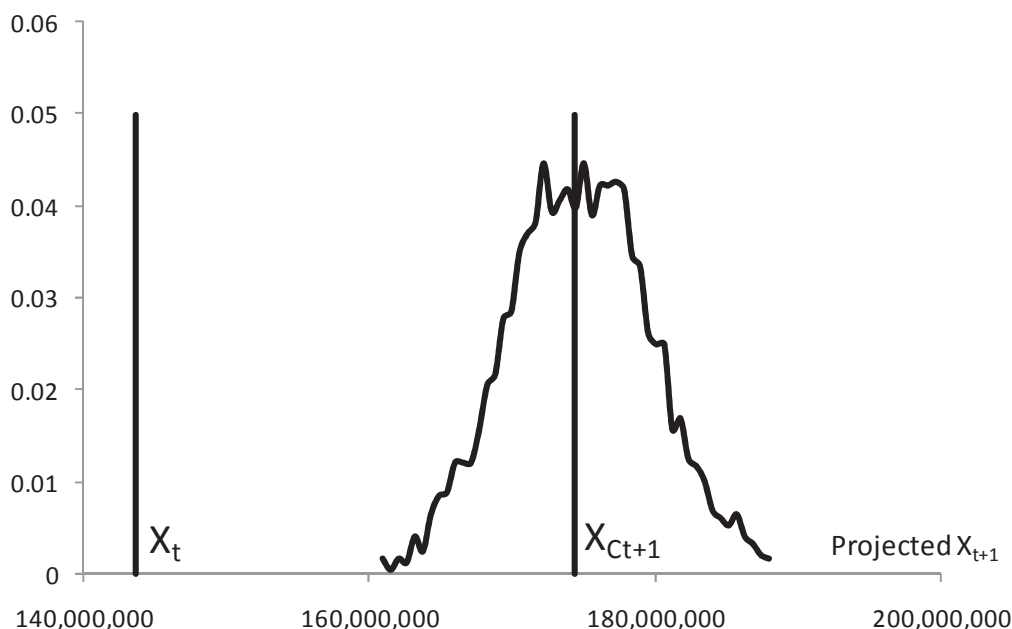
The probability density function for the projected X_{t+1} can be generated using a Monte Carlo analysis with the stock production model described above. As a starting point, assume that the buffer is set equal to zero and the F rate used in the stock projection model is set equal to F_{Ct} . The Monte Carlo analysis allows all parameters discussed above to vary around their point estimate. For each of the 1000 runs random values were

generated for all parameters by multiplying each by a random number drawn from a normal distribution with a mean of 1.0 and a standard deviation of 0.05.

The results are pictured in Figure 7.1. The probability density function of projected X_{t+1} as estimated in the Monte Carlo analysis is superimposed on the assumed value of current stock size and the estimated value of X_{Ct+1} using the point estimates of the parameters in stock projection mode. Given the assumption that the stock projection model parameter values were normally distributed, it is not surprising that the PDF is similar to a normal distribution. In this particular case $P(X_{t+1} < X_{Ct+1} | 0) = .49$.

Scientific uncertainty is a term that is frequently used to describe the less than accurate estimates of biological parameters and incomplete knowledge of the biological processes that need to be addressed when making fisheries management decisions. In that sense, this PDF provides some information on the effects of scientific uncertainty on the probability of achieving an interim target stock size. Technically, however it shows the effects of randomness in the parameters that are endogenous to the stock projection model.

Figure 7.1. The PDF of X_{t+1} .



With a zero buffer when considering randomness in the endogenous variables of the stock projection model

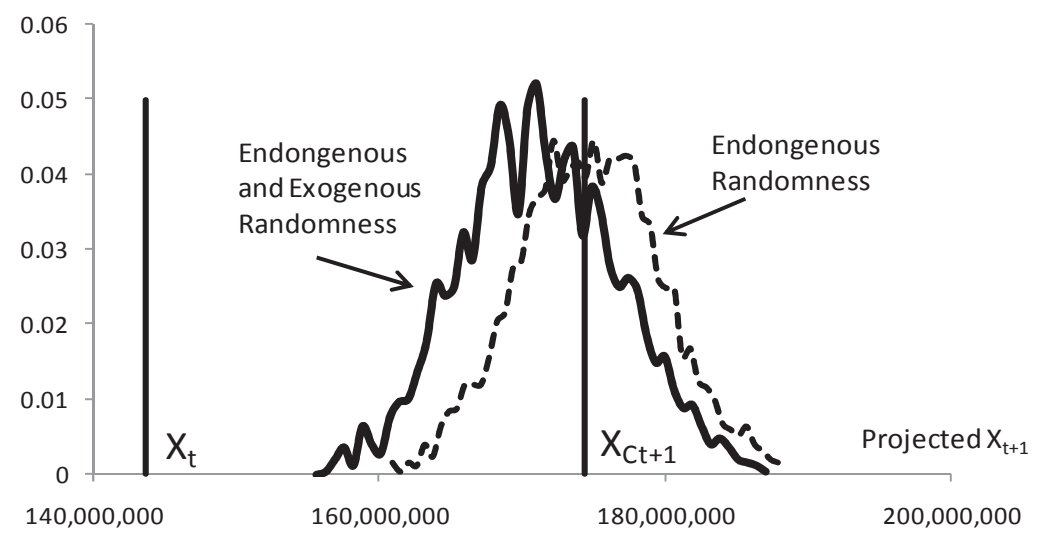
Figure 7.1 demonstrates some weakness of the common procedure of providing only point estimates of the expected result of a particular harvest level, which would result in a point estimate of X_{Ct+1} . Given these results however, one can expect that the stock will be at least that high only about 50% of the time. Put more bluntly one can expect to be correct 50% of the time. And something that is not often mentioned when applying a precautionary approach is that the point estimate can be overly pessimistic 50% of the time. However, to the extent that the estimates of the parameters in stock projection

models are normally distributed, this situation will be the normal case when looking at scientific uncertainty.

It is important to remember that that it not just the central tendency of the range of expected stock sizes, it is the length of the range, especially relative to the existing stock size. In this case, the lowest point in the range is above X_t .

However, the variability in the estimate of X_{t+1} that is due to randomness that is endogenous to the model is only part of the picture. Setting a catch level is one thing, but how it is enforced in the real world is quite another. If there is less than perfect enforcement and actual catch is different from the allowable limit, the estimates of projected stock size from the above analysis will not be as useful as they otherwise would have been. But this management uncertainty can be introduced into the analysis by changing the way that the fishing mortality rate is considered in the stock projection model

Figure 7.2. Comparison of the PDFs of X_{t+1} .



With a zero buffer with only randomness in the endogenous variables and with randomness in both the endogenous and exogenous variables

The fishing mortality rate is the control variable of the stock projection model. It is an exogenous variable that can be changed to allow for consideration of different harvest policies. However, if actual catch cannot be perfectly controlled, it is possible to get a better picture of the likely PDF of X_{t+1} by introducing randomness in the F rate used in the stock projection model. The randomness should capture the relative ability to monitor and control harvest based on historical records of actual catch relative to legal limits. One would expect that the PDF of F would not be normal and the central tendency would be higher than F_{Ct} . Figure 7.2 shows the comparable PDF of projected X_{t+1} under the same circumstances except that the Monte Carlo analysis adjusted to consider both endogenous and exogenous randomness. Randomness in fishing mortality was introduced by multiplying the F rate by a number randomly selected from the hypothetical PDF shown in Figure 7.4 in each of the trails. The mean is 1.14 and the probability of having an F

lower than the specified one is approximately 0.1. It is meant to capture the fact that catch limits are more often exceeded than the reverse.

With randomness in both endogenous and exogenous variables, the PDF is not a normal distribution and the probability of missing the interim target stock increases significantly. The range of the PDF shifts to the left and the $P(X_{t+1} < X_{Ct+1} | 0) = 0.69$. This is a useful starting point to consider how the probability of failure will change as the buffer is increased.

The first two columns of Table 7.1 show how the probability of failure in the case study decrease as the buffer is increased. For generality the buffer is expressed as the ratio of B to Y_{Ct} , the proposed harvest level that follows from the control rule. The buffer can never be higher than Y_{Ct} , and so the critical range is from zero to 100%. The values were generated by producing a series of series of Monte Carlo analyses using the stock projection model where the F rate was reduced by 5% of F_{Ct} for each new run. In each Monte Carlo run both endogenous and exogenous randomness were considered which is to say that both scientific and regulation uncertainty were considered.

Figure 7.3. PDF used to generate randomness in the fishing mortality rate. .

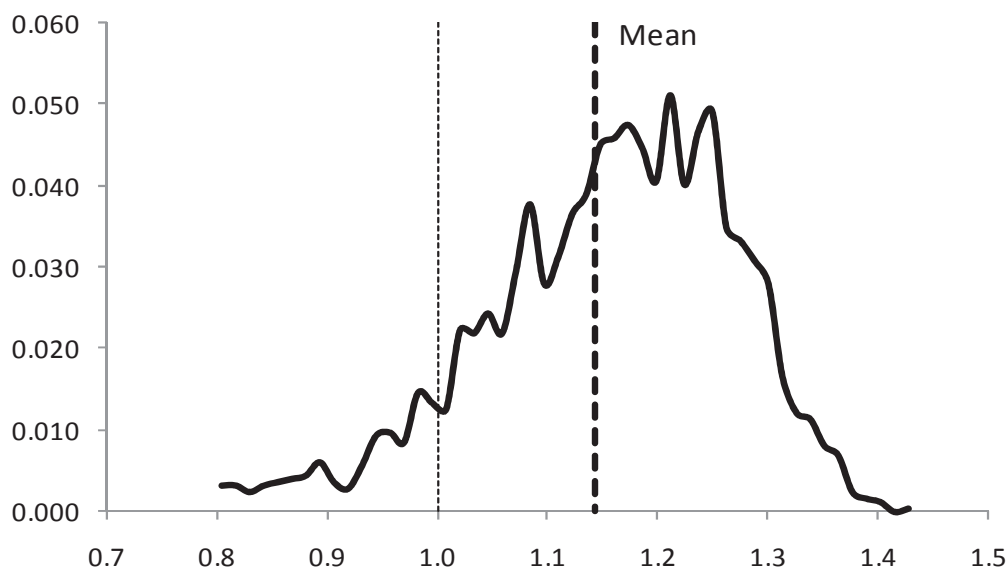
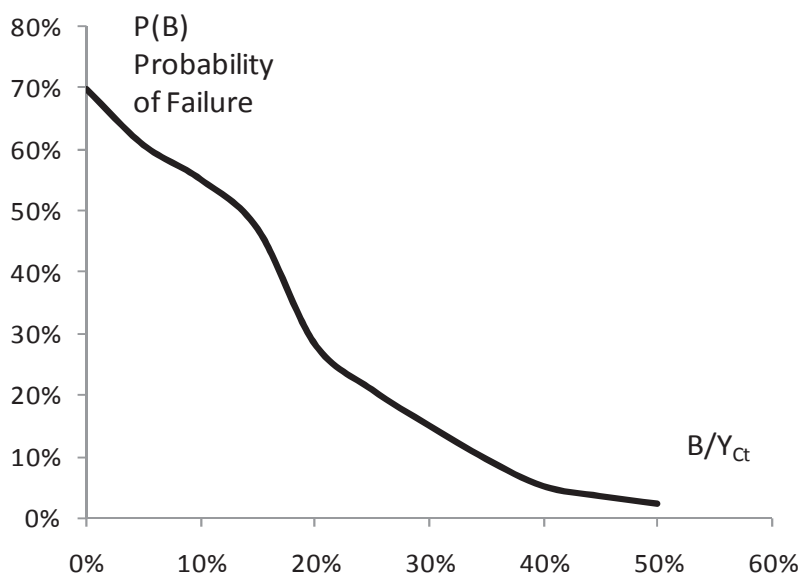


Table 7.1. The effects of buffers on the probability of failure

Buffer	P(B)	" $-\Delta P(B)$ "	Inverse
0	69.8%		
5%	60.7%	0.091	11.0
10%	55.1%	0.056	17.9
15%	47.0%	0.081	12.4
20%	28.3%	0.188	5.3
25%	20.8%	0.075	13.4
30%	15.0%	0.059	17.1
35%	9.5%	0.055	18.3
40%	5.0%	0.045	22.5
45%	3.4%	0.016	61.7
50%	2.2%	0.013	80.0

These points are plotted in Figure 7.4. Call this the probability of failure reduction curve, PFRC. The shape and slope of the PFRC is of critical policy importance. Note that the vertical intercept is the value that falls out of Figure 7.1. The horizontal intercept is the maximum buffer that is necessary to reduce the probability of failure to zero. This will occur when the analogous PDF function in Figure 7.2 shifts to the right such that the entire range is to the right of X_{Ct+1} .

One might hypothesize that the curve would be convex to the origin on the assumption that there will be diminishing returns in terms of reductions in $P(B)$ from increases in B . However, in this set of runs, this is only true of the lower range. The exact shape and position will depend upon the circumstances of the fishery involved.

Figure 7.4. The probability of failure reduction curve.

Can the PFRC be used to inform decisions on the size of the optimal buffer? In general, cases where the curve is more steeply sloped and crosses the horizontal axis at a lower percentage buffer would appear to be more likely to benefit from implementing buffers. More specifically, one possible criterion could be to set the buffer so that the $P(B)$ that considers both exogenous and endogenous randomness is that same as the $P(B)$ that only considers endogenous randomness. In this example, this rule would call for a buffer of approximately 13%

An alternative procedure would be to specify a minimally acceptable level of $P(B)$. For example if it was determined that the probability that the expected stock is less than X_{Ct+1} should never be less than 30%, then the buffer would have to be 20% of Y_{Ct} .

Preliminary thoughts on introducing risk analysis

In the simple analysis of using weather forecasting information to determine optimal policies for protection, the assumed goal was to minimize the expected cost, which is was the sum of known protection costs and the expected value of losses from bad weather. In an analogous manner, it is possible to consider the problem of specifying the optimal size of the buffer as one of minimizing expected costs. There is a cost to setting a buffer. At minimum it is the loss of the net value of the output of fish forgone. That is the difference between what consumers are willing to pay for that output and what it costs to harvest, process, and distribute it.

Conceptually there is also a loss (L) for missing the interim target stock size. This is a very hard thing to even conceptualize because of the illusive chain between missed targets in a single year and forgone future benefits. This is especially true if a similar decision is to must be made every year. But even in lieu of firm estimates L , it possible to finesse this and still provide some policy relevance.

Using $P(B)$ as the a short hand notation for $P(X_{t+1} < X_{Ct+1} | B)$, the function for the cost that is to be minimized can be written as:

$$C = P(B)*L + [B/ Y_{Ct}]*NV \quad (3)$$

NV is the net value of producing Y_{Ct} units of fish, while B is the size of the buffer. As B is increased from zero to Y_{Ct} , the cost in terms of the lost value of production will increase from zero to NV . The first order condition for a minimum is

$$-P'(B)*L = NV/ Y_{Ct} \quad (4)$$

The point estimates of $-P'(B)$ are shown in the third column of the Table. Note that $-P'(B)$ is positive. The simple economic interpretation of (4) is that the optimal level of B occurs where the marginal reduction in the value of expected losses is equal marginal cost of increasing the buffer. The term NV/Y_{Ct} is per unit net value of harvest.

Given that it is possible to obtain estimates of $-P'(B)$ and NV/ Y_{Ct} , it is possible to use either equation (3) or (4) to investigate how the optimal buffer size will change with different values of L . However, because the PFRC in this case is not convex over its full range, $-P'(B)$ does not decrease monotonically. This makes it more difficult to apply equation (4). The results concerning the convexity of the curve are plausible but they may be due to the fact that the series of Monte Carlo runs considers marginal changes in the fishing mortality rate of 5%. It would be tedious but interesting to see how the results would differ in the marginal changes were set at 1%.

Note that reformulating the first order condition obtains the following:

$$L = \{ NV/Y_{ct} \} * \{ 1/[-P'(B)] \} \quad (5)$$

This allows for the calculation of the minimum value of L necessary to justify a given buffer. This value of L is equal to the inverse of the negative of the slope of PFRC at the particular buffer level times the per unit value of harvest. These inverse values are shown in column 4 of the Table.

Over the range of buffers where the inverse is monotonically increasing the interpretation is quite straight forward. It turns out that if L is less than 9.6 times the NV per unit, the optimal buffer size is zero. The marginal benefit of the reduction in expected losses is less than the marginal costs. However, if L is actually slightly higher, then the optimal buffer size immediately jumps to 20%. In these circumstances, while the marginal gain is less than the marginal cost of the first three increments of 5% in the buffer size, the marginal net gain from the fourth increment is high enough to cover the losses from the first three. From that point on the logic is simple. If the value of L is as high as 13.4 times the NV per unit of output, a buffer of 25% can be justified, if it is as higher as 17.1 times as much a buffer of 30% can be justified, and so forth. In cases where the inverses are monotonically increasing throughout the range, this simple analysis applies for all sizes of the buffer.

Conclusion

Given our inherent limited ability to describe stock characteristics and to project future stock conditions, the problem of setting allowable catch levels in the context of a stock rebuilding plan will remain a very important issue. The very success of the plans depends upon solving it. It is hoped that this brief discussion about how to introduce an analytical analysis to the process will be useful in current policy making and will stimulate further related research.

Notes

- 1 . Acknowledgement: Support from NOAA Fisheries Office of Science and Technology and from the OECD Fisheries Policy Division is gratefully acknowledged, but the author is solely responsible for the contents.
- 2 . The subscript C refers to control rule.
- 3 . The help of Drs. Clay Porch and Shannon Cass-Calay of the National Marine Fisheries Service in getting into the details of the stock assessment reports provided by the SEDAR process and the computational assistance and helpful comments of Kathryn Semmens is gratefully acknowledged but the author takes full responsibility for data interpretations

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Chapter 8.

Information issues and constraints in the design and implementation of stock rebuilding programs

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Abstract

Rebuilding programs for overexploited fish stocks are developed from identification of overfishing and depletion to the implementation of management measures to reduce fishing mortality and improve selectivity, to monitoring and adjustment of those measures based on performance. At each stage of a rebuilding program there are specific needs for scientific information and advice to guide management. Here we consider two case studies, North Sea cod and George's Bank groundfish and describe the development and implementation of their rebuilding programs and the information needs that enabled them. We conclude with a general framework for science advice for rebuilding plans.

Recovery plans

One of the important outcomes of the 2002 Johannesburg Summit on Sustainable Development with respect to the oceans was an international agreement on the ending of overfishing and restoring depleted fish stocks to levels that can produce the maximum sustainable yield by no later than 2015. Even prior to Johannesburg, statutory requirements for rebuilding depleted fishery resources were underway in many parts of the world.

The US Magnuson Stevens Fishery Conservation and Management Act was amended in 1996 to specifically require stock rebuilding including the requirement in all fishery management plans to quantitatively define overfishing with respect to fishing mortality rates (when overfishing is occurring) and biomass levels (when a stock is in an overfished condition). For stocks in an overfished condition the law requires rebuilding to levels that will enable the stock to produce MSY on a continuing basis within a specified time frame (NOAA 1996).

In Europe, Council regulation (EC) no 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy states that the objective of sustainable exploitation is achieved through a multi-annual approach to fisheries management, involving multi-annual management plans for stocks at or within safe biological limits. For stocks outside safe biological limits, the adoption of multi-annual recovery plans is an absolute priority. The content of multi-annual plans should be commensurate with the conservation status of the stocks, the urgency of their recovery, and the characteristics of these stocks and the fisheries in which they are caught (EC 2002).

The main objectives for fisheries management during the last 25 years have been the reduction of the exploitation rates to sustainable levels and the rebuilding of depleted stocks. A key issue for the advisory system has been to develop reference points to support fisheries managers in achieving these objectives including precautionary biomass and fishing mortality rate reference points. Assessments of stock status are then compared to these reference points to measure rebuilding progress.

For rebuilding to progress, management needs to be conservative and act immediately when a depleted resource is identified. In practice, the development and implementation of rebuilding plans and associated regulations should include: 1) immediate establishment of appropriate interim measures, 2) cessation of overfishing, 3) increased monitoring and surveillance, 4) establishment of timeframes that are as short as possible while still allowing for recovery, 5) adoption of performance metrics for fishing mortality rates and biomass with regulatory adjustments to improve stock condition, 6) rapid response to new information about plan performance, and 7) conservative decision- making with respect to uncertainties in depleted resources.

Rebuilding must also be accompanied by restructuring of the fishery so that the rebuilt resource will not immediately be overexploited again. Restructuring must include a mechanism for managing fishing capacity to reduce the propensity to overexploit. Clear allocation between fishing sectors is needed and a means of aligning the incentive structure of the fishery with conservation needs is also essential. In many cases, a rebuilt fishery will rely on higher product value, lower product volume and reduced competition between fishers in order to achieve greater profitability and sustainability.

A recent review of recovery plans in the United States (Rosenberg *et al.* 2006) shows that while recovery plans have been widely implemented, many have not achieved the primary need of reducing fishing mortality rates below reference levels. Consequently, recovery has been slow and for many stocks further action is clearly needed. In many cases, this was because the plans were overly optimistic with respect to the effectiveness of management measures for controlling fishing mortality. In other cases, the timeframe for agreeing and implementing a plan was slow and stock conditions deteriorated before control measures were put in place. In many cases, plans called for long phase in periods for restrictions which allowed fishing levels to remain high for longer, further depleting stocks and undermining the chances for ultimate success of the plan.

In this chapter we discuss the information needs for recovery planning. We consider two cases studies, North Sea cod and New England groundfish from the perspective of how their recovery plans have been implemented and issues that have arisen in the process of recovery plan implementation. We then consider the types of data and information that are needed to address those issues on an ongoing basis.

Case studies

North Sea Cod

In the past several years, an EU recovery plan for cod stocks in the Kattegat, the North Sea including the Skagerrak and the eastern Channel, to the west of Scotland and the Irish Sea has been under progressive development. The recent assessment of the stock has shown the long-term decline to very low levels of all of the three stock units, and then a slight, apparent increase at the end. However the apparent increase in the most recent year for North Sea cod is from such a critically low level that stock recovery is still in jeopardy. The last significant year class of cod was in 1996 and average recruitment is clearly lower over the past 15 years compared to the previous twenty years.

An effort management regime were implemented since 2003 in the annual TAC and quota regulation and recovery measures were implemented in 2004 (Regulation (EC) No 423/2004) with the aim of reversing the declining trend in SSB and increasing the spawning stock above B_{lim} . The measures of total allowable landings (TACs), technical measures and effort management regulations did not deliver sufficient reduction in fishing mortality for the recovery of the cod stocks.

Research surveys have indicated that cod year classes were depleting faster than expected given the mortality rates targeted in the recovery plan and that recent recruitment has been poor. The level of reported catches compared to the estimated high recent mortality rates suggest that there were substantial unaccounted removals, e.g. additional discards, mis- and underreporting of catches. Subsequently, unaccounted removals have declined and now are considered to be a negligible factor in determining the short-term dynamics of the stock compared to landings and discard mortality.

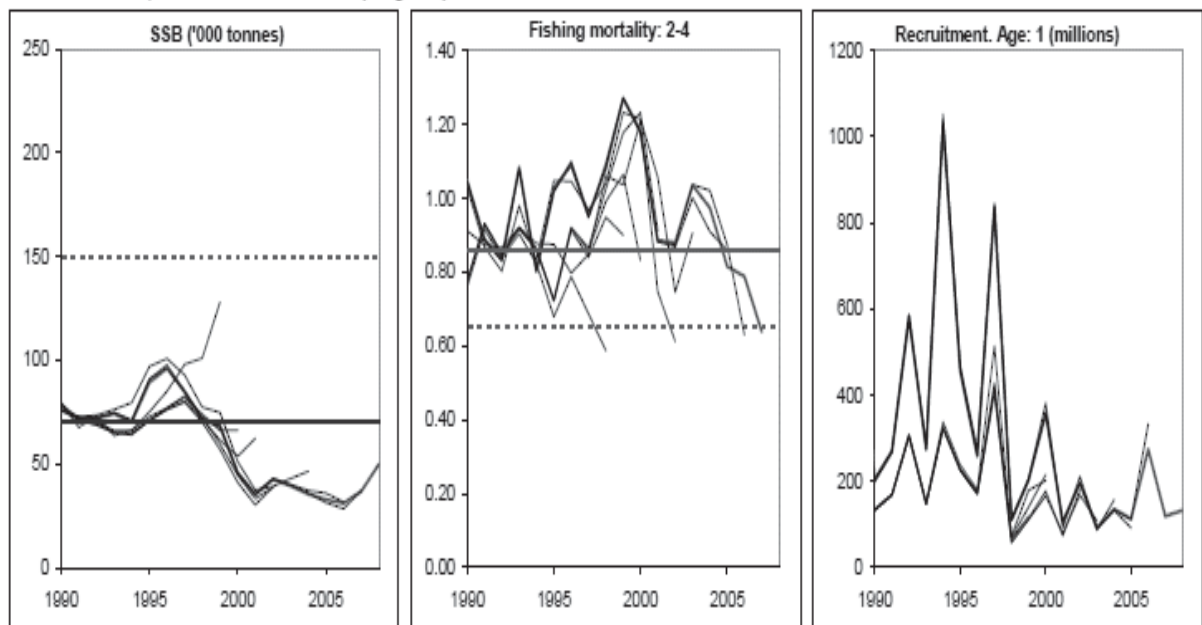
The fishery-induced mortality in the stock assessment and forecasts only include landings and discards. In the last five years, an average of 82% (84% in 2007) of the international landings in numbers consisted of juvenile cod aged 1–3. Because the fishery is at present so dependent on incoming year classes, fishing mortality on these year classes is high, and only 12% of the 2-year-olds currently survive to maturity (compared to 22% in the early 1960s). The recruitment of the relatively more abundant 2005 year

class to the fishery may have no beneficial effect on the stock if it is caught and heavily discarded. In 2006, the 2005 year class comprised 62% of the total catch by number, and in 2007 it comprised 55%. Discarding of this year class has increased to 40% in 2007. The last substantial year class to enter the fishery was the 1996 year class. This year class was a prominent feature in all surveys, was heavily exploited and discarded by the fishery at ages 1–5, and disappeared relatively quickly from the fishery with no benefit to the SSB (ICES, 2008). Continued fishing and discard mortality in 2008 and 2009 at the level seen in 2007 is expected to stabilize the SSB at around B_{lim} , but will not lead to a substantial increase in biomass (ICES 2008)

This case illustrates that complete catch and effort reporting from all gears capable of catching the stock under recovery is absolutely critical in order for recovery planning to work. It is not sufficient to limit the scope of data collection to a portion of the fleet or base it around the sector that historically targeted the depleted species because of the rapid shifts in fishing effort and catch that can occur in an adaptable fleet.

Figure 8.1. Historical performance of the stock based on recent assessment information. .

Cod in Sub-area IV, Division VIId & Division IIIa (Skagerrak)



Cod (*gadus morhua*) in Subarea IV (North Sea), Division VIId (Eastern Channel), and Division IIIa (Skagerrak).

The revised cod recovery plan implemented from 2009 has greater flexibility in modifying fishing pressure at the various recovery stages; and specific measures for discards and cod-avoidance programmes. A flexible approach will also make it possible to graduate catch and effort limitations in line with improvements in the biological condition of the cod stocks concerned. Fishing mortality will thus be reduced year-on-year by 25%, 15% or 10% depending on the gravity of the condition of the stock, until the target mortality rate of 0.4 has been met. The current fishing mortality is estimated to range from 0.7 to 1. The plan aims at changing the target from a biomass-based to a fishing mortality-based target. In those cases where scientists are unable to provide the

Commission with adequate data and advice, the plan now establishes clear rules to be followed, namely, a 25% reduction in fishing mortality when scientific advice recommends reducing catches to the lowest possible level, and a 15% reduction in all other cases. This will avert the problems encountered under the original plan, where the lack of clear scientific guidance led Council of Ministers to set annual catch limits on a purely ad hoc basis. This highlights another information need; the recovery plan measures must be clearly linked to specific provisions in the advice and that advice must be forthcoming on a recurring basis. If this linkage isn't made, then the advice is likely to be inconsistent or unclear and the resulting response will also be inconsistent (see below for discussion of control rules related to this point).

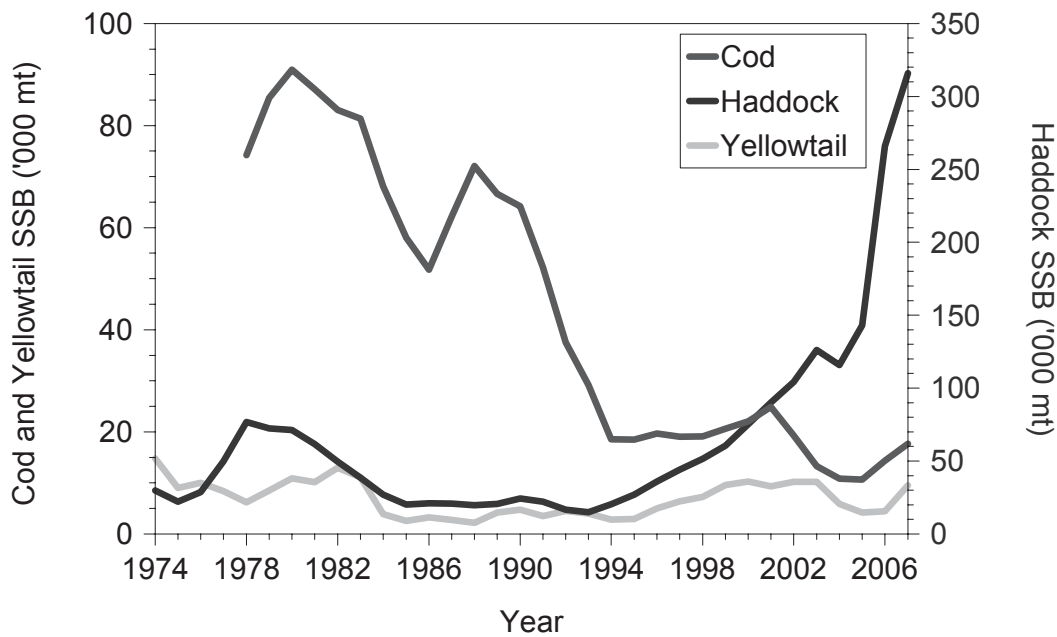
The objectives of the revised plan are to concentrate on achieving the optimum exploitation rate that will guarantee the highest sustainable yield. The effort management system is based on effort ceilings to be managed domestically by Member States to avoid derogations and to provide greater simplification of the regulation, more flexibility for Member States, and more efficient implementation. If input controls such as effort limitation are to be effective, then it must be total effort exerted on the stock, not just the target portion. While there can be flexibility, it must be within the total limitation without exceptions if fishing mortality rate is to be controlled. Therefore, effort reporting and calibration must be complete and consistent across the fleets in the fishery.

New England Groundfish

The fishery for groundfish in New England is a classic story of overfishing, stock depletion and efforts toward recovery over the last decade. The fishery has a long history (Alexander *et al.* in press) of exploitation by both domestic and foreign fleets up until the declaration of extended jurisdiction in 1976 but the United States, effectively ensuring only domestic exploitation of groundfish off the New England coast. But foreign overfishing was quickly replaced by domestic overfishing in the early 1980's and stock depletion continued.

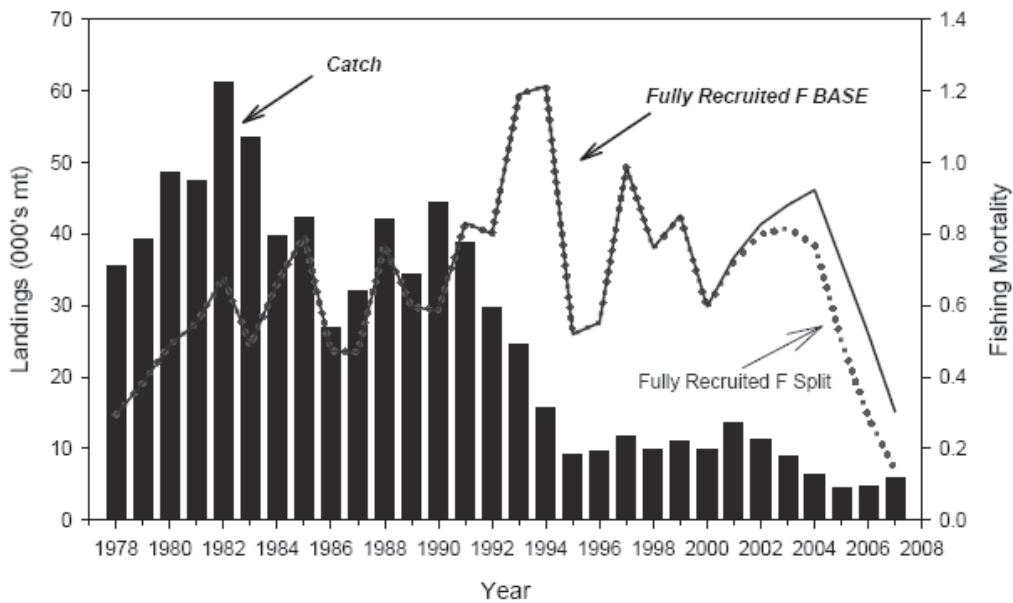
In 1994, the first major recovery plan efforts had begun and have continued to be progressively implemented since then with mixed success. Exploitation rates on some species, notably haddock, have been decreased to low levels through a combination of effort controls and large closed areas along with mesh size changes to improve the exploitation pattern (Murawski *et al.* 2000). The result has been a major recovery of the George's Bank haddock stock to levels that are capable of supporting maximum sustainable yield. However, for the two cod stocks in the region (Gulf of Maine and George's Bank) and several others stocks, these measures were less effective and exploitation rates have remained too high even under the recovery plan and hence actual recovery of stock biomasses has been much slower (Rosenberg *et al.* 2006; NEFSC 2008). The controversy surrounding management has been and continues to be intense even though some important progress has been made.

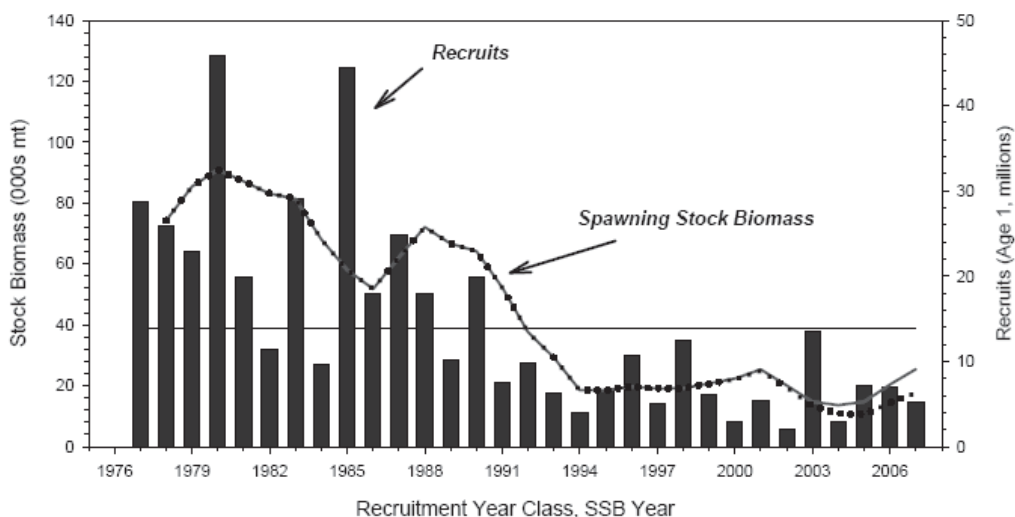
Figure 8.2. Spawning stock biomass for three NE groundfish stocks under recovery from recent assessment information.



Source: NOAA Fisheries Woods Hole, MA, USA.

Figure 8.3. Trends in catch, fishing mortality rate, spawning biomass and recruitment.





Trends in catch, fishing mortality rate, spawning biomass and recruitment for George's Bank cod from the most recent assessment

Source: Northeast Fisheries Science Centre (2008).

Reference points for fishing mortality rates for the New England groundfish stocks are substantially below those estimated for the North Sea and adjacent stocks. The fishing mortality rate at maximum sustainable yield for George's Bank cod is 0.25, while for the North Sea a value of 0.4 is used. This difference is not necessarily apparent in the biology of the stocks but is an important issue to be addressed. If the reference levels are set too high, then recovery will be truncated.

Controversy in New England is still intense because of the need to continually tighten management measures in an effort to recover species such as cod and flounders. At the same time, the higher abundance of haddock means lost opportunity for fishermen since the fishery is regulated by effort controls. If effort could target haddock without bycatch then easing of restrictions might be possible but this only is possible for portions of the fleet. As is often the case, it is allocation between fleet sectors that results in overwhelming complexity in the regulatory controls. Because total effort is included in management and there are no direct controls on output (catch quotas; opposed for many years by the New England fishing industry) the effort limitations have become increasing severe with a rise in political tension.

This highlights not only the need for complete monitoring of catch and effort, but the importance of restructuring the fishery while recovery proceeds. In New England, the restructuring has largely been through attrition, rather than a plan or process for capacity management. The result is a fishery that is struggling for survival through an accelerated restructuring into catch shares for each sector. Catch shares (portions of the quota allocated to cooperative groups of vessels) would allow internal regulation of capacity by each group and hopefully increase viability of the fishery.

Fishery management and information needs

In order to reduce fishing pressure on an overfished stock in need of recovery, both the directed fishery and the bycatch need to be reduced, in some cases by large amounts. For cod in the North Sea as well in New England, these needed reductions in fishing mortality rates can be 50% or more of past levels. Reductions in fishing effort often need to reflect the overall reduction needed in fishing mortality rates although reallocation among gear types may modify this relationship. Fishing effort reductions need to be across the fisheries that catch the stock under recovery and, fundamentally, loopholes in the rules only make the effort reductions more difficult. For example if fishing effort increases in those fisheries that target other species but have a bycatch of the recovering stock, whether it is discarded or landed, then the needed effort reduction in directed fisheries will be greater.

The fishing effort reductions implemented in the recovery plan must account for the fact that effective effort has been increasing steadily for several decades in many fisheries around the world, and certainly in the case studies outlined above. That is, effort can increase through technology change, not just the number and size of vessels. This means that comprehensive data on catch and effort are needed for implementation and monitoring of recovery plans. Managers must have current and ongoing estimates of catch effort by gear type across the fisheries, not just for the fleet targeting the recovering stock. Monitoring must be in near real-time and include as many characteristics of the vessels and the catch as possible in order for some standardization to occur. Electronic reporting of catch and effort should be the norm in fisheries to improve timeliness of the information, though implementation has been far too slow in many places include the US.

Management of bycatch and discards must be achieved through strong management of the fisheries on associated species such as haddock, hake and Nephrops and other groundfish fisheries in both case study areas. These fisheries clearly have the potential for a major impact on cod recovery. Discard and bycatch minimization measures are essential to allow cod to recover. Closed areas and technical measures such as gear modifications can be used to reduce discard of cod even in closely related fisheries such as those for Nephrops and haddock. If such measures are not closely monitored through real-time reporting and full documentation of the fishery, then cod will not recover because of bycatch and discarding. Observer programmes have been widely used for bycatch and discard monitoring and are, at present, the most effective though costly option. There is an urgent need to develop simpler more cost effective monitor systems for bycatch and discard given the expense and difficulties of deployment of observers, especially on smaller vessels.

Ideally, discard and bycatch should be eliminated if a directed fishery is to proceed. Bycatch reduction devices should be required in all fisheries capable of catching the recovering stock. For example for cod this should include large mesh square panels with truly large mesh, excluders (grids), and increased mesh size. These measures are in use for at least some components of the fishery in both case studies (e.g. the use of trawl gear in the haddock fishery that reduces cod bycatch has been implemented in New England). As noted above, the TAC should encompass the total catch and not just landings and this then means that monitoring must be complete. If discarding increases then allowable landings should be lowered. For those vessels that are primarily fishing for other species, for example in the North Sea for haddock, hake, flatfish or Nephrops, real bycatch reduction could mean the ability of vessels that rely more heavily on cod to continue fishing. The discard data must be available for scientific and management purpose, as

well as for the stock assessments if a serious attempt at recovery is made and that availability is needed in near real time. Confidentiality of fishing operations is often cited as a reason to restrict availability of fishery data. However, fisheries are operating on public trust resources (Turnipseed *et al.* 2009) and confidentiality that hinders recovery management is not appropriate.

Another means of reducing bycatch and discarding is to close areas with high concentration and vulnerability of the stock under recovery. These areas should be chosen where cod is most abundant and therefore vulnerable to the fishery, usually during spawning periods or areas that are juvenile nursery areas. High vulnerability due to aggregation implies higher catchability and therefore the fishing mortality incurred per unit of fishing effort is higher in these areas. The cod stocks in the North Sea, Irish Sea and west of Scotland have been fished and studied for a very long time. It is possible to identify areas where spawners or juvenile cod concentrate as candidates for closure. Closed areas can be enforced if appropriately monitored and provide a refuge for cod. Year round closures are preferable, as habitat is also protected. Seasonal closures can be effective in reducing fishing mortality rates if the area is chosen well, it is large to account for movement of fish and enforcement concerns, and the timing is long enough to really protect against increased fishing when the area is reopened. The information needs for closed areas are often met from research survey data detailing areas of repeated high concentration of various species. Habitat information is also critical as well as analysis of the components of the fleet that will be most affected by closures. It is important to remember that closed areas have effects on the allocation of opportunities to different sectors of the fishery and the policy debate will be affected by those allocation impacts. For example smaller vessels may be less able to relocate, or certain gear types may be less viable in remaining open areas. It is important to recognize that closed areas will only be effective for reducing fishing mortality, and often bycatch, if effort relocated elsewhere is less efficient or effective in capturing the recovering species.

Closed areas need to be large to truly provide any protection such that the fishing mortality reductions resulting from the closures cannot be easily offset by increases outside the areas. In very restricted cases, areas can be effectively closed based on observed criteria such as concentrations of small fish. However, the monitoring needed must be very extensive and the closure and notification to fishermen must be immediate. The closure then needs to be long enough to truly provide some protection. Usually, real time closure systems are problematic because of the difficulties of verifying short term events and implementing management changes in real time.

Area closures in almost all cases need to be accompanied by effort and/or catch controls to be effective in ending overfishing and allowing stock recovery (Stefansson and Rosenberg 2005). This should not be taken to mean that closed areas do not add anything as a management tool because they provide a strong buffer against uncertainty and the combination of management measures (e.g., closures and catch control, or closures and effort control) outperform the application of any single management measure (Stefansson and Rosenberg 2005, 2006). This result is in part because of the inherent implementation uncertainty accompanying any management action. In the case of stocks recovering from overfishing this is particularly important because the fishery and the stock will be under stress, such that the need to reduce fishing mortality rates is critical but the impacts of stock and catch reductions in the fishing industry will make management implementation that much more difficult and uncertain.

Effort control, implementation and monitoring

The effort control system often seems to increase bycatch and there need to be specific measures and incentives to reduce bycatch and discarding. Such incentives can take the form of increased effort allowance, or access to closed areas, or disincentives such as further reductions in kilowatt days and larger closed areas.

Capacity, effort and gear limitations can be “internalized” in some cases through incentive programs. The management program may provide incentives within the industry to reduce capacity and effort in order to reduce costs and improve efficiency. TAC or effort allocation systems that allow greater flexibility during the year for groups of vessels may improve profitability in exchange for overall capacity and effort reductions. In no cases does this mean that extensive regulatory control is no longer needed, but it may mean that the regulatory controls can focus on the overall framework with many of the fishing strategy decisions left to the industry if the incentive structure is realigned with conservation goals.

Real-time catch monitoring is needed for both landings and discarding. Either discarding must be monitored and recorded accurately or discarding must be prohibited and the prohibition strictly enforced. Real-time effort monitoring is also needed. Strict penalties for violations, such as substantial or permanent loss of fishing privileges must be imposed for major violations including mis-reporting, violation of effort restrictions, misuse of gear and any other measures which undermine recovery. This will require an increased effort on enforcement to ensure that the rules are substantiated.

Monitoring data must be used to update the recovery plan measures on a regular basis and adjusted accordingly. Managers should be very cautious about adjusting measures in response to apparent or early signs of recovery. For example, if a strong year class of one species appears available to the fishery strong measures should remain in place to allow that year class to grow and reproduce hence furthering rebuilding. There is a tendency to allow immediate increases in fishing to alleviate pressure on the fishing industry. But such relaxation of the controls will only delay or undermine recovery and therefore result in greater loss of benefits. Similarly, if the stocks are not responding to management efforts then greater protections need to be put in place as quickly as possible. This means that data on the resources must be fully available and analysed regularly in order to ensure that adaptive management measures can be taken. As noted above, management changes should be related to specific guideposts in the scientific advice and the advice must be sure to advise on those guideposts. These should be agreed as part of the plan, not the annual discussion of management measures to avoid the tendency for action in response to apparent short term changes in the stock.

Uncertainty

Uncertainty is an important consideration in all fisheries management. Uncertainties in arise in 3 principal forms:

- Random fluctuations due to natural variation in the environment effecting growth, reproduction, distribution and species interactions;
- Uncertainty in model formulation and parameter estimates of the states of nature (abundance, recruitment, fishing mortality rates, trends) in the analysis of fish stocks as well as associated ecological processes (e.g. habitat, species interactions);

- Implementation uncertainty, reflecting a lack of knowledge about the fishery system or lack of management control such as inability to control total catch including discards or the inability to control effective fishing effort.

The implication of uncertainty from all of these sources is that managers must be aware of the risk of not achieving management goals. In the context of recovery plans, this means that it is important to be cautious in light of uncertainty in setting management measures and making adjustments to a plan.

It is the nature of most stock assessment techniques that the estimates of the stock abundance and fishing mortality rates are the most uncertain in the most recent year, particularly for heavily exploited stocks like cod. The reason for this is because a heavily exploited stock is largely composed of young fish that have only been observed, through catches and research surveys, for a very few years. As fish of a specific year class are seen again and again it becomes clearer how many were in the year class to begin with and how quickly they are being removed by fishing. These stocks have been exploited at high rates for a very long time. If one calculates the reference levels by only examining recent history under heavy exploitation then the methods used by ICES and other scientific bodies tend to return a rate of fishing mortality similar to recent rates, ignoring the fact that the stocks were much more productive in the past, when exploitation rates were lower (e.g. Rosenberg *et al.* 2005).

This is a form of the “shifting baselines” syndrome described in the science and management literature (Pauly 1995). Shifting baselines refers to the tendency to assume that recent history reflects the full capacity of a resource. When data further back in time are considered, our view of stock productivity and abundance usually increases dramatically. It is far more sensible to use either a much longer time series of information on the stock or calculate the reference levels from the basic biological data on cod.

The decision on whether to implement recovery measures for a specific set of stocks or fisheries should not depend upon the completeness of the assessment information available for those stocks. Overfishing certainly occurs on resources where full stock assessments are not available due to a lack of data and the losses of those resources can be every bit as damaging to future sustainable fisheries as from those with complete stock assessment information. In many if not most cases, there is sufficient information on relative abundance, reduced size composition and other indications of overfishing to warrant reductions in fishing mortality even if a full assessment is unavailable. For longer-lived species such as cod, plaice or hake a very truncated size composition, with only a small percentage of the fish above the age at full recruitment, is a clear indication of overfishing even if the overall abundance of the stock is unknown. Even such limited information can guide the implementation of rebuilding measures as well as serve as a basis for monitoring the progress of a recovery plan. In the simple example described above, a recovery plan should include increases in mesh or other measures that increase the age at full recruitment. In addition reductions in overall fishing mortality such that more fish are living to the older ages. Size composition can continue to be an indicator of whether the recovery plan is inducing rebuilding, even while more comprehensive assessment information is being developed.

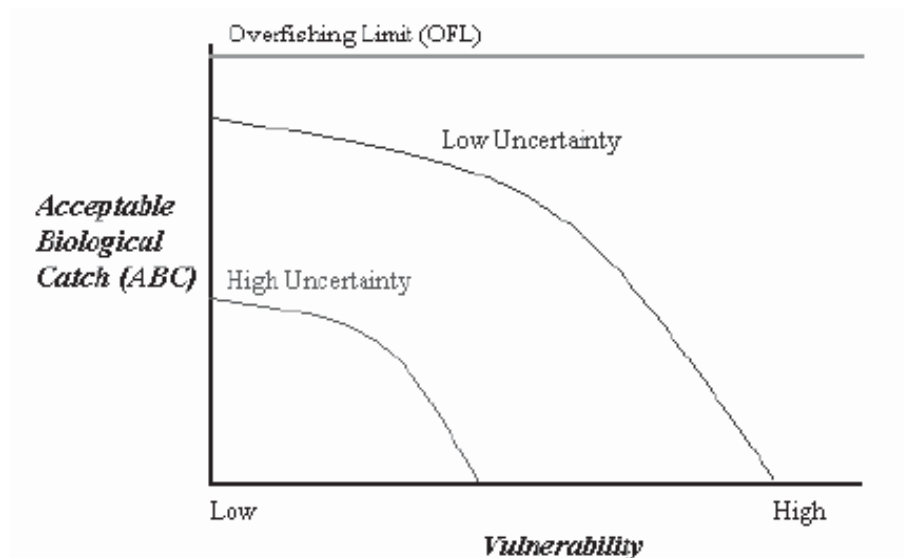
Waiting for complete information or a full stock assessment can only damage the stock and make recovery more difficult. Taking quick action based on initial information or relative indicators of overfishing may mitigate the need for more drastic actions later with accompanying greater economic and social costs.

Further, it is not just the principal target stocks that are in need of recovery if the productivity and function of the ecosystem is to be restored. Minor components of the catch are often ignored but may be important for ecological reasons such as maintaining the resilience to adapt to environmental variability or regime shifts. Obtaining information on abundance or catch trends for non-target species and including them in recovery planning is a major need in most areas.

An approach that can support recovery planning for stocks with limited information has been pioneered by Hobday *et al.* (2007) as a means of characterizing risk for a broad range of stocks. The approach scores the productivity and susceptibility of each stock subject to fishing to give a relative vulnerability score for each stock and fishery component. This methodology has then been adapted by Rosenberg *et al.* (2007) for the purpose of setting annual catch limits for managed fisheries in the US. Given standard fishery reference points such as the fishing mortality rate that is expected to achieve maximum sustainable yield, the vulnerability scoring allows the setting of buffers between target catches or fishing mortality rates and the reference point given uncertainty and inherent characteristics of the exploited stock. In the context of recovery plans, the characterization of risk and setting of annual catch limits in light of that risk can be an important tool for incorporating uncertainty directly into the management process to achieve recovery.

Reference points

Consideration of reference points for stocks shows that conservative fishing mortality rate reference points, such as $F_{0.1}$ that should be close to the rates that would give maximum sustainable yield, are considerably below the F_{pa} reference levels used by ICES and some other advisory groups. This gives scale to the levels of F and effort that should be included in a long-term management plan as a first approximation. For stocks where reference points are not available such that precautionary quotas are used, it should be recognized that these quotas should be set well below the level of recent landings for recovery to proceed. In addition, shifts of effort onto stocks not under stringent management should be carefully controlled. The level of fishing mortality rate reductions needed mean that there needs to be a transition from the current recovery planning efforts to long-term management. If recovery is successful, but at the end of the process the fleets are still as large or effort can increase back to previous levels then the hard work of recovery for overfished stocks will be lost and the fisheries will decline anew.

Figure 8.4. Setting catch limits under uncertainty.

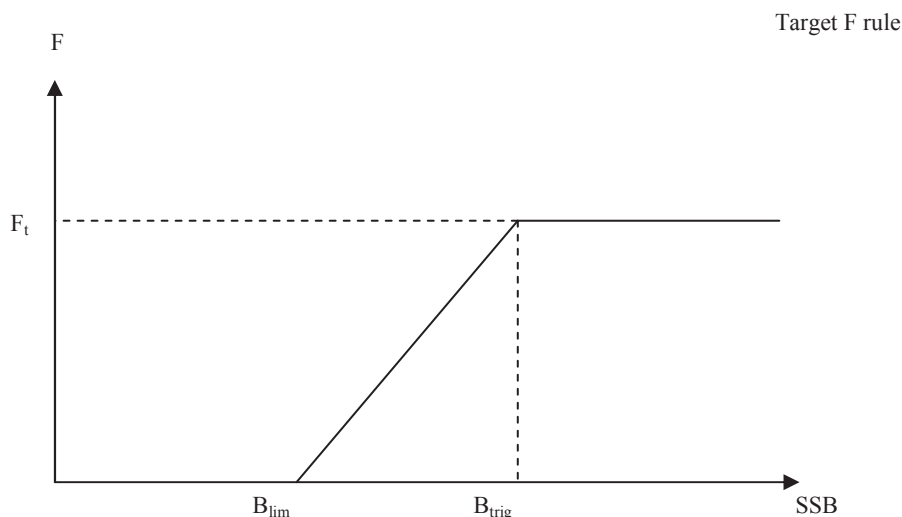
Source: Rosenberg *et al* 2007.

After recovery

The first step is the implementation of aggressive / ambitious recovery plans in order to rebuild the stocks that have been overfished. After stock recovery, managing for a sustainable fishery will require plans that avoid the mistakes of the past and allow greater long-term productivity of fishery resources. These plans should be based on the precautionary approach to fisheries management to ensure that the fisheries are sustainable and to minimise the impact of the fisheries on the marine environment. Furthermore long-term management plans must include target objectives relating to the protection of the marine ecosystem while maintaining high fishery yields, as well as limit reference points to ensure that these protections have a high probability of success. The plans must take into account interactions between stocks and fisheries, and indicators are needed to monitor the sustainability of other components of the ecosystem.

One way to achieve long term sustainability is to agree harvest control rules utilizing target and limit reference points to achieve the planned objectives. Long-term targets will be related to high long-term yield with low risk of depleting the reproductive potential for those stocks which are harvested by single-stock fisheries, where productivity is relatively stable and where biological interactions are considered of less importance. ICES has advised on the development of harvest control rules, which sets out the policy response, in terms of the harvest rate to be applied in the fishery, as a function of the status of a stock or set of stocks (Figure 8.1). The control rule calls for the reduction in the fishing mortality rate on the stock as status, expressed as spawning biomass, declines below a reference level, B_{trig} . The intention is to constrain decisions to ensure conservation of resources when reductions in harvest rates are needed.

Figure 8.5. Harvest control rule for target fishing mortality as a function of spawning stock biomass. .



Long-term management requires a set of input controls, i.e., capacity, effort, gear and closed fishing areas or seasons for juvenile protection, spawning areas, habitat protection and to contribute to effective effort reduction. The intention is to have a set of fishing parameters that match the input allowed with the expected outputs (total catch including discards, and economic return). This is a major change from the current system where the primary control is the catch output with relatively weak controls on the inputs, such that capacity, effort and fishing power far exceed the available total allowable catch. In a long-term management system, total allowable catch (TAC) control still play an important role as a performance measure for the management system as well as a final insurance provision against overexploitation. In other words, the structure of the input controls should be designed to keep fishing mortality and therefore catch at a predicted desirable level, but because of uncertainty in the implementation of the controls it is still necessary to closely monitor catch (landings and discards) to determine how well the input controls have worked.

Year to year, minor adjustments in the controls may be made if the TAC is not achieved, and periodically, say every five years, more extensive adjustments in the input controls may be necessary upon the review of performance. In this regard a long-term management plan should incorporate an overall multispecies TAC as an overall cap on the harvest of all species, and then individual TAC's for the component species that serve as performance measures. If these TAC's are set on a precautionary basis, using a harvest control rule, they may not change very much from year to year. In particular, the overall multispecies TAC may be set for, say, a five year period and then revised as new information becomes available.

The individual stock TAC's may be set for two or three years if biomass is relatively stable to provide as much predictability for the industry as possible. Setting of TAC's for each species will provide a backstop against unexpected changes in fishing power or other uncertainties. These TAC's should be set on the basis of multi-annual projections of the expected catch, including discards, for each species. All discards must be counted

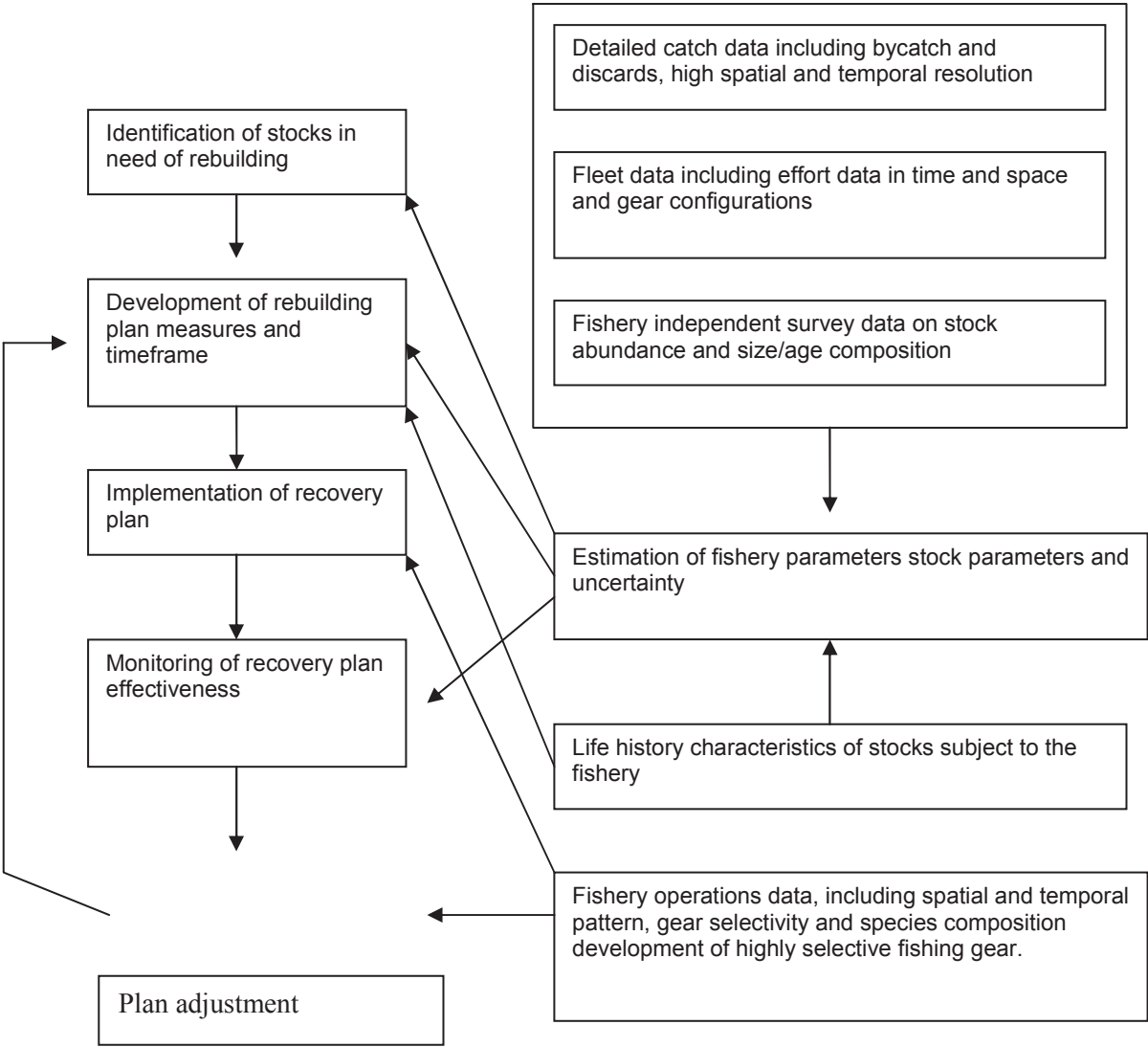
because they are an important output of the managed fishery since they contribute to the overall mortality rate on each stock. It is essential that in applying precautionary quotas that estimates or actual measurements of discarded bycatch are taken account of when setting the quota.

Finally, transitioning to sustainability will necessarily require some substantial restructuring of the fishery. If overfishing was the pattern in the past, then fishing capacity was almost certainly too high and the incentive structure for the fleet was to compete to maximize annual catches, not ensure long-term sustainability. Restructuring will depend upon understanding the capacity of the fleet and crafting of incentives appropriately. In many places including the US, fisheries are in the process restructuring into sector groups or cooperatives with an allocation of fishing privileges to the group. In other cases, individual quotas are implemented to accomplish much the same thing. The challenges are to ensure that the allocation doesn't ignore bycatch or minor components of the catch, maintains the character of the fishery, but results in incentives that support sustainability. This requires detailed analysis of fleet and vessel behaviour under different scenarios for management and incentive structures.

Figure 8.6 describes the relationship between biological and fishery information and stages in the recovery process. Comprehensive catch and effort data is needed as a basis for estimating the impact of the fishery on the stocks under management. Other biological information is needed to design reference points and management targets. Fishery operations information has a critical role in designing plans. Recovery planning needs models of fleet behaviour, not just the biological features of the stock, but this has often lagged well behind other analyses.

In conclusion, the basic needs for recovery planning and management are well known, though political difficulties still remain. Accounting for uncertainty through precaution is essential as is a restructuring of the fishery to ensure that the incentives support sustainability, rather than the historical pattern of competition which results in overexploitation. Information needs for sustainable management are substantial, though the cost of reporting on the use of a public trust resource are likely small compared to the value of the resources in the long term.

Figure 8.6. Relationship between biological and fishery information.



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Chapter 9.

Rebuilding fishery stocks in Korea:

A national comprehensive approach

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Abstract

Korea's coastal and offshore fisheries have experienced reduction in their catch in the early 2000. The amount of catch from coastal and offshore fisheries dropped from 1.7 million tonnes in 1986 to 1 million tonnes in 2004. To address such catch reduction, ecosystem-based fish stock rebuilding programs have been constantly developed and implemented. However, as fish stocks have been estimated to decrease since 2000 in spite of various management measures, the Korean government has begun to genuinely acknowledge the necessity to enhance fisheries productivity through the recovery of depleted fish stock. Based on such acknowledgement, a fish stock rebuilding plan (FSRP), combined with conventional fish stock enhancement programs was established in 2005.

Under the new FSRP, unlike the former government-oriented fisheries management system, a joint management system was established, where actual actors (fishermen) can participate in establishing, executing and evaluating the basic rebuilding plans. Furthermore, science committee and fishery resource management committee were newly organized to coordinate joint participation and role assignments to relevant stakeholders.

For stocks which have shown drastic decrease, a FSRP was set up and promoted. So far, 10 FSRPs have been established and operated, and it is planned to be expanded to 20 species by 2012. The result of pilot projects show that stocks are increasing after the introduction of FSRPs. For instance, the catch per unit effort (CPUE) of sandfish in the East Sea has increased from 0.44 in 2005 to 0.78 in 2007. Consequently, fishing income has increased by 10%. The key lessons learned during the implementation of FSRP are that causes for the stock decrease are various and complicated and it is necessary to adjust and eliminate some conventional policies that could have unforeseen negative impacts on fish stocks.

The FSRP-based fisheries management policy in Korea carries great significance, for it has changed the focus of policy from simply maintaining the status quo to stock recovery and it allows relevant stakeholders to get actively involved in the procedures of establishing and promoting the plan, leading to effective implementation of the plan. While the current FSRP is operated by species, if the FSRP can be gradually expanded to encompass the whole ecosystem, it will greatly contribute to more effective management and fish stock recovery for all species in offshore and coastal waters surrounding Korea.

Introduction

Based on the licensing system of fishing vessels and fisheries, the Korean government has traditionally used the technical measures such as closed time, closed area, mesh size regulation, etc. as well as input control to manage fish stock and the fishing industry for the last century. Then, while it has persistently promoted the vessel buyback program since 1994, it has also implemented the total allowable catch (TAC) system, one typical type of output controls, since 1999. In addition, as a part of ecosystem-based stock enhancement programs, the government has promoted the artificial reef program since 1971, the fry releasing program since 1976, marine ranching program since 2001, and seaweed forest program since 2002 in order to increase both fishery resources and fishing income for offshore and coastal fisheries.

However, despite this consistent policy effort, it was revealed that the total amount of fishery resources in the coastal and offshore areas has continued to decrease (10 million tonnes in 1980→7.9 million tonnes in 2004), though there are differences in increase and decrease of amount for each fish species. Moreover, if the current level of fishing power persists, it is highly likely that the total fish stock would be reduced much further in the future (NFRDI, 2004). According to decrease in these fish stocks, total catch of coastal and offshore fisheries has also shown to decrease (1.6 million tonnes in 1996→1.15 million tonnes in 2007).

In this context, the Korean government has begun to genuinely acknowledge the necessity of a stock enhancement for fisheries productivity first through the recovery of depleted fish stock in order to maintain a consistent development of fisheries. Hence, in 2005, it specified a recovery of fish stock as the main objective of fishery policies, and, to effectively reach this objective, it established Fish Stock Rebuilding Plan (FSRP), combined with conventional management measures and fish stock enhancement programs. As a plan to solve any problems with the conventional fisheries management policy and to attempt to effectively make fish stock recovery, the FSRP-based fisheries management policy aims to reach a specific target amount of fish stock (Kim, 2004).

That is, based on the report of fish stock evaluation, the plan attempts to reach the target amount of fish stock during the period of fish stock recovery, so it is a management policy to compliment the necessary management measures by assessing and selecting the most effective fisheries management ways with stock enhancement programs in order to reach the target. In addition, in terms of establishment and operation of ecosystem based FSRP, it was established in connection with self-management fisheries focusing on fishermen or fishing communities, presuming voluntary participation of fishermen. A more scientific management system was also constructed by assigning new operating organizations (Science Committee and Fishery Resource Management Committee) to the existing fisheries management system. As of 2007, the FSRP is currently being set up based on the pilot project for 7 species of fish and it is expected to expand the range up to 20 species by 2015 (MOMAF, 2005).

This study is intended to introduce the processes and the contents of the Korea's ecosystem based FSRP and its fisheries management policy in more details. It is also to reveal any current issues in the promotion of the ecosystem based FSRP and its fisheries management policy and to propose an improvement plan to achieve the effectiveness of the ecosystem based FSRP and its fisheries management policy. This section of Introduction is followed by section II which briefly examines the status of fishery resources and fisheries, various management measures and programs, and assesses

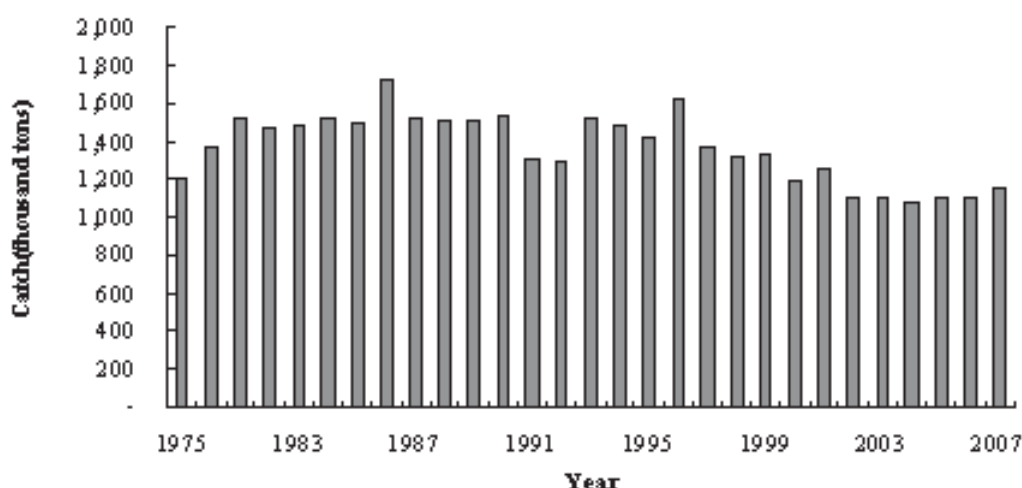
Korea's the conventional fisheries management regime and their limitations. In section III, the concept, objectives, operational plans and pilot projects of the ecosystem based FSRP and its fisheries management policy are examined. In section IV, biological and economic effects of ecosystem based FSRP were analysed based on the accomplishments of pilot projects. Using the analysis, some issues derived from operation of ecosystem based FSRP and suggestions for efficient management in the future were provided. Finally, in section V, the chapter ends with a brief conclusion.

Current situation and characteristics of Korean fisheries

The status of coastal and offshore fishery resources

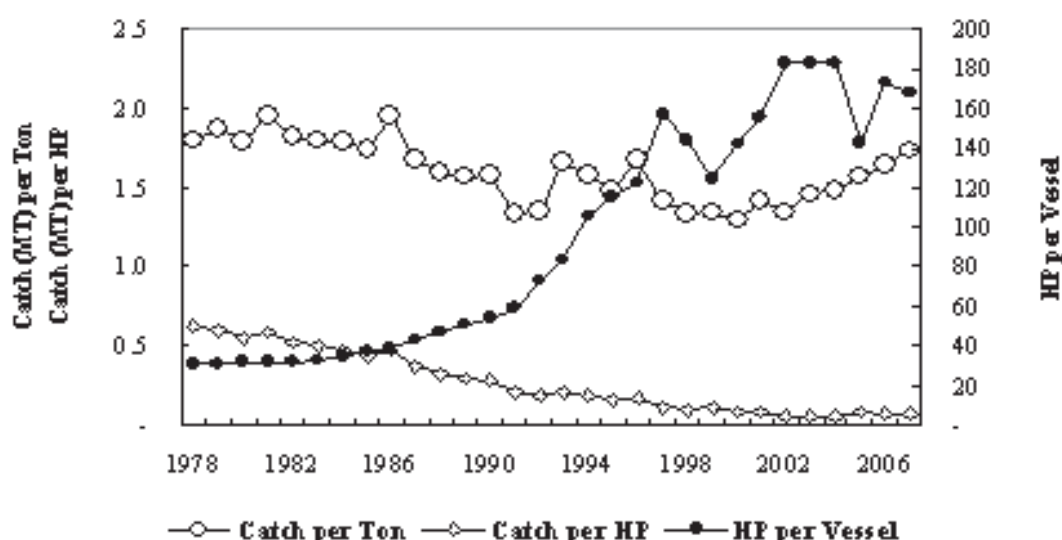
Fishery resources which used to be up to 10 million tonnes in the 1980s have consistently reduced to 7.9 million tonnes as of 2004. If this trend of catch ability persists, it is expected that fish stock would be further reduced to 3.9 million tonnes in the next 10 years (NFRDI, 2004). With a decline of fish stock, the total coastal and offshore catch that reached 1.6 million tonnes in the mid 1990s has been reduced to 1.15 million tonnes in 2007 (Figure 9.1). Especially in the 2000s, it was found that the rate of adult fish among the catch has declined to lower than 20%. This indicates that reproductive capacity of fish stock has drastically been declined, which not only aggravates the trend of the decrease of fishery resources but also increases the proportion of low-grade catch.

Figure 9.1. Annual change in coastal and offshore catch (1975-2007).



Source: NFRDI, 2004.

Even though fish stock in Korean coastal and offshore waters is declining, it was shown that actual fishing power (i.e. the level of fishing efforts) has actually continued to increase. In other words, catch per unit effort (CPUE) for tonnage and horse power in coastal and offshore fisheries has been decreasing, but actual catch ability for each fishing vessel (hp per vessel) has increased (Figure 9.2). Furthermore, catch ability of some offshore fisheries has already exceeded biologically appropriate catch ability, which means that catch pressure for fish stock is at a relatively high level (NFRDI, 2001).

Figure 9.2. Trends in catch per ton, catch per hp, and hp per vessel (1978-2007)

Source: NFRDI, 2001.

Fisheries management system and measures

As mentioned in Introduction, the Korean government has traditionally managed the fishing industry and fish stock through technical measures such as closed time, closed area, mesh size regulation, etc. as well as input control based on the licensing system of fishing vessels and fisheries. In addition to the former technical regulations and the control of fishing efforts, the vessel buyback program has been implemented since 1994, and the output control is also utilized by adopting the total allowable catch (TAC) policy since 1999. Besides these fisheries management measures, fish stock enhancement programs such as artificial reef and fry releasing programs have been also launched in order to increase both fishery resources and fishing income for offshore and coastal fisheries.

Limited licensing system and technical measures

Korea has restricted the number of participants by setting the limited number of licenses by fishery. This has been implemented by fishery types in offshore and coastal fisheries in order to control the conflicts between different areas or between fishery types and to strive for balanced development of fisheries. In the case of offshore fisheries, the limited licensing system was implemented for large otter trawl fisheries and diving fisheries in 1953 and for other fisheries (trawl, offshore angling, offshore gillnet fisheries) in 1976.

For coastal fisheries, it has been allowed to set the limited number of licenses since 1975, but in practice, among coastal purse seine fisheries, the limited number was set for *sukjo* net fisheries and *yangjo* net fisheries, and it was expanded to other coastal fisheries after the 1990s. Beside the restriction on the number of fishing vessels by fishery, the tonnage of fishing vessels by fishery has been regulated for all offshore and coastal fisheries since 1971 in order to restrict the total tonnage of fishing vessels.

Fisheries management technical measures include mesh size regulation, size limit, non-fishing species, closed time, closed area, and non-fishing zone, and the recent trend is to expand or strengthen these measures (MOMAF, 2005; MOMAF, 2004).

Total Allowable Catch (TAC)

As basic provisions were prepared in the revision of Fisheries Law on December 30, 1995; the Fishery Resources Protectorate was revised on December 31, 1995; and the “Regulations on the Management of Total Allowable Catch” was implemented on April 25, 1998, a Korean TAC management measure was enforced on a full scale.

The current operation of the Korean TAC management policy is divided into two phases of the determination of the annual TAC and their individual allocation. More specifically, based on the basic state of fish stock estimated by the National Fisheries Research & Development Institute (NFRDI), the TAC Council evaluates the annual TAC, and the Central Fisheries Coordination Committee makes a final decision on the annual TAC and the provisions on its management. Then, the Ministry for Food, Agriculture, Forestry and Fisheries (MFFAF) allocates an annual TAC to cities and provinces, and each city or province assign 70% of the allocation to individual fisherman with consideration of the tonnage of fishing vessels and the catch in the last three years. When more than 80% of individual quota is spent, additional allocation or total distribution can be done from the remaining 30%.

In 1999 when this policy was first implemented and enforced, the species of fish subject to the TAC management policy were those with large catch and heavy industrial weight as well as sedentary fish that need protection due to the drastic decrease of fish stock, and they were four species of fish - mackerel, jack mackerel, sardine, and red snow crab. As of 2007, the number of the target species of fish has been increased to 10 by adding snow crab, purplish washington clam, pen shell, spiny top shell, blue crab, and Japanese flying squid (Table 9.1).

Table 9.1. TACs by species; 2003-2007 (unit: metric tonnes)

	Mackerel	Jack mackerel	Sardine	Red snow crab	Snow crab	Purplish clam	Pen shell	Spiny top shell	Blue crab	Japanese flying squid	Total
2003	158,000	11,000	13,000	22,000	1,000	9,000	2,500	2,150	13,000	-	231,650
2004	155,000	10,000	5,000	22,000	1,000	8,000	2,500	2,150	13,000	-	218,650
2005	160,000	12,000	5,000	22,000	1,000	7,000	2,300	1,683	6,000	-	216,983
2006	155,000	19,000	5,000	24,500	1,000	5,100	2,440	1,630	4,000	-	217,670
2007	154,000	19,000	5,000	25,000	1,000	3,700	3,200	1,480	3,350	250,000	465,730

Source: NFRDI (2007), MFFAF(2008).

Vessel buyback program

In Korea, the vessel buyback program has been operated since 1994 and the purpose of this policy was to rebuild fish stock through reducing fishing capacity and to promote the growth of fishing income for residual fishermen. With the buyback program, vessels have been bought back from the types of coastal and offshore fisheries that abuse fish stock by excessive fishing or those are not competitive (Cho, 2003).

According to the records of the vessel buyback program carried out until recently, total 5 114 vessels were bought back between 1994 and 2006, including 1 942 coastal fishing vessels and 3 172 offshore fishing vessels. A plan to annually reduce fisheries by coastal and offshore vessels with relatively high fishing intensities was established and is currently being implemented, taking consideration on changes in domestic and international fishing conditions and fishery resources of the future (MIFAFF, 2008).

Fish stock enhancement programs

The main goal of fish stock enhancement programs in Korea is to increase fishable stocks and fishermen's revenue by improving the marine environment and restoring productivity of the natural population of fish. This fish stock enhancement program, comprised of an artificial reef program, a marine seaweeds forest program, a marine ranching program and a fry releasing program, is the second largest program with a USD 4.6 million annual budget among fishery-related programs in Korea, 2007.

Artificial reef program

One of the fish stock enhancement programs of Korea is the artificial reef program which was implemented in 1971. It is to increase fishery resources and improve fishing income by installing artificial reefs in the water to create habitats and spawning grounds for fishery resources. As a result, artificial reefs were installed nationwide in the total area of 202 141ha by 2007, and the project costs spent for the artificial reef program are shown in Table 9.2.

Table 9.2. Artificial reef program: area and expense (2004-2007)

	2004	2005	2006	2007
Area	5 668	5 263	5 450	4 698
Expense	33.8	33.1	30.9	31.0

Source: MIFFAF(2008); (unit: ha, USD million).

Marine seaweeds forest program

A marine seaweed forest not only are commercially important in themselves, but also play an important role in spawning, breeding and feeding grounds for many kind of fish, shellfish, lobster and other important fishery resources. Government stock enhance programs have been undertaken with particular attention focused the re-establishment of marine seaweed forests. This is due to declining populations that are a result of various factors, including human activities. Thus, there has been development of construction techniques of artificial foundation, for marine seaweed forests, and transplanting techniques of seed and adult marine algae, on artificial foundations.

The government will set up a marine seaweed forest program on the east and south coasts over the next 10 years to improve the marine environment and restoring productivity of the natural population of fish as well as growing edible seaweed. This

program will be spent USD 281 million over the next 10 years to grow 35,000 hectares of seaweed forests.

Fry releasing program

The fry releasing program has been operated since 1976. It was implemented in order to complement and enhance the recruitment of insufficient fishery resources by fry releasing; to increase catch limits through releasing; to increase the income of small-scale fishermen in coastal fisheries, and to promote the vitalization of fishing villages.

The records of the fry releasing program show that the total number of released fish between 2004 and 2007 was about 400 million and the types of released fish include giant prawn, flatfish, abalone, and rockfish (Table 9.3). The fry releasing program continues to expand with the local autonomous system and it is expected to grow with the necessity of fish stock recovery.

Table 9.3. Fry releasing program; 2004-2007 (unit: thousand fish)

	2004		2005		2006		2007	
	Amount	Value	Amount	Value	Amount	Value	Amount	Value
Total	100 670	8 101	92 267	8 958	128 359	10 624	84 728	15 954
Rock fish	999	299	2 787	783	1 586	674	7 701	2 286
Flounder	6 093	1 968	4 482	1 608	3 843	1 236	9 622	2 196
Black sea bream	1 988	499	2 967	562	2 598	514	5 214	1 202
Rock bream	909	348	1 045	520	2 183	867	2 694	780
Black rockfish	464	174	920	284	1 887	457	2 771	814
Sea cucumber	1059	253	1 532	358	4 310	997	2 243	558
Fleshy frawn	73 435	564	61 214	205	89 903	379	24 660	125
Abalone	3 415	2 885	3 856	2 913	3 516	3 122	5 003	4 111
Inland	6 724	716	8 744	932	12 541	1 433	10 973	1 730

(unit: thousand fries, USD 1,000)

Source: MIFFAF(2008).

Marine ranching program

The marine ranching program in Korea has been conducted at Tongyoung in the south coast, the Jeonnam archipelago and the East/West/Jeju coasts since 1998. It aims to improve marine habitats for the increased production of fishery resources. The program has been conducted using multiple networks, based on the industry-university-institute model, to establish optimum technical and model development. In particular, it involves four stages of researches; (1) understanding the ecological properties and model setup, (2)

improvement of habitat, (3) annexation of fish stocks, and (4) operation and management of marine ranching.

The outcomes gained from previous and recent projects of the program will be used in the development of several types of coastal marine ranching plans as base models. The data and experience gained from previous and recent large-scale marine ranching program will be also utilized to promote the implementation of small-scale marine ranching programs in various coastal areas.

Community-based fisheries management

Fisheries management under supervision of the government so far had been shown in negative aspects such as deepened lack of reliance of fishermen on the government, weakening of ownership, overfishing of resources and confusion in the fishing order. Limited human resource and budget of the government brought limitations to effective response to such problems.

Accordingly, the Korean government introduced a new self-management system in which the subjects of resource use, fishermen, voluntarily make decisions on management and use of resources in order to continue governmental support on fishery resource management and to administer a sustainable fishing through ownership awareness and independence of fishermen. A fishermen-oriented and community-based fisheries management has been implemented in 63 self fishing communities since February 2001, and the number of participating communities has expanded to 579 as of 2007 (MFAFF, 2008).

In community-based fisheries management, the fishing community is responsible for its own fishing management and adjusts fishing activities. If disputes occur between communities, industries or regions in promotion of community-based management fisheries, a self control conference is operated by the private to voluntarily resolve the problems through consultations and discussions. A public fishing village guidance serviceman was appointed for each participating community from Fisheries Office to provide technical guidance and advices to self-management communities. Also, private consultants with diverse experiences in fishing industries provide 1:1 customized education to communities that either show poor progress or newly participate in community-based fisheries management, inducing substantiality by suggesting problems and alternatives of communities.

Limitations of conventional fisheries management system

Despite the fact that such diverse policies for fisheries management are being used, total amount of fishery resources in the coastal and offshore seas was estimated to have reduced, though there are differences in increase and decrease of amount for each fish species. Direct and indirect causes of such reduction may include destruction of habitats by contamination of marine environment and climate changes and ecological changes in fish species. Due to geographical characteristics of fishing grounds, joint management by adjacent nations that surround the resources were not performed adequately, also bringing limitation in management and recovery of fishery resources by individual nations.

In addition, in terms of management policies related to fishing activities, conventional fishery management policies had ultimate objective in arbitration between industries and maintenance of fishing order, failing to show clear goal for resource recovery.

Management policies based on the amount of resources were not available and strict management and control of fishing activities were somewhat inactive. In particular, because of 'multi-species/multi-fisheries' characteristics of coastal and offshore fisheries of Korea, there were limitations in establishing policy management measures according to characteristics of each fish species. Furthermore, failure to effectively prevent overfishing of small fishes due to mixed fishing is also considered as one of the causes of reduction and depletion in resources (Kim 2004; Lee, 2004; Lee, 2007).

As a result, diverse fisheries management measures showed different effects on individual fish species, bringing insufficient effect in management of resources and actual recovery of overfished species. Therefore, in order to recover overfished fishery resources and improve fishing income through higher level of fishing intensity, it is of foremost importance to well understand such multi-species/multi-fisheries relationship, to configure the objectives of recovery for individual fish species, and to select fisheries management measures that can effectively achieve the configured objectives.

The establishment of ecosystem based FSRP

The establishment of ecosystem based FSRP: background and concept

The Korean government established the basic plan for the ecosystem based FSRP and its fisheries management policy in order to overcome the limitations with the conventional fisheries management policy and to achieve an actual recovery of fishery resources within EEZ since the UN Convention on the Law of the Sea, Korea-Japan/Korea-China Fishing Agreements have come into effect.

More specifically, due to the multi-species/multi-fisheries characteristics of coastal and offshore fisheries of Korea, the conventional fisheries management measures and stock enhancement programs could not properly manage and recover individual fish species separately, although they contributed to increasing and maintaining overall fisheries productivity. However, under the new EEZ regime, the Korean government has begun to genuinely acknowledge the necessity of policies for management and recovery of individual species to manage all fish species and achieve a sustainable and economically viable development of fisheries. Under this background, the ecosystem-based FSRP, combined with conventional management measures and stock enhancement programs, has been developed and established.

Also, as a community-based fisheries management has proliferated since 2001, fishermen and fishing communities started to recognize the importance of stock management and recovery, and voluntary participation of fishermen in establishing necessary fisheries management policy was systematized. It has increased the necessity on the recovery of depleted individual fish species by fishermen themselves and government jointly. This situation also enabled the FSRP to be established and implemented with high level political supports.

Ecosystem based FSRP is the comprehensive plan to rebuild fish stock that is excessively hunted to a target level within a certain period of time. More specifically, the policy aims to increase the level of fish stock from the current level to a target level within a rebuilding period, so it consists of a series of specific and scientific fish stock management programs including selecting the most effective fisheries management measure as well as complementing any necessary fishery management supports.

Management objectives of ecosystem based FSRP

The overall objective of the Ecosystem based FSRP and its fisheries management policy is to enhance the total fish stock to the level of 10 million tonnes by 2015 in order to maintain the stable catch limit of 1.3 million tonnes annually in offshore and coastal fisheries. It is expected that this aims to reach the optimum quantity of fishery resources that the ecosystem in Korea offshore and coastal seas can retain, to break the chains of a vicious cycle of resource exploitation and the aggravation of business conditions of fisheries, and to maintain a stable fishery production.

Action plans of ecosystem based FSRP

In specific ecosystem based FSRP, the management and recovery of fishery resources are attempted by dividing them to recovery target fish and management target fish with consideration of stock condition by species of fish. That is, for fish whose stock has drastically decreased, a fish stock rebuilding plan is set up and promoted, while a management plan is set up and promoted for fish with low decreasing rates. Here, when TAC target species are key staples, intensive management is to be provided with the TAC management policy. And the selection of species of fish for stock rebuilding and the target quantity of recovery are supposed to be determined through a series of steps in the order of understanding the condition of fishery and biological resources in offshore and coastal seas; examining applicable materials and recovery target fish; classifying fish to recovery target fish and management target fish; and setting the target quantity of recovery for each stage.

The selection and management of recovery target species

The information available to evaluate the state of fish stock by species of fish is only the catch of fish by year for the most except for a few species of fish. To evaluate the state of fish stock by using the data on the catch of fish by species of fish, according to the method used by Garibaldi and Caddy (2004), the three-year moving average of the fishery-related data was analysed. Then, when the current level of catch is less than 20% to the maximum value of moving average, it was categorized as a depleted resource. More specifically, from the fisheries production statistical data, the three-year moving average values between 1990 and 2004 (15 years) were calculated for 93 fishery classified species excluding those classified as marine algae and others. With the highest moving average value as a base, the levels of fishery as of 2004 were evaluated.

From the first analysis, the species of fish decreased by 30% and lower were selected recovery target species. Meanwhile, since fish stock considerably decreased before the 1990s, the data from the first analysis could not properly reflect the state of stock by species of fish, so the fluctuation trends of catch by species of fish were analysed to add more recovery target species. That is, with consideration of the characteristics in the fluctuation trends of catch, they were divided (i) increasing, (ii) stable, (iii) fluctuation, (iv) decreasing after increasing, (v) decreasing, (vi) low, and (vii) very low; and the species of fish in (v), (vi), and (vii) were finally selected as recovery target species. Among the species excluded from recovery target species, the levels of fish stock that are (i) increasing, (ii) stable, and (iii) fluctuation were selected as management target species.

Setting the target volume for each stage

In setting the recovery target volume for recovery species and management species of fish stock, the aforementioned method used by Garibaldi and Caddy (2004) was applied again to evaluate and determine the current level of fishing with the highest three-year moving average between 1990 and 2004 as a base value. Recovery target volume in particular was determined for mid-term (by 2012) and long-term (2017) plans.

Since stable stock recovery is needed for depleted fishery resources, the mid-term objective is to increase by 10% of the current level as a stage to create the foundation for recovery. And the long-term objective is to rebuild fish stock to a stable level and maintain the consistent fishing through efficient management, and its target is set to increase by 30% of the current level. The mid- and long-term target volumes are set with a premise that policy efforts are to be made for the future stock enhancement through efficient resource management, fish stock expansion, and environmental improvement of fishing ground. Therefore, in the mid-term plan, more efforts are focused on the expansion and management of fish stock rather than substantially increasing catch limits in a relatively short period of time. The long-term plan aims to increase a catch of fish by stock enhancement with a premise to achieve richer fish stock.

However, as shown above, in setting the mid-and long-term target numbers, there is a problem of not considering bioecological and resource-dynamic characteristics for individual species of fish. Therefore, in addition to the first target volume estimated from the analysis of fishing activities, an amount of possible recovery for each rebuilding period was estimated with additional consideration of stock parameters (growth, maturity, lifespan, natural mortality, and generation time) by species of fish. And, based on this, the mid-term (by 2012) and long-term (by 2017) recovery target volume was determined as shown in Table 9.4.

Table 9.4. Mid and long-term recovery target volume (unit: metric tonnes)

	Current Catch (2004)	Mid-term Targets (2012)	Long-term Targets (2017)
Recovery Target Species (40 species)	169 467	219 480	294 490
Management Target Species (40 species)	827 591	912 020	999 220
Others	79 629	81 310	183 960
Total	1 076.687	1 212.810	1 477.670

Source: MOMAF (2005).

FSRP operational plan by stage

It is impossible to establish and promote the FSRP for all recovery target and management target species in the current policy conditions with insufficient scientific research and review system of fishery resources and a lack of fish stock management organizations in local governments. Therefore, including the stage to establish a basic planning, the fish stock recovery plans are divided into mid-term and long-term plans. That is, the creation of foundation and the establishment of a system for the operation of the ecosystem based FSRP will first allow the mid-term goal to be achieved, and then the expansion and settlement in the long-term period can raise the effectiveness of the policy.

Operational objectives and promotional strategies for each FSRP stage are: Stage 1 – mid-term and long-term basic planning (2005); Stage 2 – the establishment of fish stock recovery system thru a pilot program of fish stock recovery (2006-2010); Stage 3 – the settlement of the fish stock recovery system through the unidirectional expansion of the ecosystem based FSRP (2011-2015) (Table 9.5). Also, in order to reach the set target volume, a pilot project, the reinforcement of fish stock research & evaluation by species, and pre- and post-management for fisheries management measures will be executed step by step.

Table 9.5. FSRP operational plan by stage

	Operational Objectives	Enforcement Strategies
Stage 1 (2005)	Establishment of Basic Mid and Long-term FSRPs and Institutional Improvement	[Establishment of a Master Plan] - Institutional improvement for implementing FSRP, including enactment of new 'Fisheries Management Act' - Establishment of annual mid and long-term FSRP - Establishment of fisheries management system and assignment of roles for governments and fishermen - Selection of species for pilot projects and establishment of FSRPs
Stage 2 (2006-2010)	Implementation of FSRPs for Species	[Mid-term Plan] - Establishment of targets that maintain a total catch at 1.2million tonnes - Implementing pilot projects for 7 species by 2007 - Establishment and implementation of FSRPs for 29 species by 2010
Stage 3 (2011-2015)	Settlement of FRSP-based Fisheries Management System	[Long-term Plan] - Achievement of targets that sustain a total catch at 1.5million tonnes - Establishment and implementation of FSRPs for 40 species for rebuilding - Transition from establishment of species-based FSRPs to ecosystem-based FSRPs - Review and revision of FSRPs

Source: MOMAF (2005).

Pilot projects

The significance of a pilot project before the promotion of the ecosystem based FSRP is to minimize errors and trials and to secure a solid implementation of the FSRP policies. In addition, it aims to increase efficiency of the policy by developing and proposing a management model which represents the characteristics by sea area, species of fish, and type of fisheries, and to expect ripple effects by target species, area, and type of fisheries through extending a pilot project year by year.

The criteria to select the species of fish for pilot projects are: first, among recovery target species, those that can be considered in the development and proposal of a management model which can accommodate different characteristics by sea area, species, and type of fisheries, and that can be included in annual extension of the FSRP through pilot projects; second, the species with high feasibility of monitoring and of acquiring the information needed for fisheries management as well as economic efficiency and artificial supervision; third, the species that can provide the ecological information for target fish stock; and, fourth, the species that allows participating fishermen to form a cooperative system and that makes it each to form an autonomous management organization.

According to these criteria, for the 2006 Pilot Project, *haliotis japonica* in Jeju area, *red crabs* in West Sea, *octopus* in South Sea, and *sandfish* in East Sea were selected, which represents the characteristics of each sea area, species, and type of fisheries. Therefore, since 2006, a pilot project with these pilot species has been promoted based on a basic plan (Table 9.6) on specific management target sea area for individual species, management subjects, a target limit of catch, rebuilding period, and specific recovery measures.

Table 9.6. A plan of pilot projects

	Blue crab	Sandfish	Octopus	Tokobushi abalone
Sea area	West sea	East sea	South sea	Jeju Island
Species	Crustacean	Fish	Cephalopod	Shellfish
Types of Fisheries	Coastal and offshore gill nets, coastal traps, coastal stow nets	Eastern sea trawl and Danish seine, Coastal gill nets	Coastal longline and traps, West southern Danish seine	Diving
Management Body	MIFFAF	MIFAFF	Local government	Local government
Characteristics of Species	International management needed	Coastal and Offshore Migratory	Coastal sedentary	Coastal sedentary
Current Management Measures	Closed seasons and TAC	Size limit (under 10cm)	-	Size limit and closed seasons
Targets (2004→2015)	2,683→8,100 tonnes	2,472→3,100 tonnes	7,023→11,000 tonnes	19→100 tonnes
Rebuilding Measures	Adjustment of closed seasons, MPA, fry-releasing program	Adjustment of size limit and MPA	Protection of habitats and control illegal fishing	Adjustment of size limit and fry-releasing program

Source: MOMAF (2005).

Management and operation system of ecosystem based FSRP

Under the new ecosystem based FSRP, unlike the former government-oriented fisheries management system, a joint management system is established where actual actors in fisheries can participate to establish, execute and evaluate basic plans. Accordingly, under the ecosystem based FSRP, it is planned that roles and functions will be efficiently distributed among central government, local governments, research institutes, and fishermen.

Furthermore, the Science Committee (SC) and the Fishery Resource Management Committee (FRMC) were newly organized for the joint participation and role assignments of those who are related to fisheries. The SC consists of experts from diverse areas (resources, ecology, statistics etc.) to establish and promote a recovery plan based on the various and collected information from different scientific areas, and it is in charge of making suggestions of measures needed for fish stock rebuilding based on the data from research and review from a scientific point of view. It is planned to carry out the operation of the plan by having four zones – East Sea, West Sea, South Sea and Jeju Island and making a committee for each sea zone.

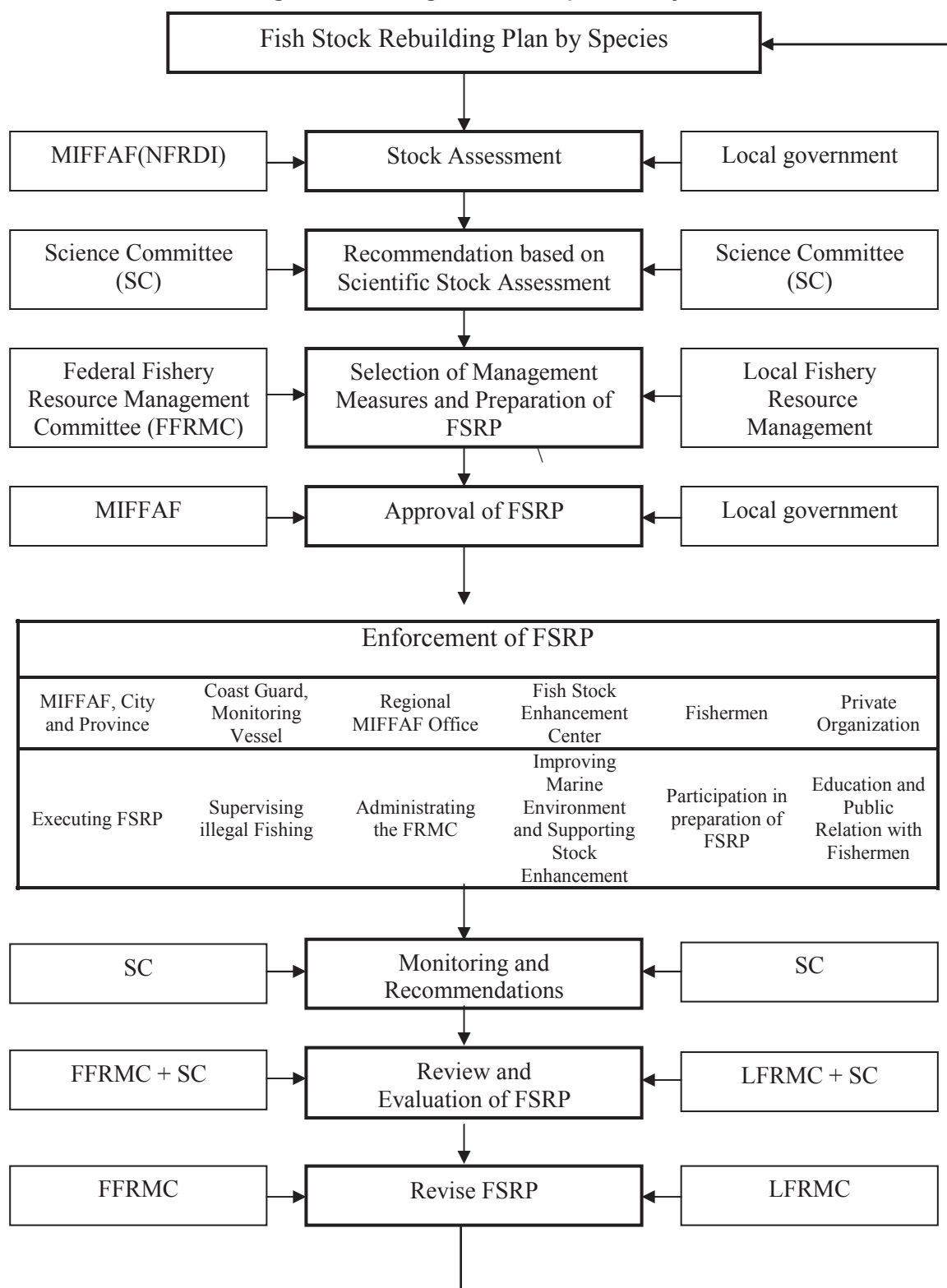
The FRMC is in charge of an intensive management of recovery target species and it is composed of with about 10 persons from government officials, academic scholars, and fishermen related to those species of fish. The head office will be housed in MIFFAF, and the Federal Fishery Resource Management Committees (FFRMC) attempts to supervise commercial species and migratory species and the Local Fishery Resource Management Committees (LFRMC) supervises the coastal sedentary species.

Including the SC and the FRMC, the overall operational system of the ecosystem based FSRP and the functions of each facility are as shown in Figure 9.3. That is, the NFRDI conducts a scientific research on fish stock for recovery target species and writes up suggestions, and then the FFRMC and LFRMC make action plans for fish stock rebuilding. Afterwards, the FFRMC and LFRMC reads all suggestions made by participants from nongovernmental, governmental, and academic fields to determine effective fisheries management measures for fish stock rebuilding. Then, the FRMC requests the central and local governments for an approval of the ecosystem based FSRP. Upon the approval, the FSRP can be pushed forward in a full scale. The FFRMC and LFRMC and the SC annually review and evaluate the progress of the ecosystem based FSRP and recommend any revisions or supplementary items for individual policy.

Characteristics of Korean Ecosystem based FSRP

Korea's ecosystem based FSRP has been established from a holistic approach at the national level and it also has adopted an ecosystem-based approach to fisheries management explicitly as a policy framework.

It was primarily aimed to achieve fish stock recovery by overcoming the limitations of the conventional fisheries management policy, so it is different from the conventional fisheries policy in many ways. First, while the conventional fisheries management policy does not have a clear goal of stock rebuilding, ecosystem based FSRP specifies the target fish stock recovery in policy.

Figure 9.3. Management and operation system of FSRP

Second, the conventional fisheries management policy was implemented not perfectly based on scientific research and evaluation on fishery resources, ecosystem based FSRP specifies which type and what content of a fishery management measure will be used after making a diagnosis of the condition of fish stock by sea area and by type of fish and establishing a clear stock rebuilding goal and rebuilding period with consideration of the characteristics of target resources.

Third, under the conventional fisheries management system, the policies were established on the initiative of the central government, restricting the participation of fishermen. However, the new ecosystem based FSRP premises the voluntary participation of fishermen, allowing fishermen to voluntarily participate in setting up and executing the plan as well as making them responsible for the outcome.

Fourth, in the application of the conventional fisheries management measures, any analysis before and after the application was absent so it was difficult to operate it with efficiency. But ecosystem based FSRP requires an analysis on a management measures by species of fish, type of fisheries, and sea area before and after an operation so that fisheries management measures can be utilized more effectively.

Fisheries management in Korea traditionally had the purposes of resolving disputes between fisheries, maintaining fishing order, and increasing fishing income of fishermen according to the multi-fisheries/multi-species characteristics. Accordingly, resource management also enforced measures for fishing effort for each fishery and technique restrictions instead of managing individual species separately. Artificial reef programs were actively implemented to increase overall fishery resources of the coastal seas from the viewpoint of overall ecosystem. In addition, commercially important species were specially managed and increased through the fry releasing program.

However, interests on policies for management and recovery of individual species increased ever since enforcement of plans to recover fishery resources, and such effort is characterized by emphasis on 'durability of fisheries' through management of individual species in connection with conventional stock enhancement programs. That is, unlike other nations, recovery of fishery resources is not only promoted through direct restrictions (or entire suspension of fisheries for fast recovery of resources) on fishing activities. Instead, while maintaining fishing activities through restrictions on individual fishery resources based on ecological system and fishery resources, the system allows effectively and quick recovery of resources. As a result, suspension or contraction of fishing activities due to resource recovery can be minimized. Accordingly, fishing business can be maintained with relative stability while promoting resource recovery at the same time.

Another characteristic of Korean ecosystem based FSRP is that it premised voluntary participation of fishermen by connecting with community-based management fisheries. Self management fisheries of Korea newly systemized the traditional management of fishing community focusing on fishing village communities. In this system, fishermen communities make voluntary decisions for them to manage and use available resources. Such community-based management fisheries can be linked with fish stock rebuilding plan to actively reflect the opinions of fishermen in establishing the plans and to obtain active participation and co-operation of fishermen in management. In particular, it is advantageous in that the efficacy of FSRP can be maximized through voluntary acceptance of restrictions for resource recovery and self control on unlawful fishing.

Biological and economic effectiveness of FSRP

Biological and economic benefits of ecosystem based FSRP

It is difficult to clearly describe the effects of ecosystem based FSRP conducted since 2006. Accordingly, the subject was limited to fisheries that had been selected as pilot projects for ecosystem based FSRP for 2006~2007 to briefly analyse biological and economic benefits from accomplishment of recovery objective.

Seven FSRPs have been established until now and are being implemented, including sandfish, blue crab, octopus and tokobushi abalone in 2006 and skate ray, cod and yellow croaker in 2007. These species were selected based on the recovery target standards mentioned in chapter III based on catch in 2004. Objective recovery amounts for each step were configured. Comparing the catch in 2004 and 2007, as shown in Table 9.7, the amount was increased in most of species. Though such increase in the catch cannot directly be stated as a result of performing fish stock recovery plans, it probably has resulted from control of fishing effort under the plan, protection of spawning grounds and active stock enhancement programs.

Table 9.7. Biological and economic effectiveness

Species	2004 Catch	2007 Catch	2012 Target Catch	Recovered Volume	Price (USD/kg)	Increase in Fishing Revenue
Sandfish	2 472	3 767	4 000	1 528	2.24	3.4
Blue crab	2 683	13 606	14 000	11 317	7.98	90.3
Octopus	7 023	6 625	11 000	3 977	11.82	47.0
Tokobushi Abalone	19	62	200	181	24.57	4.4
Skate Ray	259	375	500	241	11.67	2.8
Cod	2 641	7 533	8 000	5 359	2.69	14.4
Yellow Croaker	17 570	34 221	35 000	17 430	3.34	58.2
Total	32 667	66 189	72 700	40 033		220.5

(unit: M/T, USD million)

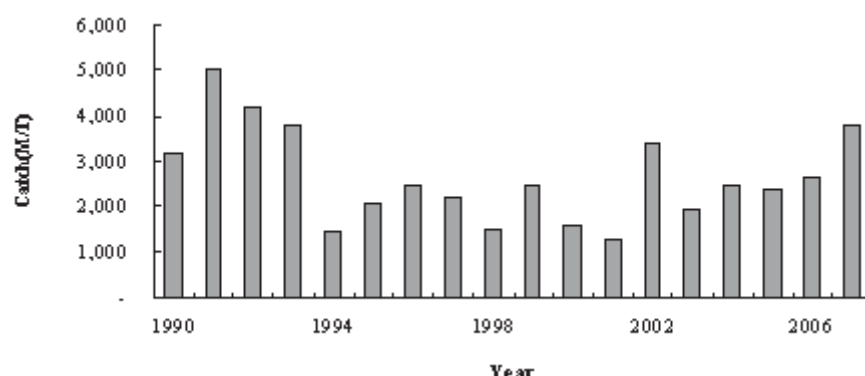
In addition, due to the limitations of available data on anticipated economic effects, increase in fishing income from resource recovery was simply analysed. Once the amount of catch of 2004 is subtracted from the objective amount of catch for the midterm (2012), recovery amount during the period can be calculated. Once this amount is multiplied by average market price, annual increase in fishing income for each species can be calculated. As a result of analysis, annual fishing income increase varied from 2.8 million USD to 90.3 million USD according to species.

Case Studies

Case 1: Sandfish Ecosystem based FSRP

Sandfish was selected as the target of ecosystem based FSRP for the East Sea region of Korea in 2006 because of large reduction in catch from destruction of spawning grounds and overfishing of adult resources and fingerlings. As shown in Figure 9.4 below, the amount of sandfish catch in early 1990s was about 5 000 tonnes but was reduced to about 2 500 tonnes by 2004.

Figure 9.4. Annual change in sandfish catch (1990-2007).



While sandfish is being caught by various fisheries, main fishing is done by East-sea trawl and coastal gill-net fisheries. Ecosystem based FSRP for sandfish was found to require resolution of disputes between fisheries and settlement of means to recover the resource through natural scientific resource investigation. Looking at the promotion accomplishments of ecosystem based FSRP for sandfish, the science committee performed investigation on the amount of available resource, selection of protected spawning grounds, TAC, and adjustment of gill-net size to 53mm or larger. Also, a fishery resource management committee composed of 16 management and operating system supervisors was formed to hold field presentations and discussions, actively performing policy promotion activities.

Also to induce active and voluntary participation of fishermen and maximize effectiveness of ecosystem based FSRP, an agreement was concluded with fishermen organizations in connection to community-based management associations. Voluntary agreements by fishermen were conducted on amount of fishing gear by vessel, limitation on trip days of fishing and appointment of spawning protection regions. Active participation of fishermen on the recommendations of the science committee was also discussed.

As a result of promoting such ecosystem based FSRP for sandfish, various fisheries restrictions are being observed well and the cases of unlawful fishing have greatly reduced. As a result, the amount of catch actually began to increase in 2006 to reach 3 769 tonnes in 2007, which is about 52% increase compared to 2004 (Figure 9.4). CPUE per vessel also increased from 0.44 in 2004 to 0.78 in 2007, showing a recovering trend of resource.

Case 2: Blue Crab Ecosystem based FSRP

With the peak of 32 000 tonnes in 1988, the amount of blue crab catch was reduced largely to about 2 700 tonnes by 2004. Accordingly, blue crab was suggested as a species that needs resource recovery and was selected as the target species of ecosystem based FSRP in the West Sea region of Korea since 2006.

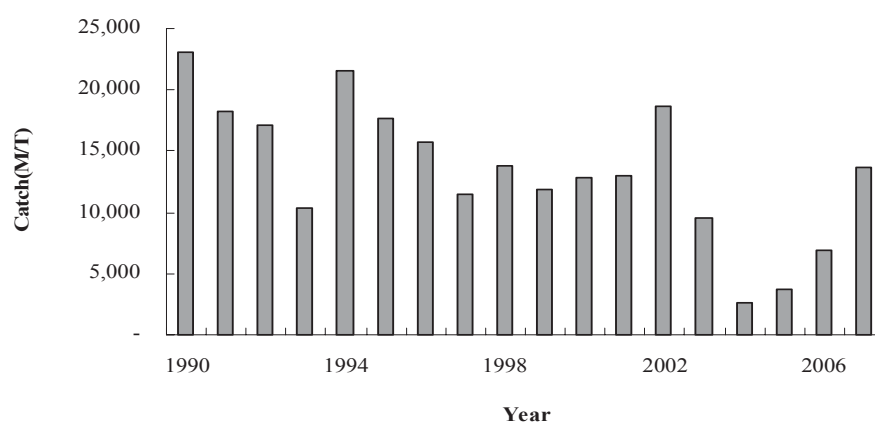
Looking at the promotion accomplishments of ecosystem based FSRP for blue crab, the science committee performed investigation on available resource, configuration of fishing prohibition period (September 1~20) during the main growing period of blue crab, configuration of fishing prohibition period (October ~ March) for protection of small sized blue crabs, and modification of prohibited length standards.

In addition, while promoting policy activities by the fishery resource management committee through field presentations and discussions, ecosystem based FSRP on policy measures and business priorities was established and prepared. Also to induce active and voluntary participation of fishermen and maximize the effects of ecosystem based FSRP, an agreement was contracted with fishermen organizations in relation to regional self management fisheries. In the agreement, duties of the government and local entities and duties of self management fishing communities were regulated. The government and local entities were made to monitor unlawful fishing activities of foreign vessels, performance of fishing control businesses, controlling of young blue crab fishing, and protection of spawning grounds.

Self management communities agreed to voluntarily perform prohibition of fishing of young blue crabs under the prohibited length, use of fishing tools with appropriate sizes, observance of fishing prohibition periods, and voluntary control of unlawful fishermen. Also, a fry releasing program was expanded to recover the blue crab resource. 909,000 blue crabs were released in the period of 2006-2007.

As a result of such active development of FSRP for blue crab, the amount of catch was found to have increased largely until now. The catch amount that stayed at 2 700 tonnes in 2004 was increased to 6 900 tonnes in 2006 and 13 600 tonnes in 2007. The science committee is currently investigating the resource of blue crab according to changes in catch and is planning to more accurately estimate the stock biomass and catch changes in the future. Based on accurate estimation, the committee will continue to supplement for the measures necessary to further recover the resource.

Figure 9.5. Annual change in blue crab catch (1990-2007).



Some Challenges

As described above, ecosystem based FSRP of Korea has not been in operation for long and therefore accompanies difficulties in judging the results. However, the amount of resource and catch of target species have so far been increasing with management by the science committee and regional fishery resource management committees, voluntary observance of recovery measures by fishermen, supplementation of conventional fishery management measures and fish stock enhancement programs. However, there are several challenges to enforcement of ecosystem based FSRP pilot projects, and such challenges can be summarized as follows.

First, while diverse data on the causes of reduction and depletion in fishery resources must be collected and effective plans must be established based on such data, the lack of available data brings limitation in establishment of plans to maximize resource recovery. In addition, the number of species that can be evaluated is limited, resulting in limitation on expansion of plans based on evaluation results of resource amount. Accordingly, investigation and data collection on resources, environment, ecology and production must continuously be expanded to more accurately and comprehensively examine various causes of reduction and depletion in fishery resources.

Second, properly functioning policy measures must be selected and utilized for actual recovery of resources. Particularly in the recovery of fishery resources, though direct restrictions on fishing activities to lower fishing pressure are necessary, policy measures that improve marine environment and reduce contamination of fishing grounds must be accompanied simultaneously. The current ecosystem based FSRP emphasize policies that reduce the fishing pressure and increase resources; they tend to neglect reclamation projects, ocean bottom sand gathering businesses, and waste (garbage) disposal in the seas that can contaminate the coastal fishing grounds. Although the departments that enforce such matters differ, related enforcement departments must mutually cooperate to maximize the efficacy of resource recovery plans.

Third, as indicated in limitations of conventional fisheries management, coastal fisheries of Korea show incomplete fulfilment of ecosystem based FSRP on individual species due to multi-species/multi-fisheries characteristics. Accordingly, the effects of ecosystem based FSRP for individual species on other related species must also be taken into consideration. Furthermore to accomplish recovery of overall fishery resources, ecosystem based FSRP must gradually be established. Means to systematically manage related multi-fisheries must also be looked for.

Fourth, as in the case introduced earlier, ecosystem based FSRP of Korea presumes voluntary participation of fishermen by connecting with community-based management fisheries by fishermen organizations. As a result, fishermen are voluntarily accepting the measures to manage and control the fishing resources, bringing satisfactory results. However, strengthened restrictions on fisheries with development of ecosystem based FSRP may cause losses in fishing income during the recovery periods and inflict limitations on recommending active and voluntary participation by fishermen. Accordingly, measures to support fishermen through stabilization of fishing business during such recovery periods must be considered in order to induce active participation (for example, supports for reduction in fishing effort such as limitation on the number of fishing days and suspension system, improvement of fishing grounds for selective fishing

of small sized fishes and avoidance of mixed fishing, aids for expenses on disposition of fishing gears, and support system on training of fishermen).

Fifth, major coastal and offshore species of Korea are jointly utilized in the EEZ of East Sea, West Sea and South Sea by Korea, China and Japan. Therefore, operation of ecosystem based FSRP only by Korea cannot obtain complete efficacy in resource recovery. A joint regional fisheries management system between Korea, China and Japan must be established in the future to mutual cooperate on large marine ecosystem based FSRP between adjacent nations.

Conclusion

The newly established ecosystem based FSRP and its fisheries management policy are meaningful for it realizes the limitations of the conventional fisheries management policy and it changes the policy focus by shifting the objective of fisheries management policy from the maintenance of fishery order or the fishery adjustment to fish stock recovery. And establishment of an ecosystem based FSRP that can more effectively and quickly recover the fishery resources through controlling of individual resources based on creation of ecological system through traditional stock enhancement programs is also meaningful. Furthermore, preparation of a new management system for ecosystem based recovery of fishery resources and promotion of participation of fishermen by connecting with traditional self management fisheries can also be considered as important. This new fisheries management policy could satisfy international recommendations including the 1995 FAO Code of Conduct for Responsible Fisheries, so a prospect is that the policy would make a strong contribution to the management and rebuilding of domestic fish stock.

The new ecosystem based FSRP is showing an increase in amount of catch and corresponding economic benefits through pilot projects. However, it has yet to improve many aspects including a system of research and evaluation of fish stock, scientific analysis of the effects of the fisheries management measures, a management system involving active participations of fishermen, and the establishment of fishermen support system. Also, there are many who voice their concerns on if the fixed mid-term and long-term target numbers can be actually achieved.

Instead of a hasty conclusion of the new ecosystem based FSRP and its fisheries management system, if we can address these problems to strengthen the policy, the sustainable and stabilized development of fisheries, which actively utilizes the characteristics of fish stock, can be promoted. Also, in order to achieve an expected success in practical stock rebuilding, confining the policy development for the ecosystem based FSRP to Korea may present the limitations due to particular characteristics of fishery resources. Thus, it is important to continue this endeavour for fish stock recovery with adjacent countries like China and Japan. Japan in particular has implemented the ecosystem based FSRP since 2001, so if a ecosystem based FSRP is established and effectively implemented jointly by Korea and Japan for fishery resources migrating between the two countries, the effects of an effort to fish stock recovery in offshore and coastal seas around Korea could be maximized. Also, while the current ecosystem based FSRP is operated by species, if the ecosystem base FSRP can be gradually expanded to encompass the whole ecosystem, and this ecosystem-based FSRP may be more effectively manage and rebuild fish stock for all species of fish in offshore and coastal waters surrounding Korea.

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Chapter 10.

Rebuilding the stock of Norwegian spring spawning herring:

Lessons learned¹

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Abstract

Norwegian spring spawning herring is one of the largest pelagic fish stocks in the world and sustains fisheries conducted by fleets from the EU, Faeroe Islands, Iceland, Norway and Russia. The fish stock has been exploited for centuries, but its size has been subject to dramatic changes. In the late 1960s a fishing pressure, too high to what the stock could sustain, led to a collapse of the fish stock. The stock stayed at a low level for nearly two decades, until it once again recovered to its historical levels.

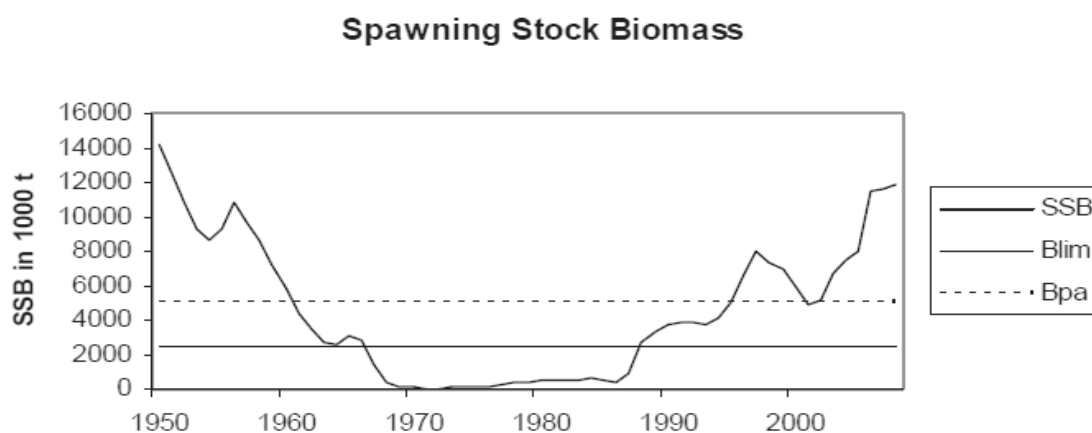
This chapter gives some background information about the stock and its collapse as well as the regulatory measures adopted to facilitate the recovery of the stock. It also discusses economic consequences of improving the exploitation pattern and exploitation rate in the fishery. The chapter concludes by stating lessons learned during the rebuilding period.

Introduction

The stock of Norwegian spring spawning herring (NSSH) in the Northeast Atlantic is one of the largest pelagic fish stocks in the world. The stock has sustained fisheries in Norway for centuries, in Iceland from 1900, and later by the fleets of Faeroe Islands, Russia and the European Union. However, during the 1960s non-optimal exploitation rate and pattern of the fishery led to the collapse of the stock.

Despite strict regulations, the stock remained at a historical low level for nearly two decades. This had severe economic consequences for the fleets traditionally exploiting the stock. At the end of the 1980s, the growth of the stock increased and the stock is now at same level as it was during the 1950s. Figure 10.1, borrowed from the International Council for the Exploration of the Sea (ICES) shows this remarkable development of the spawning stock biomass (SSB) of NSSH.

Figure 10.1. Spawning stock biomass of norwegian spring spawning herring 1950-2008..



B_{lim} and B_{pa} reflects biological reference points utilised in the current Harvest Control Rule for the stock

Source: ICES, (2008).

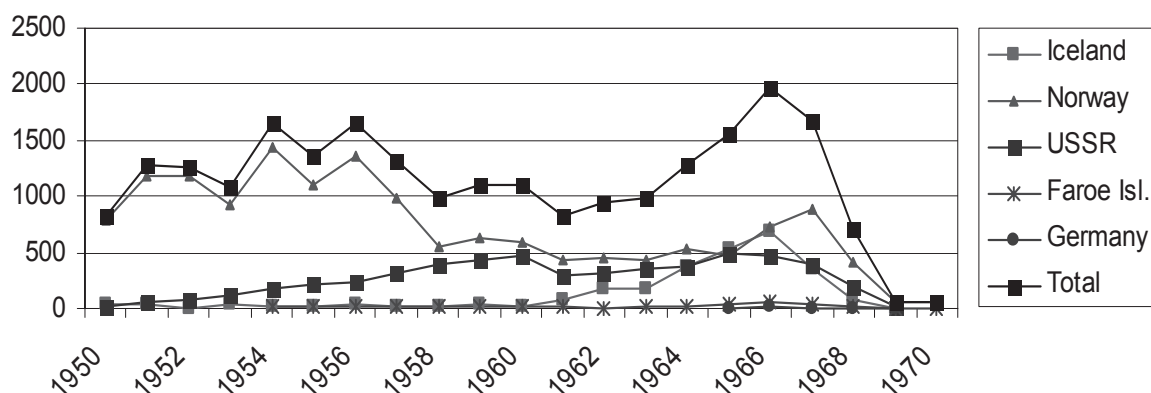
The dramatic changes in stock size pose some questions related to the regulation of the stock. First, what was done to prevent the decline of the stock towards the end of the 1960s? Second, what were the main regulatory measures implemented during the period when the stock was down and slowly recovering (1970 to late 1980s)? And third, what has been done to avoid a new collapse of the stock in the future? In the following, these questions will be addressed in a chronological order.

The period 1950-1970

Four parties exploited the fish stock during the period 1950-1970. These were the Faeroe Islands, Iceland, Norway and the USSR². Figure 10.2 shows the development of aggregate annual catches of each party during this period. The figure shows that annual catches varied substantially during the period and that the stock sustained large catches until it collapsed completely. The highest catch ever recorded occurred in 1966, and three years later the catch was only a minor fraction of this. Even though the stock declined during the period, remaining schools of herring were easily targeted and the catches on these reduced the stock even further. Data on the operating profitability of the

participating vessels from this period of stock decline is not available, but it can be concluded that it must have been positive for a number of vessels. The annual Norwegian catches and value of these catches during this period is shown in Table 10.1.

Figure 10.2. Aggregate catch by the parties harvesting norwegian spring spawning herring 1950-1970. (thousand tonnes).



Source: ICES, 1969.

Table 10.1. Aggregate norwegian catches and value of catches (in 2004 NOK) 1950-1970.

Year	Aggregate Norwegian catches (in tonnes)	Aggregate value of Norwegian catches (in 2004 NOK)
1950	885 129	1 896 527
1951	1 192 979	2 407 837
1952	1 200 899	2 315 053
1953	943 609	1 948 448
1954	1 457 294	2 669 660
1955	1 127 659	2 403 851
1956	1 367 519	2 954 448
1957	1 001 474	2 230 991
1958	598 161	1 362 044
1959	698 287	1 651 716
1960	671 615	1 546 043
1961	527 783	1 256 261
1962	543 699	1 345 288
1963	476 242	1 134 727
1964	545 461	1 135 578
1965	473 052	1 047 567
1966	729 671	1 649 623
1967	877 793	1 356 934
1968	416 482	714 671
1969	51 255	150 389
1970	62 914	255 235

Source: Statistics Norway (1994).

The Norwegian catches were at their highest in 1954, whereas the *value* of the catches was at its highest two years later (in 1956). Both in terms of quantity and value, the Norwegian fishery in the 1960s was reduced in relation to the 1950s. Then, from 1967 to 1968 the catches were reduced by 52%, and furthermore by 88% from 1968 to 1969, and the collapse was evident.

Neither exploitation rate (total catch) nor exploitation pattern (which size of fish to target) were regulated in this period. There was however a growing concern among the nations around the Northeast Atlantic of the need to regulate major fisheries in the area. The first regional organisation to address these questions was The Permanent Commission which' charter entered into force in 1953, followed by the Northeast Atlantic Fisheries Commission (NEAFC) in 1963. Reading through the Reports of the annual meetings of NEAFC from 1963 and onwards shows that the first concern about the Atlanto-Scandian³ Herring stocks was raised in 1968 where it is stated that the delegation from USSR drew the attention to a serious decline in the stock of Atlanto-Scandian herring in the Norwegian Sea and advocated the introduction of conservation measures. The chairman of the Liaison Committee⁴ informed the Commission that ICES was giving priority to the research on both North Sea and Atlanto-Scandian herring stocks, but that the speed with which advice could be presented to the Commission was limited by the availability of relevant statistics.

At the annual meeting of NEAFC in 1969 deep concern was expressed by several delegations on the serious decline of the Atlanto-Scandian herring stocks. It was agreed to set up a special ad hoc study group comprising administrators and scientists from the interested countries to examine the conclusions which the Liaison Committee should submit at its next meeting.

In light of the serious reduction of catches one may question why no stronger action was taken. Although both exploitation rate and exploitation pattern were discussed among the scientists within ICES, there was no clear recommendation to improve the exploitation pattern by increasing minimum landing size or reduce exploitation rate by restricting catches until the collapse was evident. It should however be noted that the institutions for dealing with fishery management was less powerful than today. Although NEAFC already was there as an instrument, no coastal nations had established their Exclusive Economic Zones (EEZ). Thus, NEAFC's regulatory area was vast and far larger than today. For regulations like minimum size on fish or quota restrictions to be effective there would be a need for international agreement on monitoring, control and surveillance. None of these were in force. With no regulation of total catch, the basis for agreement on how to allocate catch among the participants was also lacking. Thus, the whole fishery in the 1950s and 1960s can be characterised as an "open access" fishery. For a pelagic species that form schools, and where the operating profitability of the fleet was less affected by stock decline than would be the case for a demersal species, such an open access fishery proved fatal for the stock.

In addition to the extensive fishery, natural conditions were not favourable to the stock at the end of the period. Toresen and Østvedt (2000) have later stated that fluctuations of the stock of NSSH primarily were due to the effect which environmental conditions had on recruitment. Unfortunately, this also proved to be the case in the years to come after the collapse.

The period 1970-1990

As can be seen from Figure 10.2, aggregate landings rose to an all-time in 1966 after which it dropped to unprecedented low levels. The fishing fleets' inability to spot schools of herring was a clear indication of the collapse.

The collapse must have come as a surprise to many of the participants in the fishery. Within the scientific community the collapse gave weight to those who for some time had argued that the fisheries were at a level which the stock could not sustain in the long run. There were two main worries;

- First, Norwegian fishermen had conducted a fishery on small herring. It was argued that this had been detrimental to the development of the stock since the small herring were caught before it had benefited from its growth potential. In addition, being caught before it matured, these specimens could not contribute as spawners. Thus, the Norwegian fishery was recognised as an example of *growth overfishing*.
- Second, the aggregate catch had clearly been at an unsustainable level, so the total fishery was recognised as an example of *recruitment overfishing*.

The first worry could be rectified by establishing a minimum fish size, below which there should be no targeted fishery. To address the second, there would be a need to restrict the overall catches, either indirectly by introducing effort regulation, or directly by regulating catch.

As noted above, at its annual meeting in 1969 NEAFC had set up a special ad hoc study group for the Atlanto-Scandian herring stocks. The report from this group was discussed at the annual meeting of NEAFC in 1970. The group had agreed that a minimum size limit of 25 cm for immature herring and a quota system for adult herring should be introduced. According to the report from the meeting, there were various suggestions on which way to take these suggestions further. Whereas Norway had established a minimum size of herring at 20 cm, Iceland and USSR had established minimum sizes of respectively 25 and 26cm. The latter two had also introduced strict quota restrictions.

At the annual meeting of NEAFC in 1971 Denmark, Iceland, Norway and USSR informed that as from 1 January 1971 they had already agreed to take unilateral steps to restrict catches of mature herring to the quantity caught in 1969 and to restrict catches of small herring to 70 % of the 1969 catch⁵. For the year 1972 the three parties Iceland, Norway and USSR agreed to restrict catches further down to 45% of the 1969 catches and to 26% in 1973.

At the annual meeting in 1973, Norway proposed a ban on the fishery on NSSH with the exception of a limited quantity of herring for consumption or bait. The meeting recommended that as from 1974 fishing for herring should be prohibited in ICES areas I, II and Vb, with the exemption of a quantity of small herring no greater than 20% of the catch in 1969. This percentage was further reduced to 10% in 1975⁶.

At the meeting of NEAFC in 1975 it was agreed to prolong the ban in ICES areas I, II and Vb, with the exception of a limited fishery for own consumption (estimated to 500 tonnes). The paragraph reads: "Notwithstanding the provision in paragraph I (the ban) a Contracting State may permit its fishermen to fish herring by gill nets inside the baselines

exclusively for their own consumption and for their own use as bait. Any sale of herring caught for such purpose shall be prohibited (NEAFC, 1975).”⁷

Retrospectively, we can state that this was as close to a total ban on the fishery that was possible. According to the catch statistics from ICES, during the period 1971-1983 the annual catches were varying between 7,000 and 23,100 tonnes, with an average of approximately 15,400 tonnes. It can be argued whether this level should have been even lower. On the other hand, in relation to the volumes this fishery once had yielded, the average catch during the period 1971-1983 was at the level of 0.8% of what it had been in the “top year” 1966. The Norwegian fishermen received high prices for the small volumes of herring, whereas these prices were reduced as the quantity began to rise in the late 1980s. The Norwegian catches, the value of the catches and the average first-hand prices for herring is shown in Table 10.2.

After nearly 20 years of poor recruitment, the stock produced a strong year class in 1983. This led to the possibility of higher catches and as from 1984 the annual Norwegian catches grew to a higher level. While the stock of NSSH in the 1950s and 1960s had been a typical “straddling stock”, the collapse implied a temporary end to its straddling nature. In the following two decades the stock remained close to the Norwegian coast.

Table 10.2. Aggregate Norwegian catches, value of catches and prices of the catch (in 2004 NOK/Kg) 1971-1990.

Year	Aggregate Norwegian catches (in tonnes)	Aggregate value of Norwegian catches (in 2004 NOK)	Average first-hand price for herring (in 2004 NOK/Kg)
1971	22 36	135 60	6,0
1972	14 59	81 05	5,5
1973	8 74	67 22	7,6
1974	8 01	76 13	9,5
1975	4 35	50 54	11,6
1976	68	6 49	9,5
1977	14 13	132 81	9,3
1978	11 02	108 91	9,8
1979	5 10	51 98	10,1
1980	13 11	100 61	7,6
1981	11 50	64 67	5,6
1982	14 57	72 38	4,9
1983	18 69	80 84	4,3
1984	52 34	197 11	3,7
1985	71 54	250 09	3,5
1986	104 06	274 59	2,6
1987	102 46	229 34	2,2
1988	111 05	233 01	2,1
1989	83 01	192 59	2,3
1990	67 88	175 63	2,5

Source: Statistics Norway (1994).

The 1970s also implied changes in the institutional framework for fishery management. While the Northeast Atlantic Fisheries Commission had been the natural vehicle for discussing fishery management measures in the 1960s and early 1970s, the coastal states establishment of 200 nautical miles (n.m.) exclusive economic zones (EEZ) in the late 1970s concentrated regulatory power to these states. Norway established its 200 n.m. EEZ as from January 1, 1977. As the migratory pattern of the stock of NSSH had changed, the entire stock was then confined within the EEZ of Norway, close to the shore. This again implied that Norwegian fishery authorities then had the final word as how to regulate the stock. We will thus shift the focus from NEAFC to Norway and review what was done to avoid growth and recruitment overfishing of the stock.

Rectifying growth overfishing

Norway addressed the problem of growth overfishing in 1970 by introducing a minimum landing size in the fishery at 20 cm. This was, in 1977, increased to 25 cm. This regulation implied a ban on the Norwegian fishery on small herring – a fishery that had constituted 33% of the Norwegian fishery during the former period (1951-1970).

The ban on the Norwegian fishery on small herring implied an economic cost in the terms of a short term loss of the economic surplus that such a fishery could have given. As the stock at the beginning of the 1970s were at a very low level and, retrospectively, one can conclude that the natural environment did not support good recruitment to the stock, it can be argued that this loss was lower than what it would have been had the ban been introduced in the 1960s.

The ban on the Norwegian fishery on small herring can be treated as an investment in the stock of herring. By avoiding this particular fishery, the fish is left to grow and contribute to the spawning stock biomass of herring. In their well-known paper from 1975 Clark and Munro presents what has been later known as the “Golden Rule” for fishery management. In its most crude version, assuming constant prices for the fish and reversible investment in the fishing fleet, this rule states that one should invest in the fish stock up to the point where the marginal return on investment in the stock equals the social rate of discount. In relation to this criterion, was the ban on the Norwegian fishery on small herring a sound investment decision? I will return to the question under the section Discussion.

Rectifying recruitment overfishing

When the stock started to rebuild, Norway introduced annual total allowable catch in the fishery on herring. During the first years, levels of TAC were set without any reference to biological or economic reference points, but more from a precautionary perspective and to follow up the recommendations by NEAFC.

The first attempts to manage the stock according to a biological reference point can be traced to an article by Dragesund, Hamre and Ulltang (1980). In this article the authors discuss the relationship between the size of the spawning stock and recruitment of NSSH. Looking back on the period 1950-1970 there had been periods of both large and small spawning stock biomass and they drew the conclusion that when SSB had been below 2.5 million tonnes, a significant drop in recruitment had been observed. They further argued that if a minimum landing size protecting the 0 and 1 year class, and the fishery on adult

herring had been regulated by the fishing mortality $F_{0.1}$, the collapse of herring could have been avoided.

This paper had a great impact, both as guide for the advice from ICES and on the management of the stock. An SSB equal to 2.5 m.t. was set as the first biological reference point for the stock, called the Minimum Biological Acceptable Level (MBAL). This level was later established as the limit reference point for the stock, as illustrated in Figure 10.1 (Røttingen, 2000). The quotas were subsequently fixed according to a fishing mortality of 0.05.

Thus, during the period 1970-1990, the annual catches were restricted by at least two different principles; small quotas in the beginning of the period and at the end of the period quotas based on a fixed fishing mortality of 0.05. Along the same line of reasoning as for the ban on the fishery on small herring, we may ask if the investment in the stock, which the various restrictions on the volume of the catches implied, could be considered sound investment decisions. We will return to this question later. However, for the time being, note that the Norwegian fishery management did not apply a strict closure of the fishery, but kept a small, but valuable fishery going, also at stock levels where one theoretically could expect better payoff by a total closure of the fishery.

As can be seen from Figure 10.1, the stock recovered above the MBAL level at the end of the 1980s, first and foremost due to favourable recruitment conditions in 1983⁸. This development prompted discussion about which harvest control rule to apply when the stock was above MBAL and whether the stock could be expected to return to its historic migration pattern. Both questions will be dealt with in the next section.

The period 1990-2008

As mentioned, at the beginning of the 1990s the stock of NSSH was above the MBAL level of 2.5 million tonnes. Furthermore, in 1991 and 1992 the stock once again produced good recruitment and it was evident that one could expect a significant growth of the biomass in the years to come. It was also expected that if the stock returned to its historical migration pattern, the distribution of the stock would change from being within the Norwegian EEZ to having a distribution across international waters and the EEZ of several coastal nations. Thus, the responsibility to manage the stock were no longer confined to Norway, but to the nations whose fishermen could be expected to utilise the stock, either in international waters or in their own EEZ.

Two major questions had to be solved. First, which harvest control rule should be used to guide the annual level of harvest of the stock? Second, how should the annual harvest be divided among the coastal nations participating in the fishery? After several rounds of negotiations, which lasted for many years, the parties managed to agree both on a harvest control rule and on the allocation of the annual harvest between the various parties.

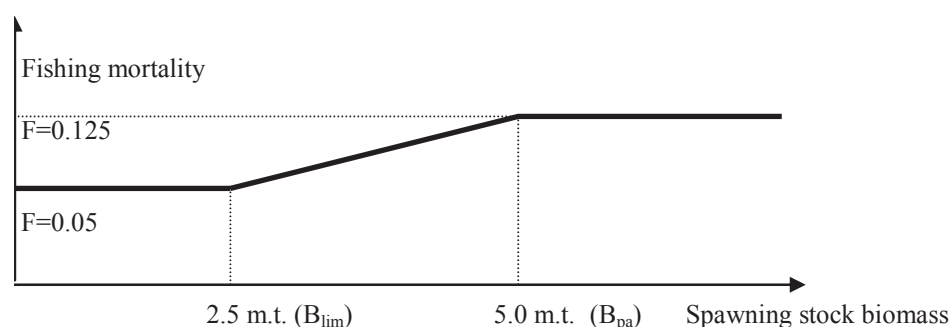
Establishing the harvest control rule

Concerning the harvest control rule the parties agreed to apply a rule where the fishing mortality rate should vary in the interval 0.05 to 0.125 depending upon the assessed size of the spawning stock. When the spawning stock biomass of Norwegian spring spawning herring is assessed to be below 2.5 million tonnes, the annual Total

Allowable Catch (TAC) shall be set according to a fishing mortality of 0.05. When the spawning stock biomass is assessed to be above 5.0 million tonnes (B_{pa}), the TAC shall be set according to a fishing mortality of 0.125, and when it is between these levels, it shall be set according to a fishing mortality that gradually changes from 0.05 to 0.125⁹. Figure 10.3 shows how the harvest control rule works.

As can be seen from the figure, the harvest rule is not a “bang-bang” regulated fishery where the effort, depending upon whether or not the stock is assessed to be below or above its Target Escapement (TE) level at 5.0 million tonnes is regulated respectively to zero or maximum. Sandberg (2005) has shown that for this fishery, where price decreases in harvest, such a bang-bang regulation cannot claim optimality.

Figure 10.3. Coastal states agreement on Harvest Control Rule for NSSH



Establishing sharing principles

The stock produced good recruitment in 1991 and 1992 and it was evident that the stock would return to its stock levels of the 1950s and 1960s. It was also anticipated that its areal distribution would change and that this would imply a distribution beyond the EEZ of Norway. To avoid a return to the open access fishery of the 1950s it became important to reach an agreement with the coastal states of the stock on how to allocate harvesting rights. The establishment of the current allocation key is beyond the scope of this chapter. Here, it should only be stated that the coastal states now have agreed upon an allocation key.

Discussion

The Norwegian spring spawning herring has, since its collapse in the late 1960s, been rebuilt and is now at stock levels corresponding to what it was in the 1950s. The management measures taken were targeting both the exploitation pattern and the exploitation rate. For a long period of time, recruitment from the stock was at such low levels that the implemented management measures were not sufficient to rebuild the stock above MBAL. However, when conditions for recruitment proved good, as in 1983, 1991 and 1992, the management measures aimed at increasing the SSB eventually paid off.

During the period of rebuilding, the income from the fishery was reduced substantially. Some of the nations that traditionally had participated in the fishery were completely out of the fishery for a long period of time (Iceland and the Faeroe Islands). For Norwegian fishermen the catch and the value of the catch were reduced significantly,

as shown in Table 10.1 and 10.2. In addition, it took nearly two decades before the payoff from the implemented management measures materialised. In the case of Norwegian spring spawning herring, it paid off to be patient. Let us have a closer look at the effect of the management measures.

The economic effect of improving the exploitation pattern

As described, a minimum size on herring was introduced in 1970 and subsequently increased. The minimum size implied that the fishery on small herring was banned. Whether or not this can be considered to be a sound investment depends on two payoffs. The first is the gain of postponing harvest until the individual fish has utilised its growth potential. The second is the long term gain of leaving more individuals in the stock to reach maturity, i.e. an age where they can contribute to the long term development of the stock as spawners. While the gain of the second to a large extent will be determined by the relationship between spawning stock and recruitment, the first can, in principle, be calculated as follows;

If N_a represents the number of herring at age a protected by the landing size, annually this number will be reduced due to natural mortality according to the following equation:

$$N_{y+1,a+1} = N_{y,a} e^{-(M_y + F_y)} \quad (1)$$

where M_y and F_y represent natural mortality and fishing mortality respectively. The number of fish at age a caught in year y can then be found as:

$$C_{y,a} = \frac{F_{y,a} N_{y,a} (1 - e^{-(F_{y,a} + M_{y,a})})}{F_{y,a} + M_{y,a}} * N_{y,a} \quad (2)$$

Multiplying this number of individuals with their weight at catch ($W_{y,a}$) and summing up over all the years the fish contribute in the fishery gives us the total yield of the fish protected by the landing size, as shown in equation 3.

$$Y = \sum_{y,a} C_{y,a} * W_{y,a} \quad (3)$$

To find the net value of the catch, the yield is to be multiplied with the price less the harvesting cost adjusted by a discount factor to display the net present value as shown in equation 4.

$$NPV = \sum_y Y_y * (P - K) * (1 + r)^{-y} \quad (4)$$

Where P and K are unit price and costs in the fishery, and r is the discount rate of society. If the NPV calculated by (4) is greater than the NPV of the potential catch of the juveniles otherwise harvested the first payoff from introducing a minimum size in the fishery can be said to be positive.

The second effect will, to a large extent be determined by how the individuals, protected from fishing by a minimum size, will contribute as spawners during their life span. The annual recruitment from the stock of Norwegian spring spawning herring varies considerably, see the ICES' advice on this stock from 2008 (ICES, 2008). However, as

the herring is not a short-lived species the individuals will have several spawning possibilities. Thus, improving the exploitation pattern for herring may also benefit the size of the spawning stock and the long-term economic yield from harvesting the stock. The latter will, however, also depend upon the general exploitation rate in the fishery.

The economic effect of improving the exploitation rate

As argued by Toresen and Østvedt (2000) the variability of the size of this fish stock is mainly due to the effect the natural environment has on recruitment from the stock. The productivity of the stock can therefore be considered, not only as a result of the harvest strategy, but also as a result of the natural environment.

To analyse the economics of restricting the exploitation rate in the fishery there is a need for simulation exercises with a bioeconomic model. We applied a model with parameter values as described in Sandberg (2005) to analyse the effect which various exploitation rates could be expected to have three different performance indicators. The indicators chosen was the Net Present Value of the Norwegian catch over a 10-year period - $NPV_{(10\text{ yrs})}$, the Spawning Stock Biomass after 10 years - $SSB_{(year\ 10)}$, and the probability that the fish stock should be above the Minimum Biological Acceptable Level (MBAL) at the end of the period - $Risk_{(<2.5m.t.)}$.

The effect which various exploitation rates could be expected to have on these three performance indicators was simulated. The lower exploitation rate was set to a fishing mortality (F) at 0.05 whereas the higher exploitation rate was set at $F=0.20$. Table 10.3 shows the results.

Table 10.3. Simulated value of the catch, the spawning stock biomass and the risk

1975	$NPV_{(10\text{ yrs})}$	$SSB_{(year\ 10)}$	$Risk_{(<2.5m.t.)}$
F = 0.05	250	0.3	99%
F = 0.20	340	0.15	100%

The risk that the stock should be below its MBAL level when exploited with a fishing mortality of 0.05 and 0.20.

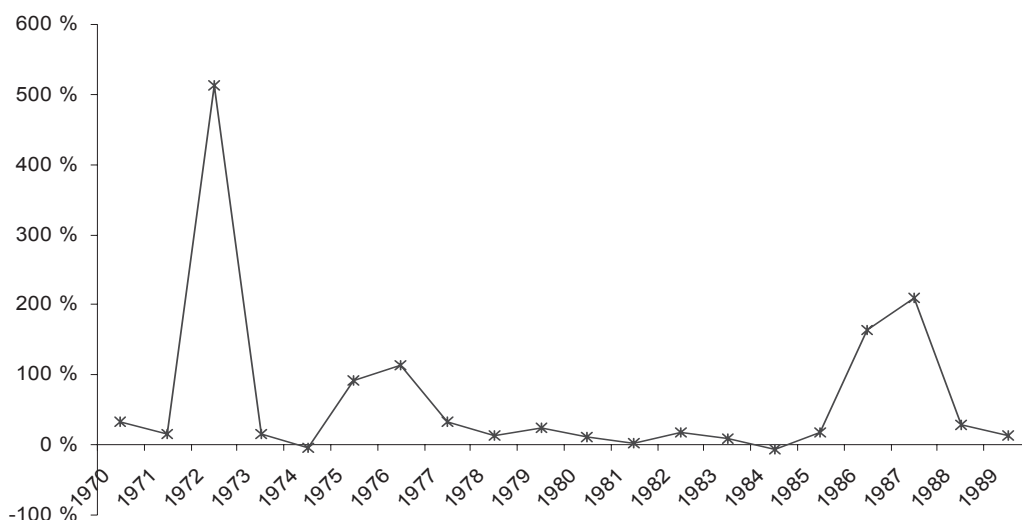
The Table shows that when reducing the exploitation rate from 0.20 to 0.05, one can expect that the NPV from the fishery be reduced and the SSB are increased (approximately doubled). Thus, in a medium-term prognosis as this, there is a trade-off between NPV from the fishery and stock rebuilding. Note, that irrespective of chosen exploitation rate the risk of being “stuck” with a spawning stock below the B_{lim} level of 2.5 million tonnes can be expected to be close to 100%.

Looking back on the period 1950-2007 one may ask how the average growth, in discrete periods, have been for this fish stock. In the figure below, annual growth – G - is calculated as follows:

$$G = (SSB_{y+1} - SSB_y + Y_y) / SSB_y \quad (5)$$

Where Y represents annual harvest. In relation to this growth, one may ask whether or not the conducted fishery have been economically rational. As to this chapter, it is of particular interest to assess how the growth of the fish stock was in the period 1970-1989.

Figure 10.4. Annual growth of norwegian spring spawning herring 1970-1989.



Annual growth determined by Eq. 5

Source: Data from ICES (2008).

The figure indicates that the growth of the stock varied, but was positive for 18 out of 20 years during the period 1970-1989. In average, the annual growth rate of the stock was 39%. This shows that, even at low stock levels (see Figure 10.1), the growth of the stock has been remarkable high. What the growth would have been had there been a complete ban on the fishery during the period is not known.

Conclusion

The experience from the collapse and the subsequent rebuilding period for Norwegian spring spawning herring leaves some “lessons learned”. Some of the most important are the following:

- The fishery on a pelagic stock that forms schools can sustain profitable fisheries even at very low stock levels. This is in accordance with common knowledge, but highlights the need to do fishery-independent assessment of the stock.
- Both fishery and environment determine the rebuilding path. In this case environment did not favour good recruitment over a period of approximately 20 years. Improvement of both exploitation rate and pattern will result in a considerable increase in the fish stock. This may be the necessary condition for a good recruitment once the environment becomes favourable.

- Improving the exploitation rate and exploitation pattern is important in order to rebuild the stock, but in the medium-term it has its costs in terms of a loss of net operating profit.
- During the rebuilding period a minor fishery was kept open. Due to market effect this gave a high payoff, whereas it may be questioned whether this fishery prolonged the rebuilding period.

The stock of NSSH is now at levels with what it was in the 1950s. It gives high economic returns to the fishermen. In addition, it has a central role in the ecosystem by being a transporter of energy from plankton to fish stocks that have herring on the menu. Thus the economics of a rebuilt herring stock extends beyond the economics of the herring fishery, but this is a topic that is not covered in this chapter.

Notes

- 1 . I would like to thank Sigmund Engesæter at the Norwegian Directorate of Fisheries and Ingolf Røttingen at the Norwegian Institute of Marine research for valuable comments to the paper.
- 2 . Germany had some catches during a 5-year period at the end of the 1960s.
- 3 . The Atlanto-Scandian herring stocks is the common name for three different herring stocks; the Norwegian spring spawning herring, the Icelanding spring spawning herring and the Icelanding summer spawning herring.
- 4 . The Liaison Committee was a forerunner to what has later been known as ICES' advisory bodies (ACFM and later ACOM).
- 5 . The catch in 1969 reached a total for all nations of 67,800 tonnes. This was only a fraction (3.4%) of what had been caught in the "top year" of 1966. In 1969, the total catch on small herring was 43,500 tonnes, so a reduction in this specific quantity was important and represented a will to do something with the exploitation pattern as well as with the exploitation rate.
- 6 . The decisions made in NEAFC in 1973 and 1974 reduced the fishery further down to almost nil and the only catch allowed was a minor catch on small herring.
- 7 . As shown in table 2, a quantity of 682 tonnes herring was sold in 1976. This was herring caught as bycatch in the sprat fisheries.
- 8 . The spawning stock biomass, which gave rise to this good recruitment, has later been assessed to 0.5 million tonnes, i.e. far below the level that Dragesund, Hamre and Ulltang (1980) noted as a level beneath which a significant drop in recruitment had been observed. As such, the extraordinary recruitment in 1983 signals the effect which a good environment has for recruitment, and hence the stock development.
- 9 . For further discussion of the Harvest Control Rule for Norwegian spring spawning herring, see Røttingen (2003).

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Chapter 11.

Community-based management for sustainable fishery:

Lessons from Japan

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Abstract

Management of Japanese coastal fisheries is often characterized as co-management—local fishermen assume a large portion of management responsibility and self-regulate their activities while government agencies provide scientific information and legal backup. While many past studies have attributed the success of Japanese fishery co-management to fishery cooperative associations (FCAs) and legally defined fishing rights, this chapter argues that the key to success is not these institutions per se but the functions they perform, which can be generalized to any fishery.

Based on the conceptual framework of the theory of clubs, the chapter points out that three conditions are necessary for successful co-management: well-defined boundaries, an affordable exclusion mechanism, and a condition of “privileged.” FCAs and defined fishing rights provide the first two. The third condition is related to enhanced profitability as a result of co-management and the question is how to achieve it. Based on a qualitative analysis of Japanese fishery co-management cases, the chapter suggests that coordinating fishing efforts and maintaining fairness are the key components. Lastly, it is important to note that rebuilding fish stocks and enhancing profitability of the fishery are interrelated and mutually dependent. That a fishery cannot be profitable without a healthy fish stock is obvious. Less obvious is the fact that without tangible rewards, such as more profits, fishermen will not be interested in or sustain their interest in stock-rebuilding efforts.

Introduction

The co-management approach in fishery management is garnering much attention in both the developing world and developed countries. Given developing countries' typically limited capacity of the government to monitor and enforce regulations as well as weak institutional infrastructures for market-based approaches, co-management is seen as one of a developing country's few viable options (Cancino, Uchida and Wilen 2007). Many case studies from developing countries have indeed been documented (e.g., Cunningham and Bostock 2005 and Wilson, Nielsen and Dengbol 2003). In developed countries, a recent trend in the U.S. provides a good example of the directions they are heading. Measures that are similar in concept to co-management, such as harvester cooperatives (e.g., the Alaskan Pollock Conservation Cooperative) and sector allocation are being proposed and promoted (Johnston and Sutinen 2009). However, the fundamental question is not how cooperatives or co-management groups should be set up but what they should do to be successful (or to avoid failure) in terms of stock rebuilding and improving profitability.

The management of Japanese coastal fisheries is characterized as co-management—local fishermen assume a large portion of responsibility for management and regulate themselves while government agencies provide scientific information and legal support.¹ The degree to which government agencies are involved varies from case to case; in general, local fishermen have greater involvement in and responsibility for devising regulations and monitoring compliance. Giving a larger stake in management to local fishermen has a positive impact because they develop a sense of ownership of the problem (Yamamoto 1995), but there are also weaknesses (Uchida and Makino 2008).² Japanese experiences are thus a mix of successes and failures. The abundance of co-managed fisheries in Japan—there were 1,608 co-management organizations in 2003 and the number continues to increase (MAFF (Ministry of Agriculture, Forestry and Fisheries) 2006)—offers numerous useful examples.

The foundation of Japanese fishery co-management is the combination of fishery cooperative association (FCAs) and defined fishing rights, which are analogous to territorial use rights for fishing. These two institutions are well-established in Japan and the history of their evolution and consequent administrative structures is well-documented in the literature (e.g., Asada, Hirasawa and Nagasaki 1983; Makino and Matsuda 2005; Makino and Sakamoto 2002; Ruddle 1987; Yamamoto 1995). However, there seems to be too much emphasis in the literature on historical background and the tradition of FCAs and fishing rights and less focus on the fundamental functions that these institutions provide. My claim is that these fundamental functions are universal to fisheries throughout the world and thus applicable to regions outside of Japan.

The chapter is organized as follows. The next section provides some background information on Japanese coastal fisheries and co-management. I then explain the functions of FCAs and fishing rights using the theory of clubs (Buchanan 1965) to make a case that these are universal and necessary (but not sufficient) conditions for successful co-management. I then examine Japanese fishery co-management cases, focusing on their key features: effort coordination, maintaining fairness, and rebuilding stocks. The concluding section discusses the lessons that the Japanese experiences provide.

Background of Japanese coastal fisheries and co-management

The coastal and offshore fisheries in which most co-management regimes have arisen are important sectors in Japan's fishing industry. While the volume landed from coastal fisheries is consistently less than that of offshore fisheries, the converse is true in terms of landed value (Table 11.1). For example, in 2005 coastal fisheries landed 1 465 000 tonnes (25.8%) of marine fish while offshore fisheries landed 2 444 000 tonnes (43.1%). In terms of value, however, coastal fisheries generated USD 4.2 billion (34.0%) of total marine fishing revenue and offshore fisheries earned USD 3.2 billion (25.9%). These figures imply that coastal fisheries harvest relatively higher-valued species.

Table 11.1. Fishery harvest (volume and catch) of Japan, 2001–2005

		2001	2002	2003	2004	2005
Volume (thousand tons)	Total	6,126	5,879	6,083	5,776	5,765
	Marine	6,009	5,766	5,973	5,670	5,669
	Catch	4,753	4,433	4,722	4,455	4,457
	Coastal	1,545	1,489	1,577	1,514	1,465
	Offshore	2,459	2,258	2,543	2,406	2,444
	High seas	749	686	602	535	548
	Aquaculture	1,256	1,333	1,251	1,215	1,212
Value (million US dollars)	Fresh Water	117	113	110	106	96
	Total	14,836	14,357	13,257	13,363	13,339
	Marine	13,905	13,458	12,373	12,502	12,488
	Catch	9,714	9,470	8,643	8,879	8,828
	Coastal	4,529	4,513	4,174	4,170	4,245
	Offshore	3,505	3,442	3,077	3,300	3,230
	High seas	1,674	1,511	1,388	1,409	1,350
	Aquaculture	4,191	3,988	3,730	3,619	3,660
	Fresh Water	930	899	883	862	852

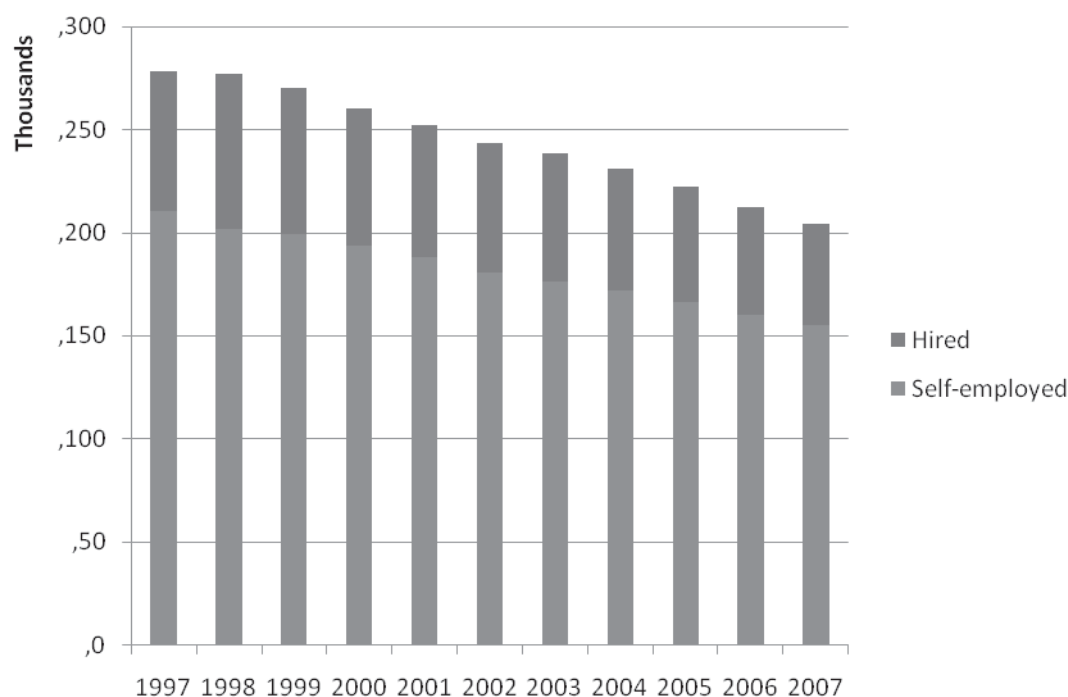
Source: MAFF 2007. Note: USD 1=120 yen.

Despite their importance, coastal and offshore fisheries have been faced with difficulties for quite some time. Based on a stock assessment by the government in 2008 for 83 fish stocks (52 fish species) caught in the waters surrounding Japan, stock levels for 50.6% of these stocks were considered low while levels for only 19.3% were considered high (Fisheries Agency 2009).³ Of those same stocks, 22.9% showed an increasing trend but 20.5% were declining.⁴ The fishermen's profitability is generally low after they deduct loan and insurance payments for their vessels. As a result, employment in the fishing industry—the sum of self-employed and hired crew members—has been steadily declining since 1997 (Figure 11.1). Numerous anecdotes suggest that the average age of fishermen is rising and that successors are very difficult to find.

For most of their history, Japan's coastal fisheries have been managed by local fishermen's groups known as fishery cooperative associations (FCAs). Members of FCAs are mostly fishing households and "small" companies, as defined by the number of employees and gross tonnage of the vessels owned. The conventional functions of FCAs are similar to those of other harvester cooperatives and include joint purchases of inputs (e.g., fuel, ice, and boxes), administration of ex-vessel markets, and provision of

insurance and credit to members. FCAs are usually associated with specific coastal communities that historically have depended on fisheries resources. Each FCA typically encompasses all of the fisheries within that community or communities, so a number of diverse fisheries—both in terms of targeted species and gear used—are under the auspices of a single FCA.

Figure 11.1. Employment trend in Japan's fishing industry (excluding corporate and aquaculture)



Source: MAFF 2008.

In addition, FCAs provide one unconventional function—managing fishing rights. Fishing rights are typically defined for a parcel of coastal water that borders the FCA's community. The borders often are defined by extending the municipal boundaries a certain distance from the shore; how far they extend depends partly on the topology of the ocean floor and partly on characteristics of neighbouring communities. Fishing rights are protected by law and granted to FCAs as an organization and not to individual FCA members; commercial fishing within the fishing rights area is only allowed to FCA members. In this sense, defined fishing rights are analogous to territorial use rights for fishing (TURFs) (Christy 1982).⁵

Co-management of coastal fisheries is carried out by fishery management organizations (FMOs). An FMO is defined by the Ministry of Agriculture, Forestry, and Fisheries (MAFF) as a group of fishers who share the same fishing ground and/or operate in the same fishery and are collectively engaged in resource and/or harvest management according to mutually agreed rules. FMOs are autonomous organizations and some of Japan's FMOs have been in operation for decades. Since the FMO was placed at the centre of national fishery management policy in the early 1980s, the number of FMOs has

steadily grown, arriving at 1,608 FMOs nationwide by 2003 (MAFF 2006). FMOs and FCAs are interrelated in a number of ways: nearly 95% of FMOs are operated by a parent FCA or its affiliate organization. As such, the operation of FMOs is supported utilizing the institutional infrastructures of FCAs and fishing rights.

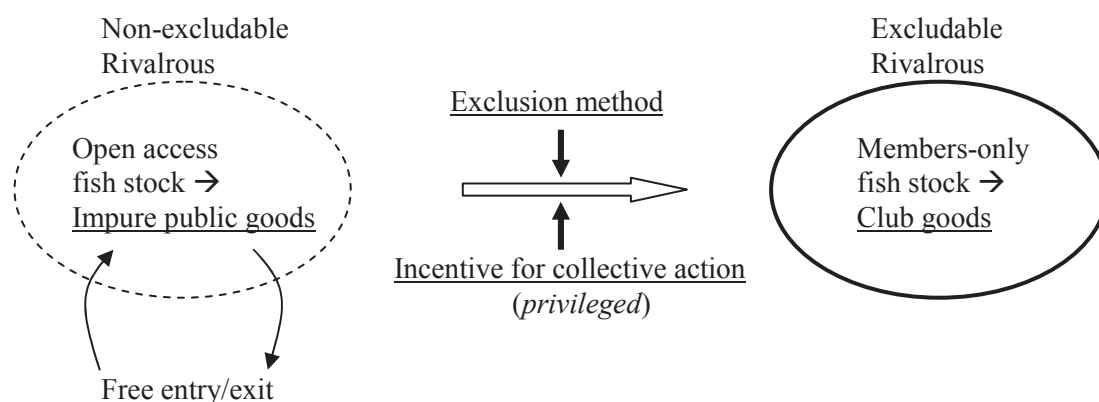
Functions of FCAs and fishing rights

Fish stocks targeted for fishing can be viewed as impure public goods; subject to rivalry but non-excludable.⁶ This is certainly true for open access fisheries but also applies to limited access fisheries, such as those governed by a license system, if eligibility to gain access is not regulated (*i.e.*, free or at very low cost). Non-excludability induces incentives to race for fish and capital stuffing. Rivalry implies that crowding or congestion becomes a problem. The result is dissipated rent.

A club good is a converted impure public good where its benefit is now made to be excludable (Sandler 1992). A club is thus an institution that converts an impure public good into a club good. Because consumers of these goods share the supply, it is important that there exists an affordable method of exclusion to keep non-club members from free-riding.

It has been established that club goods can be effectively provided by properly designed clubs. In summary, two variables must be considered: the amount (or size) of the club good and the size of the club's membership. A larger quantity of a club good provides greater benefits but at decreasing rate, while the cost of providing a club good increases exponentially with its quantity/size. A larger membership size reduces the per-member cost but increases congestion. The theory of clubs shows that there is an optimal membership fee (toll) that balances these trade-offs, thereby enabling the club to privately provide an impure public good (now converted into a club good) to a limited number of beneficiaries (club members). In other words, a club is an institutional solution to the collective-action problem that internalizes an externality through tolls (Sandler 1992).

Can fish be converted into a club good—that is, an excludable impure public good? There are three necessary conditions that must be met and they are derived from the theory of clubs: clearly defined boundaries, an affordable exclusion method, and members are privileged. The first two conditions relate to excludability while the third is related to profitability—an incentive-compatibility constraint of forming a club (Figure 11.2). The conditions are interrelated: whether a group is privileged or not depends on how well the benefits are made exclusive to its members.

Figure 11.2. Conceptual framework: transforming impure public goods to club goods

How do FCAs and fishing rights function to meet the first two excludability conditions? It is clear that fishing right boundaries define a geographical area and, thereby, a supply of fish that is exclusively accessible to member fishers. Areas defined by fishing rights do not necessarily match that of the fish's ecology, especially for migratory species. Some FMOs mitigate this deficiency by forming an alliance with neighbouring FCAs; as of 2003 there were 109 such alliances in Japan (MAFF 2006).⁷

The method of exclusion is more challenging and subtle. Since commercial fishing within an area defined by fishing rights is restricted only to FCA members, the exclusion method works by controlling membership. To be more specific, it is control over allowing non-members to become *eligible* to apply for FCA membership (Uchida 2004). The Fishery Cooperative Law defines eligibility conditions for becoming an FCA member, including local residency and a minimum number of commercial fishing days per year. The law prohibits FCAs from refusing the request of an entrant who meets the eligibility conditions without legitimate reasons and from imposing more stringent conditions on new members than on current ones. Thus, the goal is to prevent an outsider from freely gaining eligibility to entering the FCAs.

The mechanism of membership control is as follows. To become eligible to be an FCA member, one must be engaged in commercial fishing in that local region for more than a certain number of days in any given year. However, non-members are not allowed to commercially fish in areas with defined fishing rights. The only legitimate way to accrue fishing days, then, is to be hired as a crew member by an FCA-member fisherman, a business decision made solely by individuals. Thus, if consensus is built among member fishermen that they do not want new members, no one will hire a non-member, effectively excluding anyone from joining. Note that the majority of FMOs are controlled by FCAs so FCA membership control effectively extends to the FMOs.

In sum, while FCAs and fishing rights have a long and unique history that is not readily available in other parts of the world, the functions these institutions perform are universal to fisheries worldwide. It is the functions that are essential for successful co-management of fisheries, not the FCAs and defined fishing rights per se. There could be other forms of institutions that fit the cultural and traditional background of a particular region while providing these necessary functions.

While the theory of clubs provides a useful framework for understanding co-management, there is one important constraint that typical fishery co-managing groups face—the inability to flexibly adjust the club’s membership size. Particularly in the case of small-scale community-based fisheries, fishermen often are not comfortable driving some of their fishing colleagues out of business. This means that these fishermen, as a group, have an objective function other than simple profit maximization. It also implies that success in fishery co-management is more challenging. According to the theory, if the benefit level is low, one way to adjust is to curtail the number of members so that per-member benefits increase (so does the cost per member, however, which defines a new equilibrium). If adjustment of membership size is not an option, the benefit level must be increased.

This leads to the challenge of meeting the third condition—members must be privileged. The privilege condition states that the benefit to the members from collective action must exceed the associated costs even if those costs are borne solely by the members (Sandler 1992). Otherwise, no member would be interested in maintaining the club. The next section presents examples of how FMOs have endeavoured to meet the privilege condition by enhancing the profitability of the fisheries they manage.

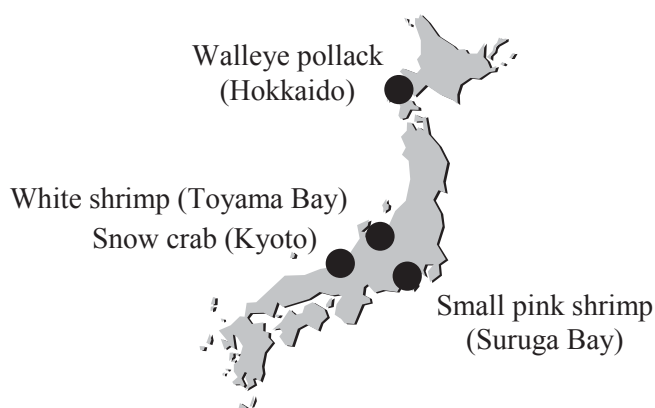
Rebuilding fisheries: the Japanese experience

Whether employed for resource stock recovery or to revitalize the fishing industry, the co-management approach has been the fundamental philosophy of Japanese national fishery policies. In 2001, along with enacting the revised Fisheries Law and associated registration requirements, the national government ramped up its resource stock rebuilding effort by launching the Resource Recovery Plan (RRP). The RRP was designed as a collaborative approach between the government and local fishermen. Local government agencies and fishermen discuss the need for resource recovery efforts and, if determined necessary, submit a request to the government. The government then presents a master plan for those efforts. Depending on the geographical coverage of the fish species and its importance, plans are developed at national and local government levels. Implementation of RRP then becomes the responsibility of local FCAs with guidance and support from government agencies. There are currently 63 RRP nationwide—17 set by the national government and 46 by local (prefectural) governments.⁸

The results of implementation of the recovery plans remain to be seen as most of them call for a planning period that ends in 2011 or later. However, there is a structural concern that could compromise the effectiveness and sustainability of the RRP: more than half (58.7% for local plans and 82.4% of national plans) of the RRP have explicit provisions for subsidies and/or compensations for potential loss of fishery revenue due to implementing an RRP. There is some rationale for such provisions—most efforts to rebuild fisheries involve reducing harvests and additional costs of management, thus decreasing profits in the short run. But the plans could be costly in the long-run as well if they do not include profit-improving efforts. Without improved profitability, collective efforts to recover stock levels are not sustainable after the subsidies lapse. This implies that even when the primary objective is biological (stock recovery) the plan’s success hinges at least partially on economic (profitability) benefits from such efforts. The biological and economic goals are thus interrelated and the importance of combining the two cannot be overemphasized.⁹

So how do FMOs achieve the privileged condition—improving profitability—while rebuilding the resource stocks? There are two fronts to pursue in enhancing profits: increasing revenue and reducing costs. In comparing co-management to individual quota systems, the comparative advantages of co-management include (i) the ability to coordinate the harvest's timing and location and (ii) collective marketing (Johnston and Sutinen 2009). These lead to the first keyword: **effort coordination**. As presented hereafter, various methods of effort coordination can be observed among Japan's FMOs. The second keyword is **fairness**, which is an important component to supporting and maintaining effort coordination. I introduce some examples of efforts by FMOs on these fronts. The examples are mostly drawn from fisheries for small pink shrimp (Uchida and Baba 2008), walleye pollack roe (Uchida and Watanobe 2008), white shrimp (Platteau and Seki 2001), and snow crab (Makino 2008).

Figure 11.3: Location of the fisheries used as examples in this section



Effort coordination

One form of effort coordination is timing the harvest. The first, more common objective of timing the harvest is associated with cost reduction: avoiding congestion at the fishing grounds and mitigating the race to fish. In the white shrimp fishery, an FMO implemented a daily fishing ground rotation scheme. FMO members were put into three groups and known fishing grounds were divided into three areas. Each group was then assigned to one of the areas and they rotated between areas on days they went out fishing. If the group size is appropriately determined, congestion in each fishing area will be mitigated, if not eliminated. And because there is no need to compete to secure better fishing grounds, there is considerably less incentive to race to fish. The cost savings come from slower steaming speeds, which increase fuel efficiency, and less damage to fishing gear due to reduced congestion.

Fishing ground rotation has also been implemented in the walleye fishery with the same purposes but across multiple (former) FCAs.¹⁰ Three groups that consist of members from each FCA work within three defined ocean areas (north, middle, and south) and they rotate on daily basis. Their coordination goes further still, reflecting the fact that they use longlines to catch pollack. As vessels arrive at their designated fishing grounds, they take a position and wait for the signal from the group leaders. Once the signal has been sent, they begin dropping lines and towing in the same direction away from shore. This additional step minimizes damage to gear; with all vessels towing in one

direction and at the same time, lines are less likely to tangle even if the lines drifted with the current while in the water.

In the small pink shrimp fishery, fishing grounds are not rotated; rather they are assigned by a “fishing committee” that meets every day during the season. This shrimp is a small zooplankton-like species. Individual shrimp concentrate together each evening as they rise toward the surface but the locations where those clumps of shrimp appear vary. A rigid rotation system could be ill-suited in such conditions—one group might find near-empty fishing grounds while another might find an overwhelming amount of shrimp. In fact, it often happens that some vessels with large catches radio the leader for help and the leader will direct low-catch vessels to the location to help haul the harvest or make additional tows nearby. This location assignment system allows for needed flexibility that is not possible in a rigid rotation scheme.

The second objective of harvest timing is to enhance revenue by deliberately avoiding the flooding of local markets. In the small pink shrimp fishery, one of the variables discussed in the committee in deciding whether to go out to fish and how much to harvest is the inventory level of local dealers/processors. They constantly contact the dealers regarding their inventories and when inventories are high the committee can opt not go out even when all other conditions are favourable for fishing. Another factor that the committee considers is weather—not the weather the day they go fishing but weather for the following day when they will be landing and auctioning their harvest.¹¹ Since the main processing of this shrimp is sun drying, if the weather is poor processors cannot sundry the shrimp and that weakens the auctioning price. Knowing this, fishermen sometimes decide to stay ashore when rain or dense overcast is forecasted for the following day.

Apart from coordinating the harvest, collective marketing is potentially an effective way to increase revenue and it is becoming increasingly popular among FMOs. Development of a private brand that can be defined by something as simple as the geographic origin of the fish is common. Other collective marketing efforts, particularly the more successful ones, involve more coordinated effort in quality control and targeted marketing.

Gaining differentiated treatment in the market based on quality requires a great deal of joint effort. The snow crab fishery offers a good example. Several FCAs along the coast of Kyoto prefecture facing the Sea of Japan harvest snow crabs but one FCA called Taiza was famous for premium quality crabs. Taiza harvesters took extra effort in careful handling of crabs when releasing them from the trawl net and invested in equipment to bring the crabs back alive. As a result, Taiza snow crab consistently fetched nearly USD 100 more per kilo in the ex-vessel market than crabs landed by neighbouring FCAs. Harvesters in these neighbouring FCAs did not necessarily handle the crabs poorly but they did tend to “hide” damaged crabs at the bottom of a packaged box since buyers bid on a per-box basis (and are not allowed to touch the merchandise prior to bidding). Consequently, buyers bidding on crabs landed by these fishermen had factored in this risk while Taiza fishermen successfully built the reputation for robust quality control. This also allowed Taiza buyers to market the crab to a particular market segment, namely the high-end restaurants in Kyoto area. This helped increase the ex-vessel price and raised the Taiza crab’s reputation still higher.

Walleye pollack fishermen in the Hiyama FCA also engage in marketing that differentiates their product, pollack roe, from the same product coming from other regions near and far. Their strategy is first to advertise that their fishing method, the

longline, is, de facto, capable of maintaining a high quality of harvested fish compared to the trawl net, a conventional method used in other places.¹² They also have implemented methods that further enhance their products' quality. For example, it was long known that over-ripened roe, which is considered as lower in quality, appears later in the season so Hiyama fishermen decided to voluntarily cut the fishing season short. Note that this decision also has a positive impact on rebuilding the pollack stock even though it is driven by a market incentive—evidence that the two concerns are interrelated and need not be addressed separately.

Importance of maintaining fairness

The importance of fairness seems obvious but there are two things worth pointing out regarding fairness because they have an important policy implication: fairness does *not* necessarily imply equity and the definition of fairness is case-specific.

Coordination of fishing locations, as previously described, is effective in reducing vessel congestion and gear damage but can lead to unfair advantage. What if my group was sent to a low-producing fishing ground and was able to harvest only a few fish while another group was sent to a so-called “hot spot” and took in a large catch? What prevents me from ignoring the rotation or assignment and starting to fish in the hot spot as well? The fairness issue is apparent in location assignment systems such as that used by the small pink shrimp fishermen but it can also occur with rotation systems because the location of hot spots can vary significantly on a daily basis.

One method for dealing with this problem—and thereby acting as a support mechanism for effort coordination—is pooling arrangements.¹³ The basis of a pooling arrangement is that the revenue from a group's harvest is pooled together and distributed back to each member uniformly or according to some weighting rule. Some costs are sometimes deducted before the distribution but typically the costs are not pooled. A pooling arrangement had been implemented by 12% of Japan's FMOs in 2003, including those for the small pink shrimp and white shrimp fisheries, and use of these arrangements is increasing (MAFF 2006).

How the FMOs use pooling arrangements varies. In the case of the white shrimp fishery, revenues are pooled until one full rotation has been completed (three fishing days). The FMO for the small pink shrimp fishery, on the other hand, pools and distributes revenue daily and those who did not fish are also paid a share. Other FMOs pay only those who actually participated in fishing.¹⁴ The small pink shrimp FMO distributes pooled revenue equally among its 120 members, in part because most of the equipment, vessels in particular, is nearly identical in size and the type of onboard gear. The walleye pollack FMO, on the other hand, involves three different vessel sizes so the distribution is weighted accordingly.¹⁵

In summary, a pooling arrangement is one method that can restore equality in response to unfair advantages inherent to effort coordination, especially location assignments, after the fish have been harvested. It is quasi-synonymous to equity.

The walleye pollack FMO used a very different method for restoring fairness prior to its implementation of a pooling arrangement in 2005. Rather than equating the results of the harvest (revenue), the FMO had opted to equate the *opportunity* of harvesting. As discussed earlier, the walleye pollack FMO used a fishing ground rotation system in which three groups rotated through three ocean areas. In actuality, this was called the “big” rotation and there were two smaller rotations in a hierarchal structure. This layered

rotation system aimed to equalize fishing opportunities at the vessel level over the course of the season. Even when the opportunity to harvest is equalized, however, actual harvests at any one location will differ depending on when one fishes, the level of skill, and other exogenous factors. Walleye pollack FMO members have long regarded such stochastic fluctuations, or luck, as part of fishing's nature. Thus, these fishermen did not regard ex-post equity as fair but guaranteed equal opportunity was important to them.¹⁶

Resource rebuilding effort

Well-maintained efforts by FMOs to conserve fish stock are often linked to the prospect of higher economic returns. This link is an important and effective way to encourage fishermen to take part in conservation and rebuilding efforts. If fishermen have a personal interest in conserving the resource, rebuilding efforts are more likely to succeed and require less monitoring and enforcement.

The walleye pollack FMO, for example, has taken the advice of a fishery biologist and established a marine protected area (MPA) at the major spawning ground within their fishing area. Recall that their main target is the pollack roe, so the major spawning ground is where the fishing would be most productive. Yet they have self-imposed an MPA in their hope to maintain the fishery sustainably. Since walleye pollack is a highly migratory species, it is unclear whether such efforts have had a sufficiently large positive impact on the walleye pollack stock. However, landing volumes for the Hiyama FCA where this FMO is located have, on average, maintained 1979 levels while landings by other regions have monotonically decreased over time (Figure 11.4).

The snow crab fishery FMO also has established a seasonal MPA during the crab spawning period. This was particularly difficult initially because the crabs' spawning ground overlapped with that of flounder, which was the main targeted species for crab fishermen when the crab fishery was closed. Their hard work was recently rewarded by the fishery's being designated as Asia's first Marine Stewardship Council (MSC) certified fishery (snow crab and flounder using bottom trawling).

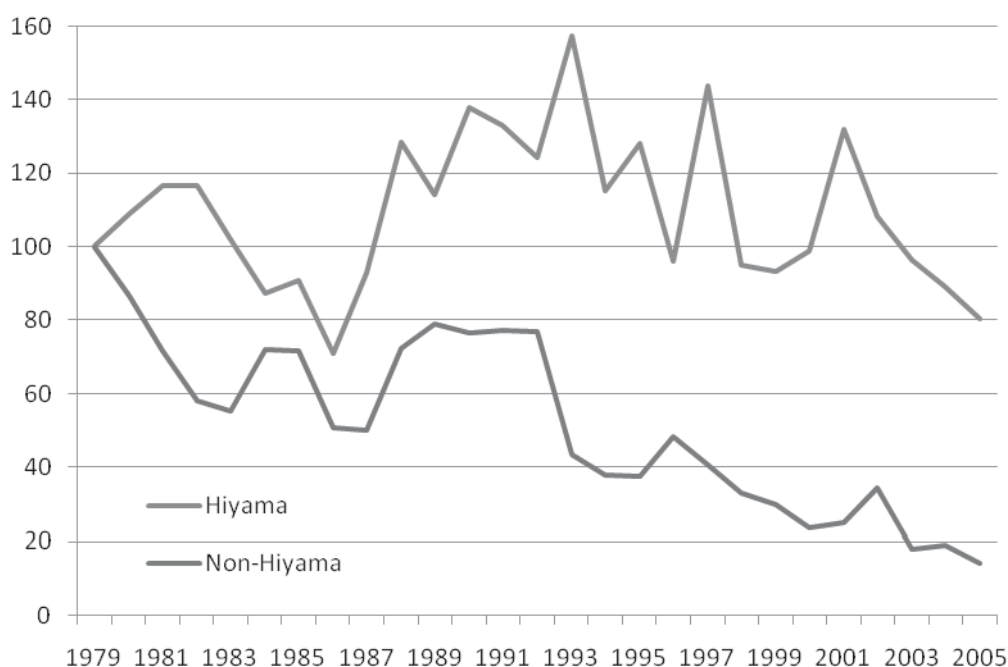
In the small pink shrimp fishery, the FMO sets a targeted annual landing volume based on an assessment of the stock and advice from the local fishery experimental station. It is effectively imposing on itself a total allowable catch limit. The limit suggested by the biologists at the experimental station was significantly lower than what it has been historically and many fishermen were initially sceptical. However, it turned out that the ex-vessel price increased as a result of fewer landings and benefited fishermen more than they had expected. Today, all of the FMO's members are firmly engaged in sustainable fishing by observing the targeted landing volume each day.

Small pink shrimp FMO is also actively conserving juvenile shrimp by preventing them from being harvested. The fishery has two distinct seasons, spring and fall, and the fall season is a mix of adult and juvenile (born over the summer) shrimp. The fishermen used to put the same amount of effort into harvesting during both seasons, but for the past decade or so they have shifted more of their efforts to the spring and less to the fall, avoiding harvesting the clump of juveniles in the fall.

The success of these efforts has been mixed, partly because external conditions have a significant impact on zooplankton-like species like the small pink shrimp. However, many fishermen agree that the situation would have been much worse in the absence of these efforts. Note that, once again, the firm commitment of fishermen to sustainable

fishery management is backed not only by their good will but also by increased economic returns.

Figure 11.4. Landing volumes of pollack relative to 1979 levels (=100)



Source: Uchida and Watanobe (2008).

Conclusion

This chapter reviewed a number of Japanese coastal fisheries' co-management experiences in order to determine whether co-management approaches can be effective in rebuilding fisheries, in terms of both resource stocks and profitability. As a prerequisite, the chapter explained the fundamental necessary conditions for co-management to function using the conceptual framework of the theory of clubs. In doing so, the chapter argued that fishery cooperative associations (FCAs) and defined fishing rights, institutions with an extensive historical background that are often identified as the source of co-management successes, are not the necessity but merely provide some of the fundamental conditions. The third piece needed is the privileged condition—that individual fishermen are better off when they join a fishery management organization (FMO) that co-manages the fishery. An important claim of this chapter is that direct translation of the privileged condition is improved profitability for FMO members but that resource recovery and sustainability are indispensable components of enhancing profitability so the two should not be separately considered.

For FMOs to endure and yield tangible positive impacts, two factors are important: coordinating efforts and maintaining fairness. Effort coordination ranges from fishing ground rotation schemes to collective marketing that aims to differentiate a product so it can fetch a higher price or increase demand. However, effort coordination often involves restrictions on individual decision making, such as choosing the location at which to fish.

This can generate a sense that the effort coordination system unfairly gives advantages to some fishermen over others. One solution to the problem of fairness is to equate the opportunity to fish; another is to equate the benefits of fishing through revenue pooling arrangements. These additional measures for increasing fairness do not necessarily result in monetary equity and the very definition of fairness is strongly case-specific.

The three necessary conditions for successful fishery co-management—clearly defined fishing-area boundaries, an affordable exclusion method, and members being privileged—are clearly not Japan-specific but rather are universal in nature. This is the basis of my argument that there is much to be learned from the Japanese experience in considering how fishery co-management can best be carried out in other regions of the world. For example, in the New England region of the United States a new management regime called sector allocation is being considered. It is effectively a group-based fishing quota; fishermen form a group (a “sector”) that receives a share of the overall total allowable catch. The question then becomes how the sector should manage its allocated quota? Some existing sectors simply allocate the group’s quota to individual members. However, Japanese co-management experience suggests that coordinated group effort can enhance fishermen’s profitability and sustainable use of the resource.

Notes

1. I use the term “co-management” rather loosely here as no single agreed-on definition exists (Jentoft 2003). Generally speaking, Japanese co-management cases share common characteristics that include significant involvement and responsibility assumed by fishermen and co-management group members are mostly local fishermen. As such, they are also referred to as “self-governance” and “community-based management.”
2. For example, multispecies and multi-region (for pelagic species) management, which typically involves more fishermen, thus making it more difficult for such groups to reach consensus and effectively monitor compliance, is rarely implemented.
3. Stock-level categorizations are based on the average harvest for the preceding 20 or more years (Fisheries Agency 2009).
4. Stock-trend categorizations are based on the average harvest volume for the preceding five years (Fisheries Agency 2009).
5. The fishing rights apply only to coastal fisheries. There are three types of fishing rights—common, demarcated, and large fixed net. In the context of this paper, common fishing rights are the only relevant category; demarcated fishing rights apply to aquaculture and large fixed net fishing rights apply to specific fishing gear.
6. Conventional examples of impure public goods include highways, golf courses, national parks, and parking lots.
7. Examples include the small pink shrimp fishery in Suruga Bay facing the Pacific Ocean (Uchida and Baba 2008) and the snow crab fishery off the Kyoto coast in the Sea of Japan (Makino 2008). There are also some efforts to establish an ecosystem-based management scheme that relies on the co-management concept (Makino 2005).
8. See http://www.jfa.maff.go.jp/j/suisin/s_keikaku/index.html (in Japanese; accessed on May 9, 2009).
9. A handful of RRP developed at the prefectural level did not include subsidies and compensations. They specifically cited that the effort would be spent on new product development and enhanced quality control, which were expected to bring higher revenue and compensate for the short-term loss. Such is the approach that must be sought.
10. These are former FCAs that are now merged into one large FCA, a trend promoted by the national government. The former FCAs are converted into branch offices and for daily operations they are mostly independent of each other.
11. Fishing for small pink shrimp takes place from dusk to midnight and vessels land their harvests during the night to be ready for the auction starting early the following morning.
12. Longlines produce high-quality catches but at the cost of a smaller catch per unit of effort. The pluses and minuses for trawl nets are the opposite: the race-to-fish incentive is in place so it is no mystery that other pollack fishermen have opted for volume over quality by using the trawl net.
13. It is also referred to as a sharing rule in other studies (e.g., Gaspart and Seki (2003) and Platteau and Seki (2001)).
14. An example is a surf clam fishery FMO on the northern Pacific coast (personal communication).

15. Specifically, the distribution is uniform per unit of longline (e.g., per meter). Since larger vessels carry longer lines, it effectively adjusts for the difference in vessel size.
16. The walleye pollack fishermen implemented the pooling arrangement not because their perceptions of fairness changed but because it was necessary to break the rotation pattern to further save operational costs in the face of rising fuel costs (Uchida and Watanobe 2008).

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Chapter 12:

Conclusions

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There are several areas I would like to comment on to add some considerations or provide emphasis. These relate to the biology and management of stocks, the importance of the transition to stock rebuilding and my feelings with respect to the outputs of the workshop and what we have learned here in Newport.

With respect to the biological considerations and stock management, a critical factor we must all remember is prevention of stock collapse. Stock rebuilding implies that something has happened that has depressed stocks, usually overfishing or habitat loss or perhaps natural variation, often in combination with these factors. What we really want to do is avoid having to rebuild stocks because we have managed them well. Our management plans need to anticipate the factors that lead to declines or may result in reduction in abundance and include measures to compensate for them. Good management plans should take into account natural or man-made influences and respond accordingly. When conditions are less favourable for a stock, we need to be more cautious in our management approach.

An additional consideration is deciding what stocks to rebuild or manage to, in complex multi-stock associations. It may not be possible to rebuild very weak minor stock components of a mixed stock fishery without shutting down the fisheries on healthy stocks, hence there is an important socio-economic issue involved and some possibly difficult trade-offs. Managers and policy makers will need to decide on the best approach which considers the socio-economic considerations, the need to protect genetic diversity, and the impacts of measures taken. Managing to the weakest stock components in a mixed stock fishery will entail social and economic impacts due to immediate foregone catch; however there may be future benefits due to protection of genetic diversity and perhaps even greater abundance of a number of the stocks involved. Like many of our discussions here, the key stakeholders and interested parties who will be affected by the proposed approach should be involved in these kinds of decisions. In engaging users, the choices and options available should be presented in an open and transparent way to assist with decision-making.

A key point from our deliberations has been our recognition of the importance of managing the transition from depressed stocks to rebuilding and the process by which this transition is achieved. This is recognized as one of our most difficult challenges as it involves changing human behaviour and in making the case for the sacrifices that need to be made to achieve rebuilding. Transition therefore, is broader than just making fisheries

management and policy decisions- it involves human behaviour, sociological, and economic considerations of both a short and long term nature. We have recognized that incentives are an important key to success, whether they be in the form of ITQ's or other measures, and that a sense of ownership, stewardship, and having a say in the future well-being of the stocks and those that exploit them is very important. If people feel they are involved in the decisions, that they are being heard, and that they may benefit from future stock abundance or the availability of fisheries resources for the future, they may well be willing to make sacrifices to achieve rebuilding. Also, if people are going to sacrifice, the approach needs to be perceived as being fair to competing interests and values, transparent so people know what is going on, and credible, in terms of the measures being proposed.

Inherent in any stock rebuilding approach, may be considerations of timing. For example, for a salmon population we might propose to rebuild the stock within a sequence of reproductive cycles. We might aim to achieve rebuilding within several reproductive cycles, each of which spans the time from emergence of the young fish from the egg stage until the time the adults return to their place of origin to spawn. A fast pace of rebuilding might involve two or three such cycles and considerable reduction of fishing effort in order to achieve rebuilding. A slower pace of rebuilding might involve four or five cycles and less impact on the fishery. The faster paced approach would achieve rapid rebuilding with considerable short term social and economic impact on the users while the slower approach would entail less impact on those users but a slower, and perhaps uncertain outcome with respect to stock rebuilding. These considerations again involve people making difficult choices. In the case of a decision to move rapidly, there will also likely be strong opposition from those affected and the need for strong policy and political will to achieve rebuilding.

In considering what we have heard here at the workshop I wanted to share a few personal feelings and observations with you. Indeed, I was quite encouraged to hear the progress being made in understanding the challenge of stock rebuilding around the world and to hear excellent examples of success such as the Norwegian spring spawning herring approach, groundfish and sablefish management in British Columbia, the effectiveness of the international Pacific Halibut Commission, and other examples that show the way forward. It is however, discouraging to hear about the ongoing state of the depressed Northern Cod population and to learn about the major challenges facing fisheries management and stock rebuilding in countries such as Vietnam. Overall, it is clear that through the efforts of the participants in workshops such as this and the leadership of organizations like the OECD, we are making progress in raising awareness of these challenges and in defining the kinds of approaches and actions that need to be taken to achieve stock rebuilding and gain support for it. Fisheries policy makers and economists, working with a broad array of disciplines in the natural sciences and the social sciences need to work together to make a strong case for fisheries stock rebuilding, particularly in the face of the growing global food supply problem and the overexploited state of many of the world's fish stocks.

Finally, inclusion of social and economic considerations, early in the process, along with the biological information, is an important and necessary requirement for achieving stock rebuilding and assisting those involved with making decisions and building support for them during transition.

Annex A: Biographies

Lee G. ANDERSON [University of Delaware, United States] gave a presented entitled *Setting Allowable Catch Levels within a Stock Rebuilding Plan: Preliminary Thoughts on a Probabilistic Approach*. Lee G. Anderson is Maxwell and Mildred Harrington Professor of Marine Studies and Professor of Economics at the University of Delaware. He has written or edited eight books and over seventy scientific papers on fisheries economics and the economics of fisheries management. He is currently the President of the North American Association of Fisheries Economists, and a member of the Mid-Atlantic Fishery Management Council. He is past president of the International Institute of Fisheries Economics and Trade and a past member of the Ocean Studies Board of the National Research Council. He has acted in an advisory capacity to the National Marine Fisheries Service, the Atlantic States Marine Fisheries Commission, the U.S. Department of State, the Great Lakes Fishery Commission, U.S. General Accounting Office, the National Academy of Sciences, the World Bank, the Food and Agricultural Organization of the United Nations, the European Union, and the Governments of New Zealand, Australia, Oman, Morocco, and Chile with respect to fisheries management and development. He has received the Rosenthal Award for Contribution to Ocean Science for his theoretical and applied work on individual transferable quotas and the Distinguished Service Award of the International Institute of Fisheries Economics and Trade for “contributions to the theory and practice of fisheries economics, and to promoting a worldwide exchange of perspectives and information on fisheries issues.”

Barbara BEST [Fisheries and Oceans Canada] gave a presentation on *Atlantic Cod in Canada*. Barbara Best was born in Toronto, Ontario, Canada. She earned a baccalaureate degree in Ecology from the University of Guelph in 1987. She was awarded an NSERC 1967 Scholarship in Science and Engineering from the Government of Canada, and moved to North Carolina to study in the University Program in Genetics at Duke University. She completed her Master’s degree at Duke in 1990, and moved to Seattle where she worked for several years as an environmental biologist. Barbara returned to school at the University of Washington in 1997 to study Natural Resource Economics. She earned a Master of Arts degree in Economics in 2000, and completed her Ph.D. in 2006. She is now a Senior Economist with Fisheries and Oceans Canada in Ottawa, Ontario.

Anthony COX [Fisheries Policies Division, OECD] presented *Rebuilding Fisheries: An Overview of Issues and Policy Approaches in the OECD*. Anthony Cox is a Senior Economist in the OECD's Trade and Agriculture Directorate and has been leading analysis on key fisheries policy issues since joining the OECD in 2000. He has worked extensively on a range of fisheries policy issues, including fisheries subsidies, political economy of reform, fisheries trade liberalisation, fisheries management costs, and international fisheries reform. Prior to joining the OECD, Mr Cox was the Senior Economist in charge of fisheries economics analysis in the Australian Bureau of Agricultural and Resource Economics (ABARE) in Canberra, Australia. While at ABARE, he undertook research into regional fisheries management organisations, economic performance indicators for fisheries, aquaculture, and economic issues in exploratory fishing. Mr Cox holds Bachelor and Master degrees in Economics from the Australian National University in Canberra. Mr Cox is currently the Head of the Environment and Economy Division in the OECD Environment Directorate.

John C. DAVIS [University of Victoria, Canada] presented *Rebuilding Fisheries: Challenges for Fisheries Managers*. Dr. Davis retired from Canada's Department of Fisheries and Oceans in 2008 after 37 years service with the Department with extensive experience in fisheries and habitat management, environmental and policy issues related to sustainable management and conservation of natural resources. As Assistant Deputy Minister of Science, he was responsible for all of the Department's science programs on a national basis. Prior to retirement, he was the Special Advisor to the Deputy Minister, on Species at Risk. He served in a number of positions with the Department of Fisheries and Oceans including Director General, Pacific Region, Assistant Deputy Minister of Science, Director General Pacific and Freshwater Fisheries and Director General, Ontario Region. John was also active as a Commissioner and former Head of the Canadian Delegation, Pacific Salmon Treaty, Commissioner on the Great Lakes Fishery Commission, and as Canadian Negotiator for the Yukon portion of the Pacific Salmon Treaty. He was Canadian negotiator for high seas driftnet fishery negotiations with Japan, Russia, Korea, and the USA. He has also done extensive work on international science initiatives in the Asia-Pacific region. Dr. Davis joined the department as a research scientist in 1971 where he focused on environmental impacts of coastal pollutants on Pacific salmon and other organisms. Dr. Davis holds a Bachelor's Degree in Zoology from the University of Victoria and a Master's and Doctorate degree from the University of British Columbia where he specialized in work with Pacific salmon. He has published extensively on impacts of pollutants on aquatic species and coastal water quality studies, including definitive reviews of dissolved oxygen requirements of aquatic life. Currently, Dr. Davis is assisting the Institute for Coastal and Oceans Research at the University of Victoria with networking and research proposal submissions involving the impacts of climate change on aquatic ecosystems in Canada.

Sigmund ENGESAETER [Norwegian Directorate of Fisheries] presented the paper written by Per Sandberg, Directorate of Fisheries, Norway on *Norwegian Spring Spawning Herring*. Mr. Engesaeter was born in Bergen, Norway in 1949. He has a Bachelor of Science Degree from Idaho State University and a Masters Degree (1974) from the Department of Economics, University of British Columbia, focusing on resource economics. Since January 1975, he has been employed at the Norwegian Directorate of Fisheries. He was initially responsible for the preparation and participation in the international negotiations in connection with the establishment of the Exclusive Economic Zones, establishment of TACs and the issue of sharing of TACs. Since then he

has been engaged in various fisheries management issues, both on national and international levels. From 1986 – 1988, Mr. Engesaeter was the Fisheries Counsellor of Norway, in Brussels, responsible for fisheries relations between Norway and the EU. From 1989 – 1990 he was the project manager for a research project focusing on the use of information technology in connection with EU Laws and Regulations. Mr. Engesaeter was the first full time Secretary of The North East Atlantic Fisheries Commission (NEAFC) and was in 1999 given the task to establish NEAFC as an independent diplomatic mission in London, a position that he held for two years. He is now senior adviser at the Norwegian Statistics Department at the Directorate of Fisheries.

Peter GOODAY [Australian Bureau of Agricultural and Resource Economics] presented the *Harvest Strategy Policy and Stock Rebuilding for Commonwealth Fisheries in Australia: Moving Towards MEY*. Peter Gooday is responsible for leading ABARE's research on productivity, water and fisheries. ABARE's work in this area is focused on providing analysis and policy advice across the areas of water reform, fisheries management, and agricultural productivity growth. At ABARE Peter has been involved in a broad range of research and analysis, including: fisheries management, policy and trade; water market reform; economic issues associated with native forestry; as well issues affecting international and domestic mineral industries and commodity analysis. His research has underpinned important policy innovations by the Australian Government. For example, work undertaken in his branch provided the basis for the adoption of individual transferable quotas as a management regime in the Northern Prawn Fishery, and provided the analysis that underpinned the recent buy-back of fishing licences by the Australian Government. Peter has an honours degree in economics from the Australian National University.

Susan HANNA [Oregon State University, United States] presented *Managing the Transition: Distributional Issues of Fish Stock Rebuilding*. Susan Hanna is professor of marine economics at Oregon State University, affiliated with the Coastal Oregon Marine Experiment Station and with Oregon Sea Grant. Her research and publications are in the area of marine economics and policy, with an emphasis on fishery management performance, ecosystem-based fishery management, property rights and institutional design. Dr. Hanna has worked within the Pacific Fishery Management Council System as a member of its Scientific and Statistical Committee as well as ad hoc committees. She has also served as a scientific advisor to the U.S. Commission on Ocean Policy, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Minerals Management Service, Northwest Power and Conservation Council and Oregon Ocean Policy Advisory Council. She was a member of the Ocean Studies Board of the National Research Council (NRC), National Academy of Sciences, and has served on several NRC Committees, including the Committee to Review Individual Quotas in Fisheries and the Committee on Protection and Management of Pacific Northwest Anadromous Salmonids.

Rögnvaldur HANNESSON [The Norwegian School of Economics and Business Administration] was a workshop *Discussant*. Born and raised in Iceland, he holds a PhD. in economics from the University of Lund, Sweden. His academic career has been in Norway, and since 1983 he has been professor of fisheries economics at the Norwegian School of Economics and Business Administration in Bergen. He has been consultant to the OECD, the FAO, the World Bank, and the Icelandic and the Norwegian governments. He is the author of several books on fisheries and petroleum, the latest being "Privatization of the Oceans" published by the MIT Press. He has published more than 60 papers in international scientific journals.

Daniel S. HOLLAND [Gulf of Maine Research Institute, United States] presented *Economic Considerations and Methods for Evaluating Fishery Rebuilding Strategies*. Daniel Holland is a resource economist with the Gulf of Maine Research Institute (GMRI) and holds adjunct professorships at the University of Maine and the University of Rhode Island. He completed a Ph.D. in environmental and natural resource economics at the University of Rhode Island in 1998 and has since worked for government, academia, and industry in different parts of the US and in New Zealand. He serves as an associate editor of *Marine Resource Economics* and on the board of the North American Association of Fisheries Economists. Dan Holland's research is focused on design and evaluation of fishery management tools and strategies that will lead to profitable and sustainable fisheries and a healthy marine ecosystem. Dan actively participates in the development of fishery policy by working with fishery stakeholders and fishery managers to develop and evaluate policy. He has a long standing interest in spatial aspects of fishery management such as marine reserves and area management. He has used simulation modelling to evaluate a range of spatial management measures including closed areas, individual quota systems with alternative spatial designs, and individual quota systems for habitat impacts. Other primary research interests include design of fishery management systems that are robust to uncertainty, and modelling the effects of regulations and information on fishing decisions.

Kieran KELLEHER [World Bank] presented *Rebuilding Fisheries and Policy Reform: Banking on Sustainable Fisheries*. Kieran Kelleher is the Fisheries Team Leader in the World Bank. He is also the manager of the World Bank's Global Partnership on Fisheries - PROFISH (www.worldbank.org/fish). The partnership includes developing countries, leading bilateral donors to the fisheries sector, and technical institutions such as FAO. With a background in biology and economics, he has spent most of his career in developing countries. He has worked as a fisherman, fish farmer, fisheries scientist, and economic advisor on fisheries to governments and in more than 60 countries. He is the author of global studies on discards, on aquaculture and on fisheries enforcement, and co-author of a recent World Bank Study, "The Sunken Billions: The Economic Justification for Fisheries Reform".

Saba KHWAJA [Fisheries Policies Division, OECD] presented the *Next Steps in the OECD Project on the Economics of Rebuilding Fisheries*. Saba Khwaja is currently on secondment to the Fisheries Policy Division of the Organisation for Economic Co-operation and Development (OECD), as one of the inaugural two candidates selected as part of the Government of Canada-OECD Developmental Program. Prior to her placement at the OECD, she spent almost eight years in various posts at the Economic Analysis and Statistics Branch of Fisheries and Oceans Canada, conducting economic analysis and provided policy advice related to the federal species at risk legislation. She holds a Masters degree in Public Policy and Public Administration from Concordia University, Montréal, Canada.

Sherry L. LARKIN [University of Florida, United States] presented *Applying Bioeconomic Models in Rebuilding Fish Stocks: Tradeoffs, Risks, and Cautionary Tales*. Dr. Sherry L. Larkin is an associate professor in the Department of Food and Resource Economics at the University of Florida. She has a teaching and research appointment in the area of natural resource economics. Her work in fisheries has concentrated on examining management issues via bioeconomic models, stochastic profit functions, and portfolio analysis. Additional work has focused on the role of individual and firm behaviour via revealed and stated preference analysis at the harvester, wholesale and consumer levels. These approaches have been used to investigate fisheries in New

Zealand, Ecuador, Korea, the Falkland Islands, and the U.S. and include Pacific whiting, loligo squid, reef fish, live marine ornamentals, spiny lobster, swordfish, sharks, reef fish, blue crab, clam scallops, and oysters. She is currently an appointed member of the Science and Statistical Committee of the South Atlantic Fishery Management Council and the Socioeconomic Panel of the Gulf of Mexico Fishery Management Council. She also currently serves as a member of the Executive Committee of the International Institute of Fisheries Economics and Trade as the North American representative.

Sang-Go LEE [College of Fisheries and Sciences, Korea] presented *Rebuilding Fishery Stocks in Korea: A National Comprehensive Approach*. Dr. Lee is a professor of natural resource economics in the Marine Business and Economics Division of the College of Fisheries Sciences at Pukyong National University in Korea. Dr. Lee attended the University of Rhode Island in the United States from 1986-1991, and completed a PhD in economics, specializing in marine resources. He is presently teaching courses in bio-economics, fisheries economics, fisheries management and applied resources and environmental economics. He is also currently serving as a Vice-Chair to the OECD's Committee for Fisheries.

Rebecca LENT [NOAA Fisheries, United States] was the Workshop *Chair*. Rebecca has a Ph.D. in Resource Economics from Oregon State University, and she completed her post doctoral work in France. She has spent eight years in academia at Laval University in Quebec, Canada. Rebecca has been working at NOAA Fisheries for seventeen years, initially as an economist for the first three years, followed by stewardship roles. At present, she is the Director of the Office of International Affairs at NOAA Fisheries. She is also currently the government of the United States Commissioner to ICCAT, as well as the Chair of the Biodiversity Conservation Working Group of the Convention on Environmental Co-operation under the North American Free Trade Agreement.

Erik LINDEBO [DG Maritime Affairs and Fisheries, European Commission] presented *Rebuilding EU Fisheries: MSY and the Economic Dimension*. Erik Lindebo is a fisheries economist working in DG Maritime Affairs and Fisheries, European Commission. Before taking up his post in the Commission in 2005 he spent 8 years working as an analyst at the Food and Resource Economics Institute in Copenhagen, researching and advising on national and EU fisheries matters. He has a PhD from the University of Southern Denmark on the topic of Managing Capacity in European Fisheries. He also has experience from working and studying in the UK, United States and Australia/NZ. His particular role has been to examine economic aspects of the Common Fisheries Policy (CFP), including impact assessment of management plans, rights-based management, subsidies, overcapacity and industry performance. For the last year he has also been a member of the internal task force on the future CFP reform.

Wayne McNEE [Chief Executive, Ministry of Fisheries, New Zealand] was a Workshop *Discussant*. Wayne was the Chief Executive of the Pharmaceutical Management Agency (PHARMAC), a position he had held since 2001, and was seconded to the Department of the Prime Minister and Cabinet for 18 months, before taking up his present role in January 2008. After completing a Bachelors degree in Pharmacy at Otago University in 1985, Wayne undertook a series of pharmacy roles both in New Zealand and England before taking up the Therapeutic Group Manager role at PHARMAC in July 1995. He then followed a career pathway within PHARMAC culminating in his appointment as Chief Executive. In 1998 Wayne was awarded a post graduate Diploma in Clinical Pharmacy at Otago University and he has undertaken leadership, management and strategic leadership programmes at Oxford University and Stanford Business School.

Gordon MUNRO [University of British Columbia, Canada] presented *Getting the Economics and the Incentives Right: Instrument Choice in Rebuilding Fisheries*. Gordon Munro is currently Professor Emeritus with the Department of Economics and the Fisheries Centre, University of British Columbia. He is also a Visiting Professor with the Centre for the Economics and Management of Aquatic Resources, University of Portsmouth. Since the early 1970s, he has specialized in fisheries economics. In this area, he has published numerous articles, papers and books on both theoretical and policy issues, including articles pertaining to the economics of investment in fishery resources. In 2007, the book, *Advances in Fisheries Economics*, was published in his honour. He has done consultation work for the Canadian Department of Fisheries and Oceans, the National Research Council (USA), the Royal Society of Canada, the OECD, the FAO, UNEP and APEC (Asia Pacific Economic Co-operation). From 1984 to 1996, he was Coordinator of the Pacific Economic Co-operation Council Task Force on Fisheries Development and Co-operation. The Task Force focussed primarily on the fisheries management problems, under the New Law of the Sea, of the developing coastal states of Southeast Asia, the Western and Central Pacific, and Pacific Latin America.

Steven MURAWSKI [Chief Science Advisor, National Marine Fisheries Service, United States] presented the *Science of Rebuilding Fisheries: State of Play and Current Issues*. Dr. Murawski is currently the Director of Scientific Programs and Chief Science Advisor to the USA National Marine Fisheries Service. Headquartered in Silver Spring, Maryland, Dr. Murawski supervises six regional fishery science centres comprised of 25 coastal laboratories and field stations, with about 2,000 scientists, technicians and support staff, using 11 ocean going ships. Scientific information produced by these centres supports the management of over 530 fishery species nationwide, as well as 170 stocks of marine mammals, endangered sea turtle populations and other marine populations. His portfolio of science includes population dynamics and sampling, oceanography, social sciences, marine ecosystem analyses and environmental toxicology and genomics. Prior to his current assignment, Dr. Murawski was the Director of the Office of Science and Technology for the Fisheries Service, and previously served as a research fishery biologist at fisheries laboratory in Woods Hole, Massachusetts. He has published over 150 journal articles, book chapters, and reports focusing on the dynamics of exploited populations, the effectiveness of marine protected areas, and ecosystem approaches to fisheries management. He is the US Government Delegate to ICES, and a member of many government panels and committees on marine science. He has received numerous honours and awards including the US Department of Commerce gold medal, and five NOAA bronze medals for scientific and advisory services. Dr. Murawski received his Ph.D. in fisheries biology from the University of Massachusetts – Amherst.

John NEILSON [Fisheries and Oceans Canada] gave a presentation on *ICCAT Swordfish*. Dr. John Neilson holds a B.Sc. (UBC), a Master of Natural Resource Management from the University of Manitoba, and a Ph.D. from Simon Fraser University. He has had more than 30 years of experience conducting research on the Atlantic, Pacific and Arctic coasts of Canada, including freshwater and anadromous fisheries, and has published more than 200 scientific and technical contributions concerning those fisheries. He currently heads the Large Pelagics Program of Fisheries and Oceans Canada, and is responsible for the stock assessments and associated research for tunas and swordfish occurring in the Canadian Atlantic Zone. He coordinates the scientific activities associated with swordfish stocks that are part of the mandate of ICCAT (International Commission for the Conservation of Atlantic Tunas).

Robert POMEROY [The WorldFish Center] presented *Challenges in Rebuilding Fisheries in a Developing Country Context: Addressing Overcapacity in Vietnam's Small Scale Fishery Sector*. Robert Pomeroy is currently a Professor in the Department of Agricultural and Resource Economics and Connecticut Sea Grant College Fisheries Extension Specialist at the University of Connecticut – Avery Point in Groton. He is also a Principal Scientist at the WorldFish Center headquartered in Penang, Malaysia. Before starting at the University of Connecticut in August 2002, Dr. Pomeroy worked at the World Resources Institute in Washington DC from September 1999 to December 2001 where he helped develop a marine program. Prior to that, he worked at the International Center for Living Aquatic Resources Management (ICLARM) in Manila, Philippines from 1991 to 1999. Dr. Pomeroy has his PhD in Resource Economics from Cornell University. His areas of professional interest are marine resource economics and policy, specifically small-scale fisheries management and development, coastal zone management, aquaculture economics, international development, policy analysis, and seafood marketing. Dr. Pomeroy has worked on research and development projects in over 40 countries in Asia, Africa, the Caribbean and Latin America.

Andrew A. ROSENBERG [University of New Hampshire, United States] presented *Information Issues and Constraints in the Design and Implementation of Stock Rebuilding Programs*. Dr. Rosenberg is a Professor in the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire (UNH) where, prior to April 2004, he was dean of the College of Life Sciences and Agriculture. From 2001-2004, he was a member of the US Commission on Ocean Policy and continues to work with the US Joint Ocean Commissions Initiative. Prior to coming to UNH he was the Deputy Director of NOAA's NMFS from 1998-2000. As Deputy Director he dealt with policy decisions on science and resource management issues nationwide as well as the administration of the agency. He was a principle agency spokesperson before Congress, the public and technical audiences. Before becoming NMFS Deputy Director, he was the NMFS Northeast Regional Administrator. Dr. Rosenberg's scientific work is in the field of population dynamics, resource assessment and resource management policy. He holds a B.S. in Fisheries Biology from the University of Massachusetts, an M.S. in Oceanography from Oregon State University and a Ph.D. in Biology from Dalhousie University. He was on the faculty of Imperial College of Science and Technology in London for six years and was the Deputy Director of the Renewable Resources Assessment Group, and internationally known quantitative analysis and policy group. He is currently the President of MRAG Americas, a consulting company with offices in Florida, Massachusetts and is a member of the Board of Directors of MRAG, a London-based international marine resource consultancy.

Per SANDBERG [Norwegian Directorate of Fisheries] wrote the paper on *Norwegian Spring Spawning Herring*. Dr. Sandberg is 48 years old and has been working with fishery management at the Norwegian Directorate of Fisheries in Bergen since 1989. One of his fields of interests has been how to apply bioeconomic theory in practical fishery management. In 2006 he defended the dissertation "Some economic aspects of relevance for harvest rules for marine fish stocks" for the degree Dr. Oecon at the Norwegian School of Economics and Business Administration. Sandberg currently works as Director of the Statistics Department at the Norwegian Directorate of Fisheries.

Hirotsugu UCHIDA [University of Rhode Island, United States] presented *Community-based Management for Sustainable Fishery: Lessons from Japan*. Dr. Uchida is an Assistant Professor in the Department of Environmental and Natural Resource Economics at the University of Rhode Island. His research interest is on the development

of socially efficient common pool resource management policy, with particular focus on the collective self-governance by the local resource users. His particular focus is on institutional designs and rules of the game adopted by such self-governing organizations, and understanding how these affect the incentive structure of resource users and the consequent outcomes. In his recent research he analysed fishery co-management organizations in Japanese coastal fisheries, both theoretically and quantitatively, utilizing extensive fieldwork and conducting surveys. He received a Ph.D. degree in Agricultural and Resource Economics from the University of California at Davis.

Douglas Clyde WILSON [Aalborg University Research Centre, Denmark] presented *The UNCOVER Project: A Multi-disciplinary Evaluation of Recovery Plans in the European Union*. Douglas (Ph.D. Michigan State University 1996) is Senior Researcher and Research Director at Innovative Fisheries Management, an Aalborg University Research Centre. He is an environmental and natural resource sociologist with extensive experience in marine and fisheries management in Africa, North America and Europe. His research addresses communicative systems theory, marine governance, and the sociology of science and knowledge. A central focus of his recent research has been the institutional aspects of providing scientific advice for marine management and he has recently published a monograph on that subject called *The Paradoxes of Transparency: Science and the Ecosystem Approach to Fisheries Management in Europe*. He has co-edited three books on fisheries management. He serves on the editorial boards of one social science, one fisheries science, and one multidisciplinary journal. He is a member of the Executive Council of the International Association for the Study of Commons and of the Global Advisory Board of the Institute of Cultural Affairs International. He is the immediate past chair of the ICES Working Group on Fisheries Systems and is the first social scientist to chair a permanent working group at ICES. He has also served as the coordinator of three Europe-wide research projects and as a work package coordinator for five others.

Annex B: Participants List

WORKSHOP ON THE ECONOMICS OF REBUILDING FISHERIES¹

Canada Department of Fisheries and Oceans	Mr. Robert ELLIOTT Director General
	Mr. Dale MARSDEN Policy Analyst
	Mr. Peter SHELTON Research Scientist
Korea Ministry for Food, Agriculture, Forestry and Fisheries	Mr. Geo Young KANG Deputy Director Fisheries Resources and Environment Division
	Mr. Young Woo SON Fisheries Economist
	Mr. Do Hoon KIM Research Specialist National Fisheries Research & Development Institute
Norway	Mr. Sverre JOHANSEN Deputy Director General Department of Marine Resources and Environment
Turkey	Mr. Durali KOCAK Director General Ministry of Agriculture and Rural Affairs
	Mr. Haydar FERSON Biologist Ministry of Agriculture and Rural Affairs
United States, NMFS	Mr. Gregory SCHNEIDER Senior International Trade Specialist NMFS

¹ Under alphabetical order by delegation or organisation. The Chair, speakers and discussants are not listed here but can be found under Biographies.

United States, NOAA

Ms. Susan CARILLO

Economist
NOAA

Ms. Sonia JARVIS

Economist
NOAA

Mr. Andrew KITTS

Economist
NOAA

Mr. Christopher LIESE

Economist
NOAA

Mr. Aaron MAMULA

Economist
NOAA

Mr. Steve MURAWSKI

Chief Science Advisor
NOAA

Ms. Barbara ROUNTREE

Economist
NOAA

Mr. George SILVA

Economist
NOAA

Mr. Cameron SPEIR

Economist
NOAA

Mr. Joe TERRY

Economist
NOAA/NMFS

Mr. Michael TRAVIS

Industry Economist
NOAA/NMFS

ORGANISATIONS/COMPANIES

Aalborg University Research Centre	Mr. Doug WILSON Research Director, UNCOVER Project Denmark
Cinvestan	Ms. Sylvia SALAS Professor Mexico
Coastal Oregon Marine Experiment Station (OSU)	Mr. Gilbert SYLVIA Marine Resource Economist United States
E-Digital Research	Mr. Lacey TUDUR Research Analyst United Kingdom
Environmental Defense Fund	Mr. Richard ALLEN Fishery Policy Analyst United States
Environmental Defense Fund	Ms. Pamela BAKER Senior Policy Analyst United States
Environmental Economics Services (Consulting)	Mr. Jack DONNAN Principal Economist United States
Gentner Consulting Group	Mr. Brad GENTNER President United States
Göteborg University	Mr. Kofi VONDOLIA Ph.D. candidate Sweden
Goucher College	Ms. Gina SHAMSHAK Assistant Professor United States
Gulf Of Maine Research Institute	Mr. Daniel HOLLAND Resource Economist United States
Gulf States Marine Fisheries Commission	Mr. Alexander MILLER Staff Economist United States

Memorial University Newfoundland	Mr. Ahmed KHAN Ph.D. candidate Canada
OECD	Mrs. Emily ANDREWS-CHOUICHA Trade and Agriculture Directorate Assistant, Fisheries Policies Division
Oregon States University	Ms. Anne SHRIVER Executive Director IIFET
	Mr. Gert van SANTEN Private Consultant Fisheries development and management specialist
UNEP	Mr. Moustapha Kemal GUEYE Fisheries Economist Switzerland
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University of Copenhagen	Mr. Peder ANDERSEN Head of Department of Economics Denmark
University of Southern Denmark	Mr. Lars J. Ravn-Jonsen Researcher
University of Montana	Mr. Robert McKELVEY Professor Emeritus United States
University of Rhode Island	Mr. Christopher ANDERSON Professor United States
University of Southern Denmark	Mr. Thanh Nguyen Viet Ph.D. Candidate
University of Texas	Mr. Wade GRIFFIN Professor

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The Economics of Rebuilding Fisheries

WORKSHOP PROCEEDINGS

Rebuilding fisheries is a key challenge for many countries as some stocks are in a poor state while others are depleted. The World Summit on Sustainable Development (2002) called for attaining sustainable levels of stocks by the year 2015. But how will nations rebuild their fisheries, while taking into account biological, social, economic and environmental factors?

The OECD Committee for Fisheries is undertaking a major study to address this issue. In May 2009, economists, biologists, fisheries managers and policy makers participated in an OECD Workshop on the Economics of Rebuilding Fisheries as part of this effort. The Workshop was designed to identify and analyse economic uncertainties, policy issues, biological conditions and information constraints, and to review the role of key players in programme delivery. This report presents an overview of the major economic and institutional issues associated with rebuilding fisheries and provides examples of national and international initiatives.

The full text of this book is available on line via this link:

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