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MEASURING SUSTAINABLE DEVELOPMENT

APPLICATION OF THE GENUINE PROGRESS INDEX TO NOVA SCOTIA

THE NOVA SCOTIA GPI FISHERIES & MARINE ENVIRONMENT ACCOUNTS

A PRELIMINARY SET OF ECOLOGICAL, SOCIOECONOMIC AND INSTITUTIONAL INDICATORS FOR NOVA SCOTIA'S FISHERIES AND MARINE ENVIRONMENT

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January 2002.

EXECUTIVE SUMMARY

"The sea was swarming with fish, which could be taken not only with the net but in baskets let down with a stone, so that it sinks in the water."
– John Cabot's crew off the Atlantic coast in 1497

Why We Need New Indicators

In the late 1980s, Nova Scotia's fishery for cod and other groundfish seemed to be booming. The media reported steady catches, high exports, and strong contributions of the fishery to the province's Gross Domestic Product (GDP), the conventional measuring stick of the economy.

A few years later, many fisheries were collapsing and the fabric of many coastal communities began to unravel. Our conventional economic measuring sticks – such as catches, exports and GDP – did not warn of the impending disaster. While catches were kept high, the decline of the groundfish stocks remained hidden from public view, as we focused excessively on a narrow set of economic measures that failed to incorporate all that we value in the fishery – notably healthy fish stocks within a healthy ecosystem, supporting strong fishing communities and a sustainable fishing economy.

Another example of failing to measure what we value may be found in the marine oil spills that have occurred in the ocean ecosystems of Nova Scotia and beyond. Every such oil spill is good news for the economy, because cleaning up the mess causes money to be spent, producing an overall positive effect on our conventional economic indicators such as GDP. Yet, as with the collapse of fish stocks, oil spills clearly represent a decline in well-being and sustainability and not an increase in prosperity as our conventional measures of progress imply.

If the protection of the marine environment is important to us, we clearly need a set of measures that better reflect the reality of what we value and that assess the well-being of the fishery and the marine environment more accurately. Unlike the confusing signals sent by our economic growth statistics, genuine indicators of fisheries and marine environment health would move in a positive direction to reflect positive outcomes, and decline in response to declining fish stocks, oil spills and other liabilities. Such declining indicators can also send early warning signals to policy makers that could potentially avoid disasters like the collapse of the groundfish stocks.

Such indicators would enable us to track over time the state of Nova Scotia's fish stocks, the fishery's contribution to our economy, the quality of the marine environment, the well-being of the communities that depend on the ocean for their livelihood, and the effectiveness of the institutions that govern fishing activities and ocean use. Developing such a comprehensive, accurate and meaningful overall assessment of the state of the fishery and the marine environment is a crucial challenge for society, particularly in a region like Atlantic Canada whose well-being has historically depended on the ocean.

Framework of the GPI Fisheries and Marine Environment Accounts

The *GPI Fisheries and Marine Environment Accounts* for Nova Scotia represent an initial response to this challenge, through the creation of a framework of indicators that can be monitored and applied on a regular basis to evaluate the well-being and sustainability of the fisheries and the marine environment.

Remarkably, this is among the first, if not *the* first, such effort to appear anywhere in the world. The report has been prepared as one of the components of Nova Scotia's Genuine Progress Index (GPI), a comprehensive set of measures that enable us to assess our social, economic and environmental well-being more accurately. The GPI includes a full set of natural resource accounts that value our *natural* and *social* wealth just as our conventional accounts value our produced or manufactured wealth.

Each indicator in the *GPI Fisheries and Marine Environment Accounts* measures one particular aspect of the marine system, dealing with the ecosystem, socioeconomic progress, the well-being of coastal communities, and the institutional integrity of fishery and ocean management. The indicators are therefore organized into major categories, reflecting the fundamental components of well-being and sustainability that must be simultaneously achieved within a process of sustainable development:

- *Ecological Indicators*
- *Socioeconomic and Community Indicators*
- *Institutional Indicators*.

The first of these categories includes aspects specific to fish stocks, as well as those pertaining to the marine ecosystem more broadly. The second category includes the conventional economic indicators, as well as those describing the current state and sustainability of the social, economic and community aspects of the fishery and other ocean use sectors. The third category concerns matters of financial, administrative and organizational capability, including the manageability and enforceability of resource use regulations, and organizational integrity in ocean management.

Within these three categories, a very wide-ranging set of indicators has been examined in this report. These indicators, listed at the end of this Executive Summary, were selected primarily on the basis of perceived importance and data availability.

Some Results of the GPI Fisheries and Marine Environment Accounts

- Many fish species, especially many groundfish species, declined in recent decades, while others, notably shellfish, did not. Shrimp, for example, appears to have increased in biomass since 1995 and the lobster biomass (as reflected in catch levels) appears to have been relatively constant since 1990.

- While there was no overall trend in the size (at specific ages) of herring or cod between the early 1970s and late 1990s, the average size of pollock decreased considerably, suggesting significant changes in that stock.

- Many non-target species are poorly understood compared to commercially important species such as cod, herring and shrimp, even though the health of these non-target species may be important for commercial species and for the marine ecosystem as a whole. Studies of non-target fish species are very rare. One recent study drew attention to the plight of the barndoor skate, a species that has been severely depleted through unmonitored and uncontrolled capture in Atlantic Canadian trawl nets. Further in-depth study is needed of the health of non-target species, as part of the emerging ecosystem approach to fishery management.

- High levels of bycatch, discarding and dumping of fish can be a serious problem for the health of the fisheries and marine ecosystem. Even though it is very important to understand both the level of bycatch, discarding and dumping of fish and also the trends in these activities, it is not presently possible to track progress in reducing bycatch and discard amounts. This is a serious data gap and a challenging task. Major research efforts are needed to monitor these important indicators of sustainability in fisheries more effectively.

- Population trends of North Atlantic right whales are subject to uncertainty, but there is general agreement that the current population now (just under 300) is above what it was at its lowest level, but far below levels that existed prior to exploitation.

- Ocean gear can adversely affect the ocean bottom, which provides shelter, spawning, nursery grounds and feeding for many fish species. It is therefore important to monitor the human impact on the ocean bottom far more effectively than at present, particularly through studies of fishing grounds impacted by trawling. One estimate suggests that on the American side of George's Bank, an area two to four times the size of the bank was trawled *each year* between 1976 and 1991. Since this location is adjacent to Canadian fishing grounds, these results may provide insights into potential trawl impacts in Nova Scotian waters.

- Concentrations in seabird eggs of PCBs, DDE, HCB and dieldrin – chemical contaminants present in the marine environment surrounding Nova Scotia – all declined overall between 1972 and 1996, suggesting some 'genuine progress' in this aspect of marine environmental quality.

- Government data indicate that Nova Scotia accounts for about 47% of the total number of locations closed to shellfish harvesting in Atlantic Canada. It has been estimated that area closures have increased by an average of 34 square kilometres per year for every year since 1975, and by 264 sq. km. since 1995 alone, a 38% increase in less than five years.

- The value (adjusted for inflation) of fish landed by Nova Scotians increased steadily from 1961, the first year for which data are available, to reach a peak of $701 million in 1987 and the declining to a value of $482 million in 1997. Despite this drop, landed values in 1997 were double what they were in 1970. This can be explained by the increased effort in harvesting species such as lobster that command a high market value. Meanwhile, the fishery

GDP has declined by about one-third in the last decade, and its *percentage* contribution to provincial GDP has declined even more as total provincial GDP has continued to grow.

- Employment 'per fish' taken from the sea can be measured as the number of people employed in Nova Scotia's fishing industry *per unit of harvest* (i.e. per tonne of fish caught), or *per unit of landed value* (i.e. per million dollars in landed value). The first of these indicators has been increasing fairly steadily since the mid-1980s, due largely to the decline in total landings by weight, while the employment per unit of landed value declined in the late 1980s and early 1990s, and then began to increase in the late 1990s.

- Natural capital includes the value of fish stocks remaining in the ocean. In 1997, the natural capital in Nova Scotia's cod stocks was about $74 million lower than in 1982. In 1997, Nova Scotia's haddock stocks had depreciated by about $53 million compared to the level in the early 1980s. The measured 'depreciation' of cod stocks around Nova Scotia since 1990 appears minimal, but caution is needed in interpreting natural capital calculations, since serious resource declines are masked by price rises when natural capital values are assessed according to changing market prices.

- The annual value of ecosystem services for the oceans off Nova Scotia is calculated very roughly as $US119 billion (1997 dollars). The enormity of this figure highlights the fact that the total value of ecosystem services provided by Nova Scotia's marine environment is clearly not captured in the fishery's GDP. Indeed the value estimated here is more than 340 times greater than Nova Scotia's fishery GDP has ever reached.

- Distribution of access to fisheries, and of the benefits produced by the fisheries, is an important part of a GPI account. DFO data show that in one part of the fishery, the ITQ-managed Scotia-Fundy mobile gear groundfish fishery, ownership of 'quota' (representing effective access to the fishery) became concentrated in fewer hands between 1990 and 1998. This arose through a decline in the total fleet size, from roughly 350 vessels to under 150, and a less even distribution of the catches among existing boats. By contrast, the distribution of catches in the *lobster* fishery, while not entirely even, shows no trend over time, remaining roughly constant. However, in terms of *access* to the fishery, there is apparently a recent trend toward the buying up of control over lobster licenses, increasing effective ownership concentration.

- The dependence of Nova Scotian fishers on the various marine species has varied over the years. There is some evidence of a reduced reliance on single fisheries, and thus a more diverse set of fishery livelihood options, over the course of the past century. This may imply greater resilience within fishing communities, a positive trend. On the other hand, the steadily increasing dependence on the shellfish fishery following the groundfish collapse in the early 1990s may be a danger signal of reduced resilience in the future if the shellfish fishery should be threatened for ecological reasons.

- When fishers hold licenses to fish multiple species, this can enhance resilience in the fishery and in coastal communities.There was little change between 1985 and 1993 in the proportions of fishers holding single, double or multiple species licenses, but there has been a gradual positive trend towards greater multi-species licensing between 1993 and 2000. In 2000 more than 86% of fishers held licenses for at least 2 species, up from fewer than 76% in 1993..

- Between 1931 and 1990 in Nova Scotia, there have been decreases of approximately 5% in both the proportion of young fishers (15-24 years) and the proportion of older fishers (45-65 years) while the proportion of middle-aged fishers (25-44 years) increased by roughly 10%.

- In the aquaculture sector, there have been upward trends in the produced value of each component of aquaculture (shellfish, finfish, and 'other'), as well as in the generation of full-time employment. Finfish, notably salmon, dominate in value terms, but shellfish production generates an important source of employment in many parts of the province. More research is needed on the potential impact of aquaculture both on the ocean habitat (through pollution, disease transfer, etc.) and on fisheries (through habitat impacts, market interactions, etc.)

- There is no consistent trend suggesting that the Nova Scotia fisheries are becoming more or less safe overall for fishers, but the current average of 50 accident claims per year for every 1,000 fishers employed (a 5% rate) remains high.

- Available data suggest that in the three years leading up to the early 1990s groundfish collapse, DFO expenditures decreased significantly on basic scientific work (such as ecosystem and ocean science studies), and on surveillance and enforcement of fishery regulations. Assessing the sufficiency of institutional resources is an important part of a GPI analysis, and requires more extensive development of institutional indicators.

Key Themes in the GPI Fisheries and Marine Environment Accounts

- *The Big Picture*. In the past, there has been a tendency to look at the fishery separate from other ocean uses, and to look at a given fishery, or the harvesting of a particular species or set of species, as separate from other fisheries, ignoring connections among them. In other words, there has been too much compartmentalization.

  The picture that emerges from this report is an integrated one that recognizes the complex interconnections within the marine ecosystem, and among the humans reliant on that ecosystem. The set of indicators explored here reflects some of the breadth needed to monitor and assess our fisheries and the marine environment more fully and comprehensively than has been the case to date.

- *No Simple Answers*. It does not seem possible to draw a simple conclusion about the current state of Nova Scotia's fisheries and marine environment. The results present a sense of the complexity within the marine environment: There are major problems, reflecting in part the set of crises experienced in Atlantic fisheries in recent years, with some indicators at low levels. On the other hand, other indicators are stronger, and many show no clear trend at all.

  This reinforces the need to use multiple indicators, and to look at each indicator individually, to understand its particular nuances, rather than merely adding up the results. Indeed, this is the major reason that **GPI***Atlantic* has avoided a 'bottom line' composite Genuine Progress Index, but is slowly constructing each component of the index as a separate entity.

- *A Focus on Resilience*. Resilience is a crucial requirement of sustainability, reflecting the ability of an ecosystem or a human system to 'bounce back' from shocks and to maintain its integrity. For ecosystems, genuine progress is assessed by the capacity to maintain the ecosystem's health over time, in response to human-induced or environmental stresses. Possible determinants of ecosystem resilience include biodiversity and the 'integrity' or well-being of the ocean habitat.

  On the human side, the socioeconomic system and coastal communities must be able to 'bounce back' from dramatic changes in the natural resource base or in the overall economic system. Socioeconomic and community resilience may require attention to such indicators as debt levels, diversification of total fishery landings across multiple species, access of individual fishers to multiple fisheries, diverse age structure among fishers, economic diversification within the fishery, and community-level economic development initiatives that expand diversity and reduce reliance on a single industry.

- *The Ocean's Natural Capital*. To account fully for the 'benefits' of a given harvest, measures of catches and exports must be accompanied both by a measure of the value of the fish remaining in the ocean after the fishery has taken place, and by a measure of ecosystem health. Together, these measures reflect the values of '*natural capital*', the natural assets that include not only the fish in the sea, but also the quality of the water, the ocean bottom habitat, and other elements of the marine environment.

  Some of the benefits that natural capital provides are obvious (like fish to eat), while others, such as the value of habitat provided for non-commercial species, may not be directly apparent to humans. Given the interdependence of all components of the marine ecosystem, it is prudent to recognize *all* benefits, since all have significant and real value. For example, the less visible benthic (ocean-bottom) environment keeps commercial fisheries functioning, among other roles. It is therefore important to monitor the full range of natural capital services if we are to assess accurately the economic health of the fishing industry and other components of the marine economy.

  This report provides an initial, and admittedly overly-simple, effort to assess the state of natural capital over time. By introducing a 'balance sheet' of underlying resource health, on which the fishing industry depends, the GPI approach provides a more accurate and comprehensive measure of resource industry strength and health than conventional accounting systems.

- *The Need for Natural Resource Accounts*. Among the key messages of this report is the importance of publicly accessible natural resource accounts. Had fisheries accounts been included in our core measures of progress in Atlantic Canada in the 1980s, information would have been available to policy makers and the general public to encourage conservation actions *before* the collapse of the cod and other groundfish stocks and the economically devastating moratorium that followed. A major role of the Genuine Progress Index, and of natural resource accounts in general, is to provide timely early warning signals to policy makers that will allow appropriate responses to resource depletion, to help prevent such catastrophic losses in the future.

Challenges in Future Development of the Accounts

GPI*Atlantic* believes that, quite apart from any specific results, the value of this report lies in providing a prototype for a new approach to looking at fisheries and the marine environment in the form of an integrated set of GPI indicators. However, the set of indicators in this report is by no means exhaustive. In particular, greater attention has been paid to fisheries data than to the marine environment, reflecting the relative abundance of environmental indicators already, and the consequent challenge of developing an accompanying set of fishery indicators. In future versions of these accounts, it will be important to incorporate more detail with respect to the marine environment.

There are good reasons why a set of fisheries and marine environment accounts has not been attempted previously, and these constitute major challenges for future development of these accounts. In particular, data availability is such a major issue in this area that even Statistics Canada did not include fisheries data in its new Canadian System of Environmental and Resource Accounts. A major goal of the report is therefore to highlight where gaps exist in the information base.

The indicators chosen for this report were mostly ones for which data were available to assess trends over time. Nevertheless, clear gaps in data were apparent, and a challenge for future development of these accounts lies in overcoming such data limitations. In particular, there is a need for new databases and improved data availability on community well-being and sustainability, and on institutional indicators.

Another 'data challenge' for the future lies in integrating a wider range of sources of knowledge within the database that is used to generate marine indicators. The indicators in this report are based on whatever numerical data are available, even though these data may sometimes involve relatively short time series. Such data typically omit the rich knowledge and historical accounts of fishers, other ocean users and those in coastal communities – the kind of 'data' that do not fit easily into graphs but which are no less accurate, profound and insightful than statistical data.

A reliance on relatively recent experience – for which data are more available and/or more reliable – may, for example, present a distorted picture of the health of our fish stocks. As the quotation from John Cabot's crew in 1497 (at the start of this summary) indicates, a reliance on recent statistics will lead us to forget that large healthy fish and large healthy fish populations were once standard fare! Efforts are therefore needed in the future to integrate the various sources of knowledge about fisheries and the marine environment more fully.

Discussions of data availability, and indeed of additional data sources that have yet to be utilized, highlight another major challenge for the future. The process of improving the *Fisheries and Marine Environment Accounts* must be an ongoing one, requiring a participatory approach that involves government departments, academic institutions, non-government organizations, the many users of the ocean environment, and others.

It is hoped that the prototype presented here can be further developed through such a process, and implemented on a regular basis. To this end, **GPI***Atlantic* invites feedback to improve methodologies, data sources and indicator selection.

A Closing Comment

A carefully formulated GPI analysis can assist greatly in providing the information needed for informed decision-making. It can also assist our society and Nova Scotia as a whole to achieve a key policy goal – ensuring that our natural resources are used in a sustainable manner that benefits citizens, communities, and the natural environment both now and in the future. The GPI *Fisheries and Marine Environment Accounts* are intended as a starting point in that endeavour and as a contribution to that process. The diverse set of indicators discussed here need future refinement, but they already go beyond conventional measures, and are ready to be used and applied by policy makers, fishers and other ocean users, coastal communities, and indeed everyone concerned about the health of our fisheries and the marine environment.

Indicators Included in the GPI Fisheries and Marine Environment Accounts

Ecological Indicators

Primary Commercial Species
- Fishable Biomass
- Catch Levels
- Size at Age
- Condition Factor
- Age Structure

Non-Target Species
- Discard Rates
- Right Whales: Population and Reproduction

Resilience and Biodiversity
- Shannon-Weiner Index
- Area of Bottom Habitat Impacted

Marine Environmental Quality
- Organochlorine Contaminants in Seabird Eggs
- Contaminants in Mussels
- Area of Shellfish Closures

Socio-Economic / Community Indicators

Economic Valuation of Fishery Resources and the Marine Environment
- Total Landed Value
- Fishery Gross Domestic Product (GDP)
- Value of Fishery Exports
- Employment per unit of Landed Weight
- Employment per unit of Landed Value
- Market Price
- Natural Capital (Fish Stock Value)
- Annual Depreciation (or Appreciation) in Natural Capital
- Value of Marine Ecosystem Services

Distributional Indicators
- Distribution of Access and Catch among Fishers within a Fleet Sector
- Distribution of Catch among Fishers within a Fishery
- Distribution of Landed Value by Vessel Length

Resilience
- Debt Levels among Fishers
- Reported Bankruptcies
- Bankruptcy Liabilities
- Distribution of Landed Value across Species
- Proportion of Fishers with Multiple Licenses
- Age Distribution of Fishers
- Diversification of Employment Sources

Aquaculture
- Value of Aquaculture Production
- Employment in the Aquaculture Sector

Workplace Safety
- Accident Claims Registered per 1000 Fishers
- Accident Claims Compensated per 1000 Fishers

Institutional Indicators

Sufficiency of Institutional Resources
- Total Expenditures
- Distribution of Expenditures by Category

Acceptability of Institutional Expenditures
- Expenditures as a proportion of Landed Value

PREFACE AND ACKNOWLEDGEMENTS

This is one of a series of reports issued by **GPI***Atlantic*, a nonprofit organization working to develop a comprehensive Genuine Progress Index (GPI) for Nova Scotia and beyond. These *Fisheries and Marine Environment Accounts* form one of 22 core components of the GPI. Other reports include those on Forests, Soils and Agriculture, Greenhouse Gas Emissions, Water Quality, Sustainable Transportation, and the Nova Scotia Ecological Footprint, as well as a range of social, socioeconomic and time use analyses. Please refer to the **GPI***Atlantic* web site (www.gpiatlantic.org) for details on these reports and the organization itself.

The authors of this report are grateful to Ronald Colman, Director of **GPI***Atlantic*, for his support and inspiration along the road to preparing this report. We also thank Larry Hildebrand, Mark Butler, Arthur Bull, Glen Herbert, Janis Raymond, Ted Potter and Clarence Stevens for helpful comments on earlier versions of the report. However, any errors or misinterpretations, and all viewpoints expressed, are the sole responsibility of the authors and **GPI***Atlantic*.

Inspiration for the Nova Scotia Genuine Progress Index came from the ground-breaking work of Redefining Progress, which produced the first GPI in the United States in 1995. Though **GPI***Atlantic*'s methods differ in many ways, particularly in not aggregating index components for a single bottom line, we share with the original GPI the attempt to build a more comprehensive and accurate measure of well-being than can be provided by market statistics alone. **GPI***Atlantic* also gratefully acknowledges the pioneers in the field of natural resource accounting and integrated environmental-economic accounting on whose work this study and the GPI natural resource accounts build.

Needless to say, any errors or misinterpretations, and all viewpoints expressed, are the sole responsibility of the authors and ***GPI****Atlantic.*

 Copies of this report and of other **GPI***Atlantic* publications may be ordered through the GPI web site at www.gpiatlantic.org. Membership information is also available at this web site. Members receive a 25% discount on all publications and a subscription to the *GPI News,* published eight times a year, which contains updates on **GPI***Atlantic* activities, work in progress, latest results, and useful statistics on social, environmental and economic realities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THE NOVA SCOTIA GPI FISHERIES & MARINE ENVIRONMENT ACCOUNTS

1. Introduction

Nova Scotia's fishery in the late 1980s seemed to be booming. Media reports typically focused on how much fish was being caught, how much money was produced in the fishery, and how rapidly fish exports were growing. All of these factors contributed to a growing Gross Domestic Product (GDP), the conventional measuring stick of the economy. A few years later, however, many fisheries were collapsing and the fabric of many coastal communities began to unravel. Conventional economic measures, such as the fisheries GDP, did not warn of the impending disaster because they did not capture all we value in the fishery – a healthy marine environment and healthy fish stocks, supporting strong fishing communities and a strong fishing economy.

How should we go beyond traditional economic measures to better assess the well-being of our fishing industry, and of the marine environment around the province? We need to consider the state of the fish stocks, the fishery's contribution to our economy, the quality of the marine environment, the well-being of the communities that depend on fishing and the ocean for their livelihood, and the effectiveness of the institutional structures that govern fishing activities and ocean use, and support coastal communities. Including these elements in an overall assessment is certainly challenging, but their inclusion makes an assessment of the state of the fishery and the marine environment more meaningful, more complete and more accurate.

This report represents an initial effort to produce such an assessment, through a *Fisheries and Marine Environment Account* – a set of indicators of well-being and sustainability in the Nova Scotian context, prepared within the framework of the Genuine Progress Index. The GPI is a comprehensive approach that enables us to measure our social, economic and environmental well-being more accurately, and this report provides one of several GPI components, or 'accounts.' The key goal of this report is to initiate an approach to evaluate the well-being and sustainability of fisheries and the marine environment on a regular basis, through a 'status report' based on a set of measurable 'indicators.'

Indicators are tools to help managers, scientists, fishery participants, other ocean users, and the public to visualize the state of the marine environment and the fishery, and discuss issues of common interest and concern. Indicators enable us to track the state of Nova Scotia's fisheries and marine ecosystems over time; following such trends can provide insight into where current practices may lead in the future. Each indicator in this report measures one particular aspect of the system – dealing with the ecosystem, the socioeconomic aspects (as with GDP, above), the well-being of coastal communities, the institutional integrity of fishery and ocean management, and so on. Some indicators are 'observable' and 'measurable' (such as population size or employment rate) while others are more subjective (as in a survey, in which results are merely reported on a scale from 1 to 10).

Such indicators are well established for environmental aspects of marine systems, but only rarely bring together both natural and human aspects – see Charles (1997a, 1998), Chesson and Clayton (1998), and FAO (1999) for illustrations of this approach. Charles (1997b) provides a review of indicators in fisheries, coastal areas, watersheds, and beyond.

The indicators in this report are organized into major categories, reflecting the fundamental components of well-being and sustainability – ecological, socioeconomic, community and institutional – that must be simultaneously achieved within a process of sustainable development (Charles 1994). The rationale for indicators within each component is described in turn below:

- *Ecological Indicators* incorporate (a) the long-standing concern for ensuring that harvests are sustainable, in the sense of avoiding depletion of the fish stocks, (b) the broader concern of maintaining the resource base, non-commercial species and overall biodiversity at levels that do not foreclose future options, and (c) the fundamental task of maintaining or enhancing the resilience and overall health of the ecosystem.

- *Socioeconomic Indicators* focus on measuring how well we are maintaining or enhancing overall long-term socioeconomic welfare, based on a blend of relevant economic and social indicators. These indicators deal with such aspects as generation of sustainable net benefits, reasonable distribution of those benefits, and maintenance of the system's overall viability within local and global economies. Each indicator in this grouping is typically measured at the level of individuals, and aggregated across the given fishery system.

- *Community Indicators* revolve around the desirability of sustaining communities, both for their contribution to sustainability in the marine environment and the fishery system, and as valuable in their own right, as more than simple collections of individuals. Hence, indicators in this grouping focus on the maintenance or enhancement of the economic and sociocultural well-being of coastal and fishery-dependent human communities, as well as their overall cohesiveness and long-term health.

- *Institutional Indicators* measure how well we maintain suitable financial, administrative and organizational capability over the long-term, as a prerequisite for the above components of well-being and sustainability. Ideally, indicators here would measure the manageability and enforceability of resource use regulations, and of the organizations that implement management approaches – the bodies and agencies that manage the fishery and protect the marine environment, whether governmental, fisher or community, and whether formal (e.g., the legal system) or informal (fisher associations and nongovernmental organizations).

Based on these components, sets of indicators were developed in three categories: ecological, socioeconomic/community and institutional. In selecting indicators to be used for this report, a set of desired qualities was sought: the indicators had to be (a) based on scientifically valid data, (b) available on a broad geographical scale and for a sufficient time series, (c) accessible, easy to understand and relevant to those involved in Nova Scotia's fishing industry, and (d) practical in terms of monitoring (whether by government, ocean users or interested community groups). It is notable that in most cases, these qualities were not universally met. Indeed, the marine environment appears to be among the most challenging for developing indicators, due in part to the lack of 'fit' between political and ecosystem boundaries.

Components of Well-being and Sustainability
Ecological (*Avoid Foreclosing Future Options*)
Socioeconomic (*Sustainable and Equitable Economic and Social Benefits*)
Community (*Valuing Community as more than a Collection of Individuals*)
Institutional (*Long-Term Capabilities / Manageability*)

A particular challenge lay in dealing with indicators that are relevant, but for which data were either totally unavailable or available only for a specific time or location. In such cases, an effort has been made to discuss the indicator qualitatively (in the absence of data) or over the time or space for which it is available.

Along these lines, a particularly troubling concern arises when the 'best' numerical data for a key indicator – such as the biomass of fish – is available only for a relatively short time series. Such a situation can distort how we perceive the state of the world around us. To illustrate this, consider the case of a depleted fish stock. Graphs showing only the relatively recent experience with the stock – for which the data is more available and/or more reliable – can mislead us into accepting an undesirable state of the world as the norm, while forgetting that large healthy fish and large healthy fish populations once were standard fare:

> *"The sea was swarming with fish, which could be taken not only with the net but in baskets let down with a stone, so that it sinks in the water."*
>
> *– John Cabot's crew off the Atlantic coast in 1497*

Around Nova Scotia, and Atlantic Canada more broadly, are many fishers with many decades of experience, who tell us of the great abundance of fish, and the large individual fish, that were available in the past. This 'data' does not fit easily into graphs – the kind of graphs found throughout this report – but it is exceptionally important. It tells us what is possible, what we might wish as a society to pursue in the marine environment. With efforts underway around Atlantic Canada to reconstruct, from the traditional knowledge of fishers and coastal residents, the state of fish stocks and the marine environment dating far back in time, it will be possible to include such analyses, together with the specific individual knowledge of fishers and others in Nova Scotia, in future versions of this report.

The above is but one of many aspects of this report that one hopes to improve in the future. In particular, the set of indicators presented here is by no means exhaustive, and omits many that, in theory or in practice, may be desirable. The authors are very aware that many readers will note one or more indicators that should have been included, or for which data are available that we have not accessed, or for which our analysis is in some way faulty. This is undoubtedly a hazard involved in attempting for the first time an analysis of this type. Particular examples of limitations in this report include the following.

- Since the report focused on indicators applicable at a provincial (Nova Scotia wide) scale, and since financial and time considerations prevented obtaining specific data at a local level, aspects of community well-being and sustainability were not dealt with fully.
- Limitations on data and the time frame of the study, and an absence of suitable survey data, meant that institutional indicators were not developed as extensively as would be desirable. Even for the more quantitative ecological and socioeconomic indicators, it was not possible to locate the data needed to provide a full analysis of some indicators.
- Considerable data and analysis are already available on the marine environment of Nova Scotia. Indeed, these marine ecosystems are among the best studied in the world. On the other hand, integrated analyses of fishery systems are much rarer, and in fact, this report is among the first efforts to undertake such an analysis. Given this situation, research for the present report focused more on fisheries than on the marine environment; it is hoped that subsequent reports will incorporate the wealth of environmental indictors available.

Therefore, it must be emphasized that this report is but a prototype of an approach that may be desirable to develop and maintain into the future. Indeed, despite the limitations of this present version, there is herein a diverse set of indicators relating to Nova Scotia's fisheries and marine environment – indicators that can be used and applied by policy makers, fisher interests and coastal communities. The results are diverse as well, with a spectrum from upward to downward trends in the indicators. (Despite several resource collapses within the Nova Scotian fishery over the course of the late 20th century, the indicators are not all now moving in a negative direction.) This makes it dangerous to aggregate results; instead, indicators are reported individually, leaving it as a matter of debate to determine the balance among them, and the consequent actions required. Indeed, while for some indicators it may be clear what 'progress' represents, for others this may be the subject of debate.

Ultimately, it is up to each reader to decide what genuine progress 'should be.' In any case, it can be hoped that among the wide range of indicators herein, those that prove useful will continue to be assessed in future years, and key indicators currently missing will be added, so continued monitoring of progress in fisheries and the marine environment will be enhanced in the future.

2. Ecological Indicators

Any attempt to 'measure' the progress of society in the area of fisheries and the marine environment must clearly include indicators describing the state of the marine species as well as the marine ecosystems in which the fish live. Yet this requirement is difficult to achieve, because the marine environment is among the most complex and least understood on the planet. Thus, while this report explores the idea of a set of ecological indicators relevant to marine ecosystems and fisheries, limitations both in the scope of the report and in the available understanding of Nova Scotia's marine ecosystems mean that at best a prototype of a desirable set of indicators can be presented here.

For example, in the fishery context, while Nova Scotian fishers harvest a wide variety of species, this report focuses on only a few of these, to illustrate the various fishery trends. In theory, it would be desirable to focus attention on a set of ecologically-relevant 'indicator species' – those that, in their up's and down's, best reflect the state of the corresponding marine ecosystem. For some aspects of marine pollution, mussels and certain bird species are well-established as indicator species. It has been suggested that some species of crabs, as well as cod, may be suitable as well. However, the choice depends on precisely what variables one wishes to track, and the desirability of the species chosen is typically unclear. (Indeed, a useful focus for marine research may well be the determination of optimal indicator species.)

In this report, a more *ad hoc* approach is taken, with the species to be examined chosen based on their economic or ecological significance in the region, and on the availability and reliability of pertinent information. Our choice of examples may result in an unbalanced portrayal of the state of Nova Scotia's fisheries and marine ecosystems, since data are often more available for commercially-important species.

One of the most fundamental difficulties in developing a set of ecological indicators for marine ecosystems around a politically defined region – in this case, Nova Scotia – is that such regions only rarely coincide with the ecosystems themselves. For example, George's Bank, a rich fishing ground for many species including scallops and groundfish such as haddock, is located in both Canadian and American waters.

It is even more difficult to describe fishery resources as belonging to individual provinces because fishery management is under federal control and fishing zones do not correspond directly with provincial boundaries. Even if management zones did correspond directly with provincial political boundaries, ecosystem components in adjacent boundaries would still interact across the boundaries and affect each others' well-being.

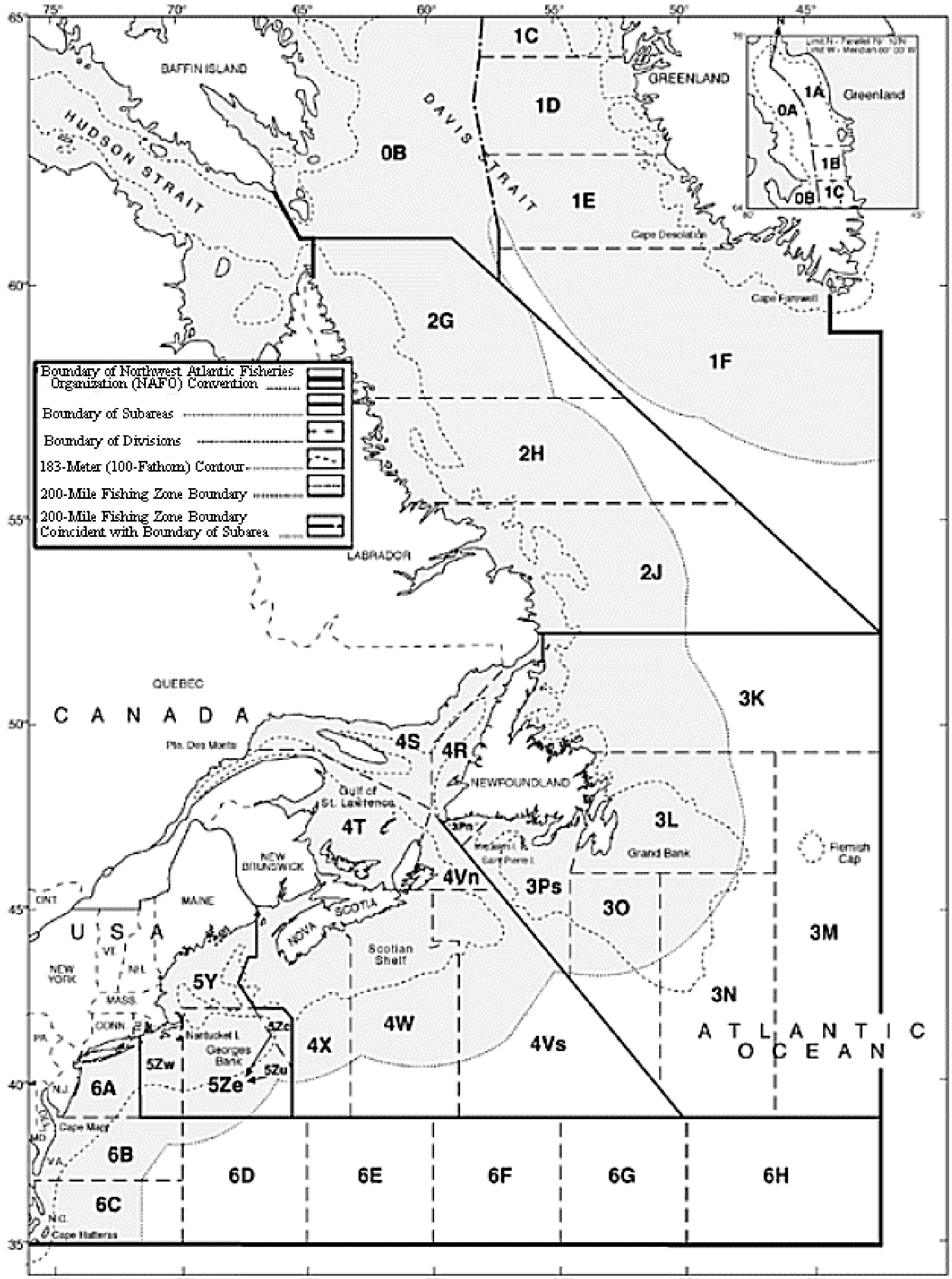
Political definitions were especially problematic in the Bay of Fundy and the southern Gulf of St Lawrence. (See Figure 1 for a map of the waters around Nova Scotia and within Atlantic Canada more broadly.) In the following analysis, biomass estimates and other ecological measures are based on data that include the entire Bay of Fundy (as part of NAFO subdivision 4X) and the southern Gulf of St. Lawrence (NAFO subdivision 4T) – even though the Bay of Fundy is shared between Nova Scotia and New Brunswick and the southern Gulf of St. Lawrence is shared by Nova Scotia, New Brunswick, Prince Edward Island and Quebec. This confusion of political and fishing zone boundaries is an artifact of the form by which data is available, but may be justified based on interdependence of these inter-provincial ecosystems.

2.1. Primary Commercial Species

Biomass

Research vessels trawl Nova Scotia's waters every year to estimate abundances of commercially important fish species. Estimates are made according to distinct population groups called fish

Figure 1. Northwest Atlantic Fisheries Organization (NAFO) map of Canada's 200 Mile Exclusive Economic Zone, designated fishing zones, and oceanographic features



Note: Throughout this report, indicators refer to the fishing zones shown on this map. For example, the notation 4TVWX in Figure 2 refers to fishing zones 4T, 4V, 4W and 4X on this map.

stocks. A given stock's *total* biomass is the weight of all fish in that stock, while the *fishable* biomass is the weight of fish in the stock that is legally harvestable (according to fish size and/or age). The *spawning* biomass is the portion of the total biomass that is capable of spawning. The Department of Fisheries and Oceans annually publishes biomass estimates for many marine species in the waters surrounding Nova Scotia.

Biomass trends are reported here for only a small sample of the many species caught in Nova Scotian waters – specifically, cod, haddock and herring. These species share two key features: they are of major commercial importance, and a reasonable quality and quantity of data are available for each. Collectively, these species represent bottom-dwelling (benthic) and surface (pelagic) species, as well as both depleted and healthier stocks. The DFO Regional Advisory Process (RAP) office provided biomass estimates for these stocks to update data from stock status reports and research documents (DFO, 1999d).

It must be noted that while the accuracy of biomass estimates has presumably improved over time, reflecting advances in the study of marine ecology, in technological tools, and in sampling and estimation techniques, there remain many sources of uncertainty in the biomass estimates (deYoung *et al.*, 1999; Lassen and Halliday, 1997). These arise due both to technical problems in the estimation process, and to variability in the biomass levels themselves, which are affected by environmental factors such as food availability, water temperature, and the integrity of the bottom habitat used for spawning; by toxicological impacts on eggs, developing embryos and juveniles; and by predation pressure, including impacts of fishing by humans.

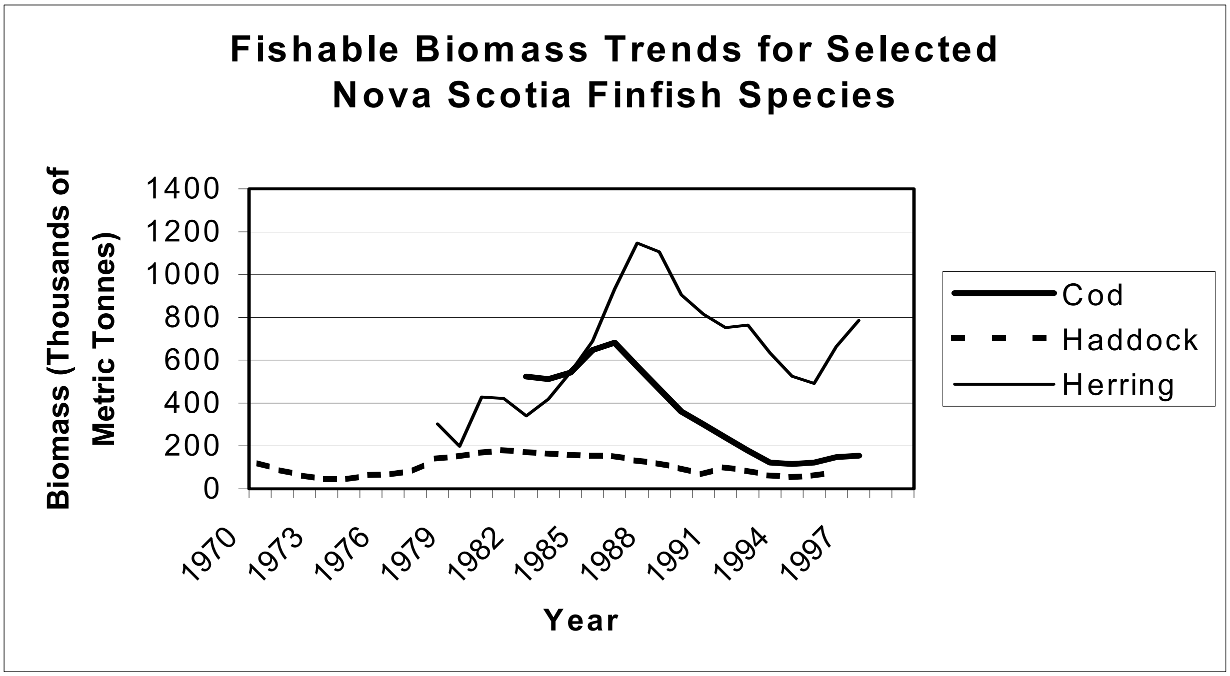
Figure 2 illustrates the declines in 'fishable biomass' (i.e., the amount of fish large enough to be caught in the fishery) for the selected finfish species – cod, haddock and herring – since the late 1980s. The fishable biomass for each species was in decline around Nova Scotia by the mid-to-late 1980s. For haddock, the fishable biomass declined in the early 1970s and then rebounded between the late 1970s and 1980, when it reached its highest level in 25 years But the stock has since been in slow decline. The biology of herring leads to greater fluctuations in the fishable biomass than is the case for haddock. This biomass peaked for herring in 1987 and has declined since, though not reaching the low levels of the late 1970s, and showing some recovery recently. The fishable biomass of cod began its decline in 1986, and at this time, the cod stocks show few signs of recovery from their collapse in the early 1990s (Thorne, 2000; Hutchings, 2000).

The latter point highlights a key message of this report. Had publicly accessible natural resource accounts been compiled across Atlantic Canada in the 1980s, as core measures of our progress, information would have been available both to policy makers and to the general public to encourage conservation actions before the actual collapse of the cod stocks and the economically devastating moratorium that followed. A major role of the Genuine Progress Index, and of natural resource accounts in general, is to provide timely early warning signals to policy makers that will allow graduated and measured responses to resource depletion that can prevent such catastrophic losses in the future.

While many fish species, especially many groundfish species, did decline during this period, many other species, especially shellfish, did not. Shrimp, for example, appear to have increased in biomass since 1995 (Koeller *et al.*, 1999), and, as Figure 3 demonstrates (below), lobster biomass from Nova Scotia as a whole appears to have been relatively constant since 1990 (DFO, 2001a).

Note that later in this report, an alternate approach to examining biomass trends is examined, from an "ecological economics" perspective, with biomass translated into monetary values, for comparison with traditional economic measures.

Figure 2. Trends in fishable biomass of cod (4TVWX, 5Zjm), haddock (4TWX, 5Zjm) and herring (4TVWX)



Source: DFO (1999d).

Catch Levels

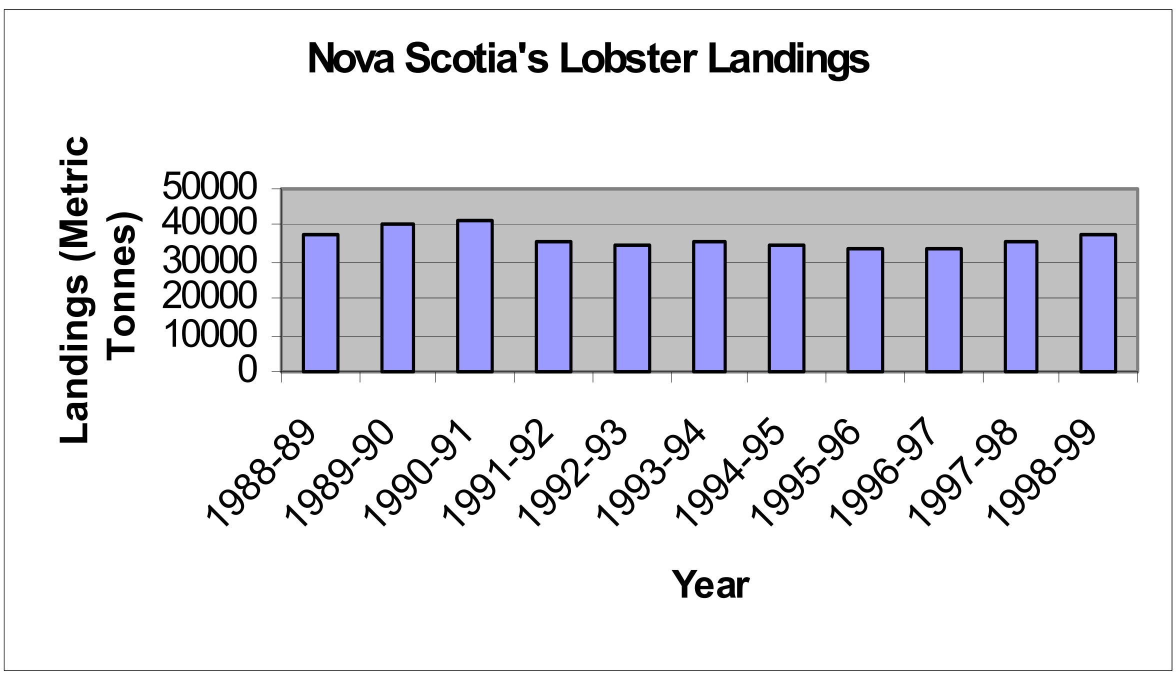
The use of catch data as an ecological indicator, or an indicator of the health of a fish stock, can be dangerous. Catch levels can send misleading signals about biomass because many variables other than biomass, including fishing effort and technology, can affect landings. Indeed, there are many examples of fisheries around the world in which high catch levels were mistakenly interpreted as implying strong stocks, when in reality they merely meant that powerful fleets could seek out and catch fish even as stocks declined.

Nevertheless, with careful interpretation, catch data can be useful as an indicator of the health of some fish stocks. An important example is that of lobster stocks in the Atlantic region, for which biomass estimates are not available. Catch levels currently provide the best available approximation of lobster biomass, but this information must be interpreted within the context of fishing effort and of the technology used in the fishery. A time series of landings data will be affected by the changes in fishing effort and technology, and will not necessarily reflect biomass trends.

Since 1990, there has been little change in the fishing effort and technology used in Nova Scotia's lobster fisheries (Pezzack, 2001) and thus, within this time period, catch levels provide an approximation of biomass trends. Figure 3 indicates little variation in Nova Scotia's lobster landings between 1988 and 1999 (although this aggregates over a number of lobster stocks, and thus hides some variations among them). Preliminary catch levels in 2000-2001 are high, suggesting a high stock biomass, and fishers are reporting an abundance of juveniles that could contribute to a healthy fishery in the future (Medel, 2000).

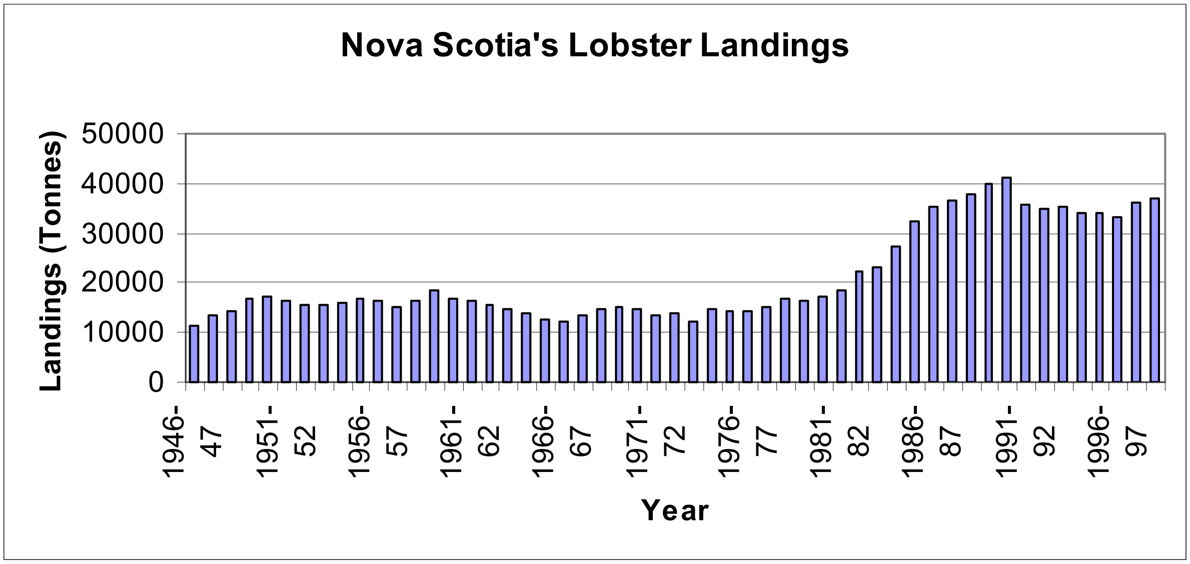
Shown in Figure 4 is a second time series of lobster landings, this one extending back to 1946. This illustrates two key points. First, there was remarkable stability in catch levels over several decades prior to the 1980s. Since there seems to have been no major trend in the effort devoted to lobster fishing over that time, this can be interpreted as a case of stable stocks. Second, there was a rapid increase in catches over the course of the 1980s, which might be due to some combination of environmental conditions, predator-prey changes and/or increased effort. Since the mid-1980s, average catch levels have been about double the average levels in the previous 40 years.

Figure 3. Lobster landings in Nova Scotia since the late 1980s



Source: DFO (2001a).

Figure 4. Lobster landings in Nova Scotia since 1946



Source: DFO (2001a).

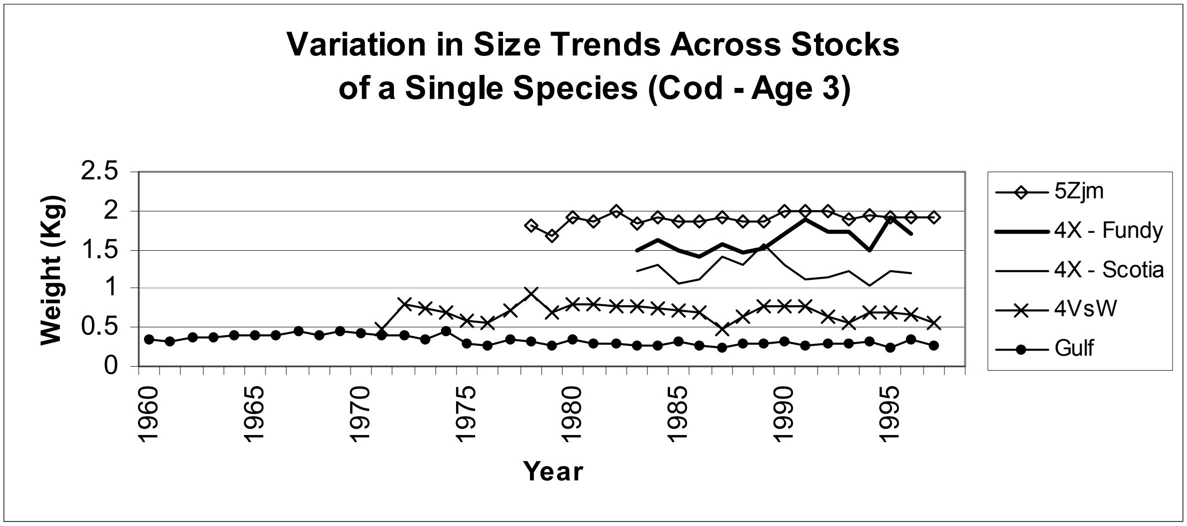
Fish Size and Condition Factor

While traditionally the focus of scientific attention with respect to fish stocks has been on the total biomass, it is also important to monitor another fundamental indicator of the health of the stock – the well-being of individual fish. Two key measures of this are *size at age* (the average length or weight of a fish of a given age) and *condition factor* (which essentially tells us whether the fish are growing well; whether they are 'skinny' or 'plump'). Even if the biomass remains at a reasonable level, a declining trend in size at age or in the condition factor may indicate stress on the fish population or genetic changes in the population due to selective harvesting (Trippel, 1995), and warns of potential problems with fishery sustainability.

The health of individuals may reflect the overall health of the marine environment since fish size and condition may be influenced by factors such as pollutants and water temperature (Riget and Engelstoff, 1998). Furthermore, these indicators have economic implications, because smaller fish fetch lower prices on the market and can require more fishing effort per tonne of fish.

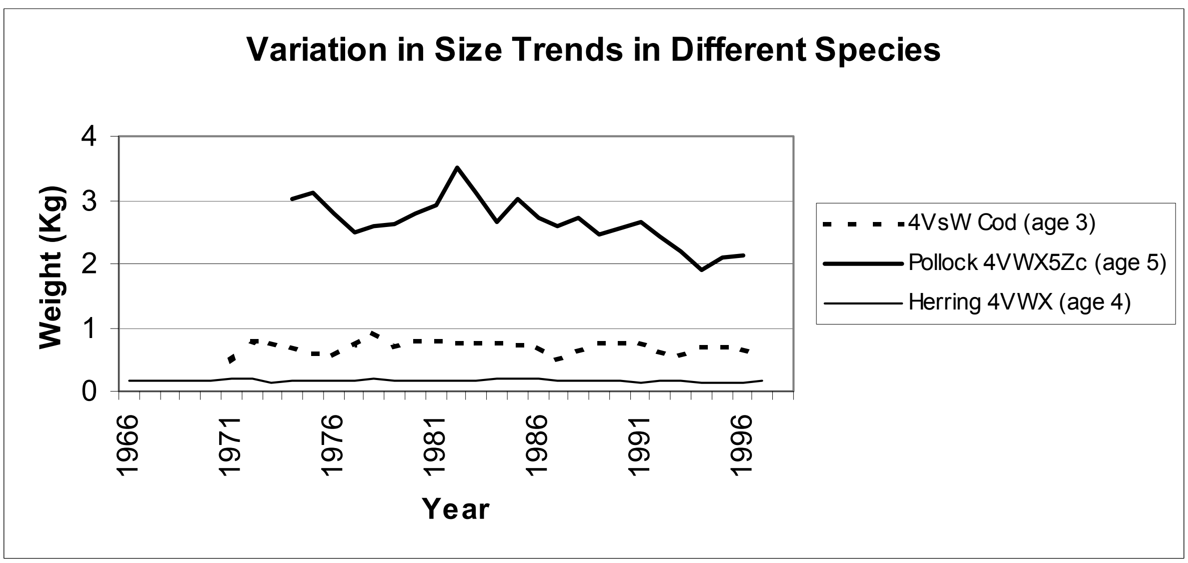
Figure 5 shows a time series for the weight of three-year old cod in various stocks around Nova Scotia. It is clear that geographical location affects the size of a fish at a particular age, and for a particular species, in this case cod. Not surprisingly, cod in the warmer southern waters (5Z and 4X) are larger at age 3 than cod living in the colder waters off the eastern shore (4VsW) and in the Gulf of St. Lawrence. Figure 5 also indicates relatively small changes over time in average size at age for each of the cod stocks, including a slight decrease in the Gulf and an increase in the 4X area off southwestern Nova Scotia.

Figure 5. Size trends across cod populations in waters around Nova Scotia



Source: Hunt and Buzeta (1997), Clark (1997), Sinclair *et al.* (1998) and Stephenson *et al.* (1998).

Figure 6. Fish size trends for cod, pollock and herring



Sources: Neilson *et.al.* (1997), Clayton *et al.*(1997) and Stephenson *et al.*(1998).

Figure 6 considers the 'size at age' indicator from a different perspective, exploring how size at age trends vary across species. Different species living in a similar region differ both in the overall size at age and in the trends over time. While there was no overall trend in size at age for herring or cod between the early 1970s and late 1990s (despite some fluctuations up and down), the average size of pollock decreased considerably. This suggests a significant change, one that may indicate a potential decline in the value of that stock.

Size and Age at Maturity

An important element in fishery management is to ensure sufficient spawning – production of eggs and resulting juveniles – to produce a healthy stock over time. One aspect of this lies in ensuring that enough fish have an opportunity to spawn before being captured. One approach to analyzing this is to compare the age (or size) at which the fish become sexually mature with the age (or size) at which they become vulnerable to the fishery. If the latter is too low relative to the former, conservation problems could arise. However, not all fish reach maturity at the same age, so one must speak of measures such as 'the age at 50% maturity,' i.e., the age at which approximately 50% of the fish in the stock reach reproductive maturity. (Similarly, entry into the fishable stock occurs over a range of ages and sizes.)

The age of maturity in a fish population may fluctuate from year to year depending on population size, on competition for food and space both internally and with other species, and on environmental conditions such as water temperature (Trippel, 1995). Indeed, age at maturity can be a useful indicator of population stress. Furthermore, analysis of the age at maturity provides an indicator of the biomass of fish that will reproduce in a given year (the spawning stock biomass) which can help managers predict roughly the number of fish that will enter the fishable stock in subsequent years (the recruitment). This can aid in fishery planning. While this information would be useful in a variety of ways, it requires extensive monitoring and is not available for all species (Trippel *et al.*, 1997). Further elaboration of indicators in this area will be important for future development of the fisheries and marine environment accounts.

Resilience: Age Structure

A fish stock that contains a reasonable number of individuals within each age class, from juveniles to very old individuals, will be better able to withstand a range of negative environmental impacts that have different impacts on different stages of the life cycle. In other words, such a fish stock will be more resilient. It is not necessary or even desirable to have each age equally represented in a populationIt is natural for fish to be more abundant at younger ages, and it is also common to observe very high recruitment of young fish from time to time, leading to 'waves' of abundance.

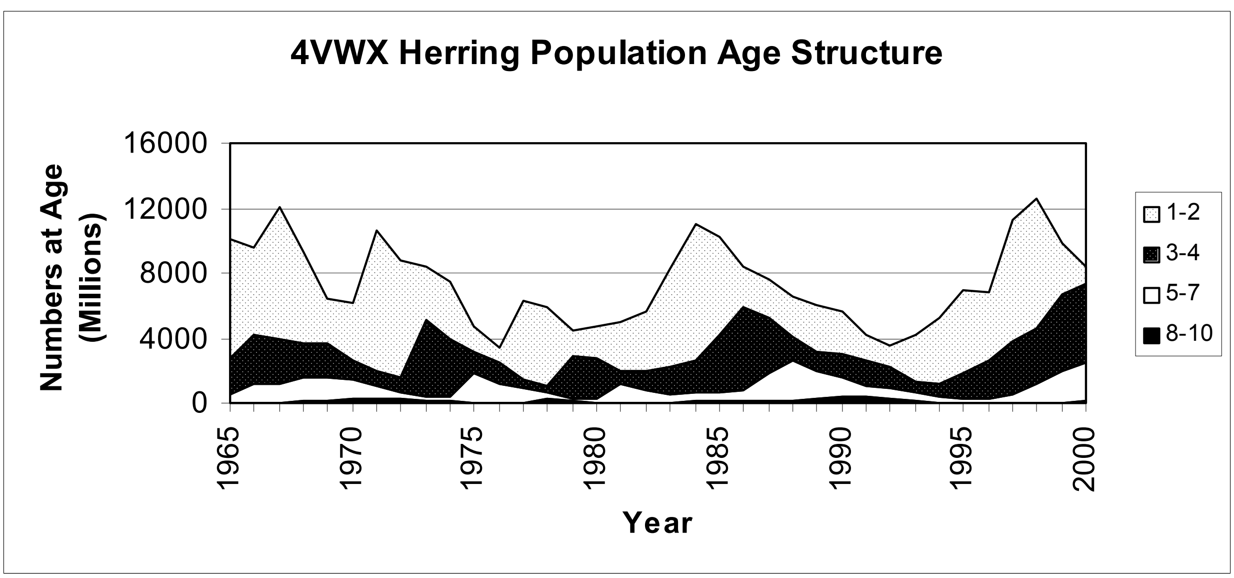
Determining a desirable age structure – the actual levels of young and older fish that are wanted in the fishery – is a challenge that is not only complex, but indeed as yet unsolved. Nevertheless, it is clearly desirable to have a substantial fishable stock (for a strong fishery today), a healthy number of juvenile fish (for good fishing in the immediate future), a strong sexually-mature spawning stock (for subsequent recruitment) and within the latter stock, a reasonable level of older fish.

In some species, older fish are more prolific spawners and their offspring have greater chances of survival than those of young spawning fish. In the case of cod, older fish may be critical to reproductive success of the population (Trippel, 1995). Thus, the likelihood of maintaining or re-building a healthy fish stock is improved not only by allowing enough fish to reach reproductive maturity and reproduce before they are harvested, but also by allowing enough fish to mature to an older age, at which they will lay a greater number of eggs, each with a greater chance of survival. It is therefore of considerable concern that in many fish stocks, notably cod, very large individuals (known in Newfoundland as 'mother fish') are now almost absent, reflecting a severe loss of age structure from historical levels.

Age structure may be assessed either directly, through aging of fish samples, or in the case of species that are difficult to age accurately, it is possible to infer trends in age structure by size (if there is a reasonable correlation between size and age). For example, the average size of shellfish can be a useful indicator of the age distribution of that species. Declines in this average size through time may indicate that there are relatively fewer old fish.

Figure 7 provides an example of trends in age structure, in this case for the 4VWX herring fishery. Herring, which are aged according to the number of rings appearing on their otolith (a bone used for detecting sounds and vibrations), vary widely in abundance. This figure shows how 'cohorts' of fish (those born in the same year) move through the fishery over time. Unlike the disturbing trends that have occurred in many cod stocks, Figure 7 does not indicate a major problem with age structure in the herring fishery, with reasonable maintenance of older fish stocks (age 5+) over time.

Figure 7. Age structure of the herring population in NAFO divisions 4VWX



Note: Ages are grouped into four categories, which, from the top, are: 1-2 years, 3-4 years, 5-7 years and 8-10 years of age.

Source: Stephenson *et al*. (1999).

2.2. Non-Target Species

Fish harvesting impacts a wide range of non-target species as well as those species actually targeted (Greenstreet and Rogers, 2000). Impacts may be direct, for example if non-target species are harvested incidentally as 'bycatch.' Impacts may also be indirect, with non-target species affected by (a) population changes among target species, through predator-prey relationships or changes to resource availability, and/or (b) impacts of the harvesting process, as is the case when the gear used modifies the habitat on which non-target fish depend. (See the discussion of benthic integrity later in this report.)

The inter-relationships among marine species are complex. Impacts on non-target species will inevitably affect the overall well-being of the marine ecosystem, including the well-being of fish stocks that are commercially important. Non-target species may be prey or predators for target species, or they may be indirectly connected through the food web. Indicators of biological trends in non-target species may therefore be vitally important to ecological sustainability.

Some non-target species such as marine mammals (see below) may be well studied, but many more are poorly understood compared to commercially important species such as cod, herring and shrimp. Studies of non-target fish species are so rare that a recent one attracted considerable attention by examining the plight of a species, the barndoor skate, that has been severely depleted through uncontrolled capture in Atlantic Canadian trawl nets (Casey and Myers 1998). **GPI***Atlantic* strongly recommends further in-depth study of the health of non-target species, as part of the emerging ecosystem approach to fishery management.

Bycatch

Perhaps the only aspect of non-target fish species that has been relatively well-studied is the matter of bycatch – the fish that are caught incidentally (notably in trawl nets) but are not the primary targets of the fishing effort (Clucas, 1997a). Some bycatch, while incidental, may in fact be valuable, and in some cases even the less valuable bycatch can be processed and sold. Still other forms of bycatch can be returned to the ocean relatively unaffected. However, the unfortunate reality around the world is that most bycatch is discarded either dead or in poor condition (Clucas, 1997b).

Fishers may discard bycatch if it contains prohibited or undesirable sizes, sex or species of fish, or if it was obtained from prohibited areas, during prohibited seasons or with prohibited gear. Discarding may also reflect market influences and preferences when less valuable fish are discarded to make room for more valuable fish within a limited quota, a practice referred to as "high grading" (Breeze, 1998). Fish may also be discarded if the catch size exceeds the vessel's remaining holding capacity (Hall *et al*, 2000).

Discarding is problematic both ecologically and economically. It is often unmonitored and therefore reduces the biomass of fish stocks to an unknown extent. Discards themselves cause imbalance in species composition and ecosystem function as they become a food source for scavengers and other organisms at lower trophic levels (Chesson and Clayton, 1998), possibly leading to eutrophication and oxygen depletion.

Undocumented discarding hinders fishery management efforts, to the detriment of both fish stocks and fish harvesters, since unreported discards are not accurately accounted for in harvest statistics and therefore lead to inaccurate stock assessments. Discards also represent an economic cost, since time, energy and labour spent harvesting and dumping fish could be used more productively in other ways. Some non-target species are valuable to other fishers. By discarding these fish, they often die and are lost to that fishery. Similarly, discarding juveniles, that are then unable to survive, can have a negative impact on future stocks (Diamond *et al*, 2000) and thus on the value of future harvests.

To measure progress toward sustainability, it is useful to have some quantitative measures both of the 'efficiency' of harvesting, with respect to avoiding bycatch, and of estimated discards. For example, Hall (2000) refers to two measures of harvesting efficiency, each measuring the physical output of the fishery relative to the total 'kill' of fish (catch plus bycatch). The *target utilization efficiency* is the ratio of target species yield to the total catch plus bycatch, where the yield includes *only* target species. Similarly, the *biomass transfer efficiency* is the ratio of total 'useful' yield to total catch plus bycatch, with yield including the 'useful' landings of all species combined. The higher each of these ratios, the less 'waste' is occurring.

Clearly, to determine these measures, one must have an accurate estimate of bycatch. However, with respect to discarding, it is difficult to obtain accurate estimates, since discarding is illegal in most cases. There have been some attempts to estimate discard rates in Canadian waters over the past decade (Alverson *et al.*, 1994; Duthie, 1997), sometimes using onboard observer and dockside monitoring information, and in some cases comparing Canadian estimates with estimates in nearby fisheries (i.e., in the Northwest Atlantic).

For example, Table 1 – from Duthie (1997) – shows a set of estimated discard rates, with the highest indicating a 57% discard rate for capelin harvested with seine nets or fish traps. The latter arises because males are undesirable and are discarded after onshore sorting. The table also indicates that groundfish bottom trawl fisheries have the next highest bycatch rates, followed by Greenland Halibut (turbot) caught by sunk gillnets.

Table 1. Discard Rates of Selected Species in Atlantic Canada by Gear, 1994

	Bottom Trawl	Setnet/Gillnet	Other
Cod	0.35	0.2	0.15
Greenland Halibut	0.10	0.30	
Pollock	0.35	0.20	0.15
Haddock	0.35	0.20	0.15
Sea Scallop	0.25		
Capelin			0.57
Other (especially flatfish)	0.25		0.10

Source: Duthie (1997).

It is important to note that the high bycatch rate for scallops includes small scallops that often survive the harvesting and subsequent return to the water. Indeed, one must be careful in general with reported discard rates for shellfish. These may appear high – e.g., around 30% (Duthie, 1997) – but for fisheries like that of lobster in Nova Scotia, 'discarding' is in fact part of the fishery's conservation practices, allowing juveniles to return alive to the sea to grow further, with most surviving the relatively less traumatic harvesting and ocean return process. For this reason, results for these other shellfish species are not included here.

It is important to attempt to understand not only the level of bycatch, discarding, dumping and so on, but also the trends in these activities. However, there is little if any time series data on discarding rates in Atlantic Canada and thus it does not seem possible to track *quantitatively* any progress in reducing bycatch and discard amounts. **GPI***Atlantic* recommends research efforts to monitor these important indicators of sustainability in fisheries.

Even qualitatively, determining such trends is not entirely straightforward. Consider, for example, the challenge of assessing the impact and success of specific measures that have been taken to reduce bycatch and discards. Duthie (1997) compiled such qualitative measures, under the headings (a) gear selectivity improvements, (b) area closures and restrictions, (c) monitoring and (d) use of bycatch. Gear selectivity measures include the required use of Nordmøre grates on vessels in the shrimp fishery, to reduce bycatch of groundfish, and regulated large cod-end mesh size in many gadoid trawl fisheries. Area closures and restrictions noted by Duthie include 'small fish protocols' for many fisheries, in the form of temporary (10 day) area closures if 15% or more of the fish caught are below regulation size, annual closure of some spawning and nursery areas, and restriction of the silver hake fishery to areas that reduce bycatch of other species. Monitoring measures include 100% onboard observer coverage on all large groundfish and shrimp vessels, and dockside monitoring for most fisheries. Bycatch use measures include a 'zero discard' rule requiring landing of 100% of all groundfish catches and discards, and bycatch allowances specified in groundfish quota allocations to permit minimal landings of valuable non-target species.

Unfortunately, while these measures demonstrate that some efforts have been made to reduce bycatch and discards, their existence alone does not prove their effectiveness. Conservationists continue to express concerns about bycatch and discarding related to many of the above measures. They suggest, for example, that:(a) Nordmore grates do not solve the problem of catches of juvenile fish, such as redfish and turbot, (b) cod-end mesh size regulations in gadoid fisheries clearly do not deal with non-gadoid fisheries, (c) '100% observer coverage' may imply that every vessel has an observer, but not that the observer is able to monitor activities 24 hours a day, and (d) the 'zero discards' rule for bycatch cannot be fully enforced and thus is just a rule that does not reflect reality.

Whatever the validity of these concerns, it is clearly the case that, despite efforts to reduce bycatch and discarding, these remain important issues. In particular, Duthie (1997) notes that there may still be unreported high-grading and dumping of groundfish. There have been very few independent studies of such practices. One such effort is an Ecology Action Centre report (Breeze, 1998), based on interviews with fish harvesters, that found that over a million pounds of groundfish may have been dumped (discarded) in just one location – George's Bank – in a single year (1998).

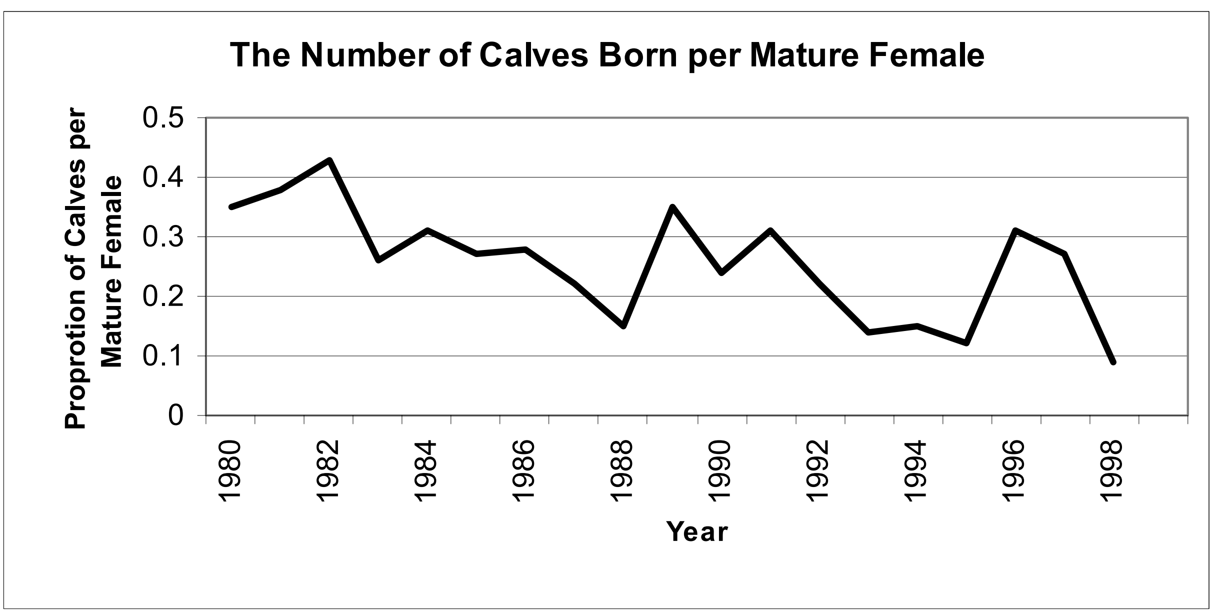
A further Ecology Action Centre report noted a high rate of discarding in Nova Scotia's swordfish longline fishery, based on DFO observer reports (Fitzgerald, 2000). While swordfish harpooning produces significantly less bycatch, longlining represented 90% of the Canadian swordfish quota in 1998. It seems that various species of shark are the primary bycatch, but over twenty different bycatch species have been identified (Butler, 1998).

In summary, then, it appears that efforts have been made in this area, but that their effectiveness is unclear Serious concerns about discarding, dumping and high-grading remain in a variety of fisheries. Development of reliable measures for this important indicator is clearly important to any set of Fisheries and Marine Environment Accounts.

Marine Mammals: The Right Whale

A group of 'non-target species' of critical importance in Nova Scotian waters are the various species of marine mammals. Perhaps none is more closely monitored at present than the North Atlantic Right Whale, thereby providing substantial time series data for trend analysis that can serve as a useful indicator of success in marine conservation efforts. The North Atlantic Right Whale is among the most depleted species of whales world-wide. This is due in part to a lack of reproductive success (Figure 8) although current information suggests that 2001 may be a particularly good year for the birth of young right whales.

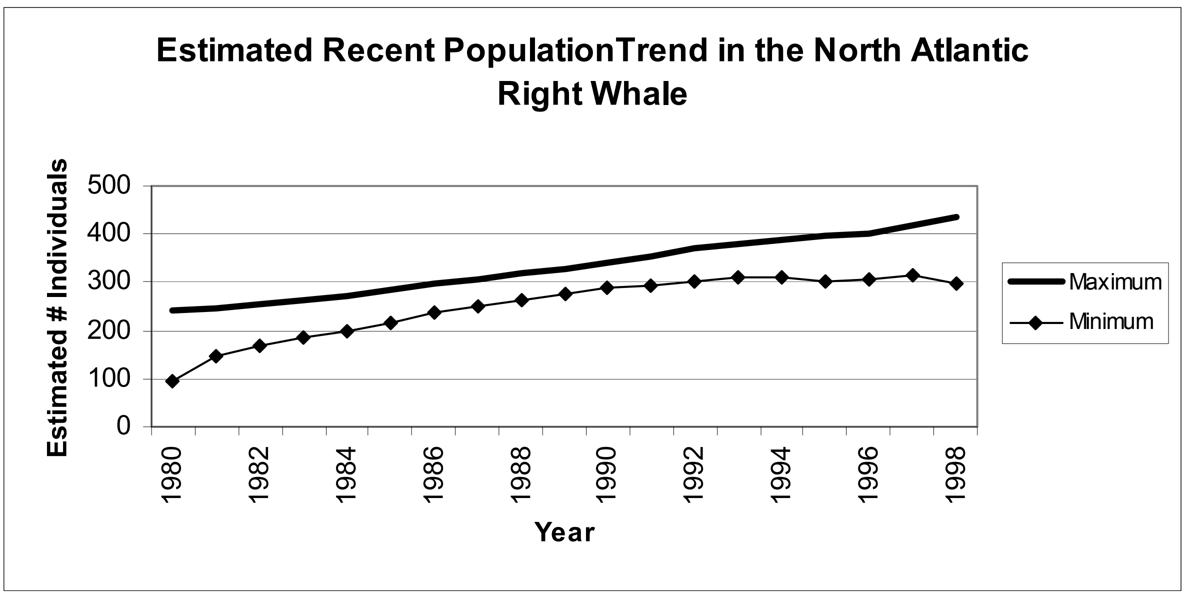
Figure 8. Number of calves born annually per mature female right whale



Source: Kraus *et al*. (2000).

Population trends of North Atlantic right whales are not universally agreed upon, particularly when one looks far back in time. Only very rough estimates are available for the level of the population in pre-exploitation times; Reeves *et al*. (1992) have estimated this level at perhaps somewhat over 1,000 right whales, but place many caveats on this number. They also estimate that the population may have fallen to less than 100 when the right whale became protected in 1935 (Office of Protected Resources, 2000). Brown *et al*. (1994) have determined that the right whale population did not increase significantly from that low level during the initial 50 years of protection. This is reinforced by the analysis of Kraus *et al*. (2000) – see Figure 9 – indicating that the population was of the order of 100 in 1980, rose to some extent since then, but seems to have leveled off recently, with the estimate of current population size being at just under 300. In summary, then, despite the uncertainties involved, there is general agreement that population size is now above what it was at its lowest, but far below levels present prior to exploitation.

Figure 9. Estimated recent population trend in the North Atlantic right whale



Source: Kraus *et al*. (2000).

2.3. Resilience and Biodiversity

The resilience of an ecosystem is its ability to recover from or adapt to 'shocks', which may be due to harvesting or to environmental stresses. In this section, two of many possible determinants of resilience are explored: (1) biodiversity and (2) benthic integrity, the 'integrity' or well-being of the ocean bottom. It should be noted that in neither case is a definitive indicator described here. Resilience is a challenge to measure, and these are but two possible approaches.

Biodiversity

Biodiversity – including such elements as genetic diversity, species richness, functional diversity and landscape diversity – is widely acknowledged as critical to maintaining healthy, resilient ecosystems (deYoung *et al*, 1999; Stachowicz *et al.*, 1999), and to reducing negative impacts of disturbances and changes. Furthermore, while diversity within a given ecosystem is important, diversity among ecosystems also contributes to overall biodiversity (Hammer *et al,* 1993). While it is thus crucial to incorporate measures of biodiversity as indicators of ecological sustainability, marine biodiversity is very difficult to measure. For example, a common tool for measuring species abundance and spatial and temporal occurrence – the trawl survey – is affected by a wide variety of variables (Walsh, 1996).

Estimates of biodiversity often incorporate more than one measure of diversity. Popular diversity indices are described by Magurran (1988), Clarke and Warwick (1994), and Kaiser and deGroot (2000), among others. One such index is the Shannon-Weiner index, which measures species ‘richness’ and equitability, and is the most common measure of terrestrial diversity. Other indices include both simple measures (including a variety of approaches to counting the number of species), and more complex measures of richness, evenness, ‘dominance,’ and ‘taxonomic diversity’ (Kaiser and deGroot, 2000). These indices are used to measure a variety of aspects of diversity (see, e.g., Jennings and Reynolds, 2000).

On the Scotian Shelf, Bianchi *et al*. (2000) estimated species diversity among groundfish using the Shannon-Weiner index and concluded that there was no evidence to suggest that fishing has reduced species diversity. Indeed there was an increase in the number of species identified on the Scotian Shelf between 1970 and 1998. However, it is unclear whether this increase was due to an increase in species diversity, an increase in the abundance of formerly rare species (which could be interpreted as increased evenness of species abundance), or improvements in sampling methods (Bianchi *et al*., 2000).

In addition to overall diversity indicators, there is a need to develop a suitable indicator to assess the extent to which Nova Scotian fisheries are following the global trend of “fishing down the food web,” whereby the prey of traditionally harvested species comes under greater and greater harvest pressure, as species higher in the food chain (such as cod) become depleted (Pauly *et al.*, 2000).

For example, following the collapse of Atlantic Canadian groundfish stocks, a fishery for krill (a pelagic zooplankton) was proposed for the Scotian Shelf in 1995. Such initiatives are likely to continue, although in the case of krill, the proposal was never implemented in large part due to its controversial nature (Nicol and Endo, 1997). It was unknown what effect the harvest would have on the krill stock itself or on its many predator species within the Scotian Shelf ecosystem, and it was feared that larvae and juveniles of commercially important species could be harvested as bycatch (Nicol and Endo, 1997).

Related to this is the need for an indicator of endangered or threatened species. Casey and Myers (1998) have shown that there is risk of a reduction in biodiversity in Nova Scotia’s waters through inadvertent depletion or even extinction of species. They have suggested that the barndoor skate (*Raja laevis*) has reached a point of near extinction essentially without anyone noticing. This discovery emphasizes the limitations to our current appreciation for biodiversity in Nova Scotia's marine waters.

Another biodiversity issue concerns the possibility that over-fishing can provide an opportunity for foreign or native species to invade and take advantage of newly available habitat (Pimm and Hyman, 1987, Stachowicz *et al.*, 1999). Foreign species have been known to compete with native species in the Northwest Atlantic. While this may not produce a net reduction in local diversity, competition could lead to a reduction of *native biodiversity* and thus reduce biodiversity globally (Stachowicz *et al.*, 1999). This further illustrates the difficulty of measuring ecosystem health according to political boundaries alone.

Finally, while the above discussion has focused on species diversity, equally important is the matter of genetic diversity within a species. The existence of such sub-populations has been clearly established for salmon, cod and other species, and indeed there is increasing evidence of a loss of genetically distinct sub-populations in the Maritimes.

Overall, our knowledge about the diversity of marine life in Nova Scotia, and globally, is still very limited. There are currently no comprehensive data on biodiversity in Nova Scotia's marine areas, and, as noted earlier, scientific surveys have typically focused on commercially important species (Bianchi *et al*., 2000). On the positive side, however, DFO's current attempts to develop an ecosystem-based approach to management, using tools such as the Traffic Light Method (Jamieson, 2001), hold promise for the development of suitable biodiversity indicators and for accompanying efforts to undertake comprehensive biodiversity studies.

Benthic Integrity

The suitability of ecosystem habitat to sustain various species depends on both the structure of the habitat and its integrity (Turner *et al*., 1999). Physical habitat structure influences water flow and provides shelter for organisms. Habitat substrate and structure determine what vegetation can grow, which in turn influences habitat suitability for fish and other mobile organisms (Auster, 1998). Specific habitat features are good for shelter, spawning, nursery grounds and feeding. The heterogeneity of habitat types influences community structure (Turner *et al.*, 1999).

Fishing gear can alter the complexity of the benthic (bottom) habitat – an integral component of marine ecosystems – by removing sedimentary structure, sedentary plants and animals on the ocean bottom (Watling and Norse, 1998), and also by removing mobile species that enhance habitat complexity by burrowing and otherwise building benthic structures (Auster *et al*, 1996). Reduced complexity can increase predation rates and thus reduce survival rates of some fish. For example, the survival rates of young cod increase with habitat complexity, which suggests that at low population levels, habitat complexity becomes crucial (Auster, *et al* 1996). (For this reason, the reduction in habitat complexity due to bottom trawling – dragging – is considered by some to be a factor in the failure of cod and other groundfish stocks to recover from their depleted state.) Scallops are also adversely affected by reductions in habitat complexity. For example, seagrass destruction can hinder scallop settlement, production and growth rates (Auster *et al.*, 1996).

Fishing gear can also affect non-target organisms directly – especially organisms that live in burrows or on the ocean floor itself. While not the only gear affecting the ocean bottom, trawl gear is widely seen as having the greatest impact. Such impacts can include reductions in average size of individuals, in the biomass of populations, and in species diversity within communities (Ball *et al*, 2000). Timing and frequency of trawling over a fishing ground can affect the community's ability to endure the stress, with some organisms better able to cope than others (Auster, 1998).

Species with short life cycles, of one year or less, are better adapted to re-colonizing a fishing ground that is frequently disturbed by fishing. Organisms with longer life spans are unable to reestablish their populations if their habitat is continually disturbed (Auster, 1998; Walters and Bonfil, 1999). Several species with long life spans are found in Nova Scotia's waters and are therefore particularly vulnerable to habitat disturbance that can produce potentially irreversible consequences for the marine environment. For example, deep sea coral forests found in Nova Scotian waters provide important habitat for many species (Breeze *et al.*, 1997) Small colonies of the gorgonian coral *Primnoa reseda* have existed on George's and Brown's Banks for approximately 500 years (Watling and Norse, 1998).

All this points to the importance of carefully monitoring indicators of benthic integrity. Such measures might be direct, in the form of actual measurements of the state of the benthos, or indirect, such as measurements of the level of use of trawling and other gear on the ocean floor (both the area impacted and the frequency of impacts). For example, one global estimate suggests that every few years an area equivalent to the world's continental shelf is swept by trawlers (Watling and Norse 1998: p.1190).

Table 2 summarizes some previous specific estimates of fishing grounds impacted by trawling both locally and throughout the world. Five cases are shown, three in waters near Nova Scotia and two of a global nature. For each case, the description of the area is given, along with the ocean area involved (in the local cases), the years covered by the study (if known), the percentage of the area that is trawled annually, and the corresponding reference. For example, a conservative estimate suggests that on the American side of George's Bank, an area two to four times the size of the bank was trawled each year between 1976 and 1991 (Auster *et al.*, 1996). Since this location, lying adjacent to Canadian fishing grounds, has the closest physical proxmity to Nova Scotia results obtained for this area may provide some insight into potential trawl impacts in Nova Scotian waters.

Interpretation of impacts of fishing on the ocean bottom are complicated by the fact that some locations within a fishing area will be impacted repeatedly while others may not be impacted at all. Therefore an estimate of "percentage of area trawled annually" applied only to the areas actually impacted, will be even greater than estimates applied to the total area of the fishing zone itself (as in the George's Bank case above). A simultaneous estimate of the frequency of impacts would help to distinguish between areas that are more or less severely impacted by fishing gear.

A desirable indicator of impact might be based on two steps. First, the area of ocean bottom habitat impacted would be calculated as the product of (a) total time fishing (with gear in the water), (b) average speed, and (c) the width of the trawl or dredge. This calculation would be made on a gear-by-gear basis due to differences in impacts from different gear types on the ocean floor, and could also take into account differences in habitat types and in oceanographic conditions. These differences indicate that different levels of impacts will result from the same amount of fishing activity according to the sensitivity of particular areas. Second, the frequency of fishing gear impacts would be assessed through an interview process.

Table 2. Some studies of the extent of bottom habitat impacted by trawling and dredging

Area	Year	% trawled annually	Reference
George's Bank (37,000km^2)	1970	21	Caddy 1973
US George's Bank (40,806km^2)	1976-1991	200-400	Auster et al. 1996
Gulf of Maine (650,130km^2)	1976-1991	100	Auster et al. 1996
World's continental shelves		5.6-53*	McAllister 1995; Slavin 1981

* Lower figure, for 1978, excludes impact of trawlers under 100 tonnes; Upper figure is extrapolated to estimate total effect of trawling from the impact determined for shrimp trawling.

The resulting indicator would be useful for regular production as an important component of a set of fisheries and the marine environment indicators. As noted earlier, these initial GPI Fisheries and Marine Environment Accounts are severely constrained by limited data availability in several vital areas. One of the primary tasks at this early developmental stage is therefore to identify data gaps and data requirements for key indicators of fisheries and marine environment health that should be included in future development of these accounts. In that context, the impact of fishing on the health of the benthic environment is clearly a vital indicator that requires regular and systematic monitoring.

2.4. Marine Environmental Quality

Environmental quality and levels of pollution are important indicators for all the natural resource accounts in the Genuine Progress Index. Not only are suitable indicators of environmental quality essential to assess the state of marine ecosystems in their own right, but the health and abundance of fish are also greatly determined by the quality of their habitat. Many marine contaminants can directly affect the integrity of an organism's genes, its normal physiological functions, its development, and its ability to remain healthy.

Air quality, freshwater quality, and soil quality are commonly monitored, but there is relatively little systematic assessment of the quality of the marine environment. Several monitoring projects have been initiated in Atlantic Canada in the last 30 years to address this problem, but there are still few cases of long-term monitoring of marine environmental quality.

While there are many possible indicators relevant to marine water quality, this report discusses only a small sample of three such indicators:

1. organochlorine contamination in seabird eggs;
2. contamination levels in mussels (based on Gulfwatch data); and
3. the prevalence of shellfish closures.

These were chosen as examples of measures that may be useful within the context of this report, not necessarily because they are the 'best' indicators of overall marine environmental quality, but simply because data are currently available for these indicators and because they are directly linked to specific aspects of ocean use. Indeed, many environmental indicators exist in the literature, and no attempt is made here to paint a comprehensive portrait of marine environmental quality. Future development of these accounts will hopefully include a more comprehensive set of marine environmental quality indicators.

Organochlorine Contaminants in Seabird Eggs

Long-term data on levels of contamination in seabird eggs have been collected by Environment Canada in the Bay of Fundy. This monitoring program is especially interesting because it considers three different species of seabirds, each with very different feeding strategies. Cormorants feed on benthic and pelagic fish below the water surface inshore, petrels feed on plankton and surface fish offshore, and puffins feed on pelagic fish below the water surface offshore. Comparing levels of contaminants in these different seabirds therefore allows us to identify the parts of the ocean that are most contaminated and the fish most likely affected by that contamination.

PCBs, DDE, HCB and dieldrin are all chemical contaminants present in the marine environment surrounding Nova Scotia (Pearce *et al*, 1989). Concentrations of each of these chemicals in eggs declined overall in all species sampled between 1972 and 1996. The most significant fluctuations during this period were an increase in HCB concentrations in Atlantic Puffin eggs between 1972 and 1976 and a peak PCB concentration in cormorant eggs in 1980 (Figure 10). Overall, the trend lines both for PCB concentrations in seabird eggs in Figure 10, and for the other measured contaminants not graphically illustrated here, provide relevant indicators of genuine progress in this aspect of marine environmental quality.

Contaminants in Shellfish

The Gulf of Maine Council on the Marine Environment initiated a monitoring project called Gulfwatch in 1991 to monitor contaminants in blue mussels in the Gulf of Maine and Bay of Fundy. This monitoring project compares differences in contaminant levels between locations and over time at benchmark sample sites in the Gulf of Maine. Digby is the benchmark site in Nova Scotia, monitored on an annual basis, while other sites are monitored on a three-year rotation (Jones *et al*, 1998).

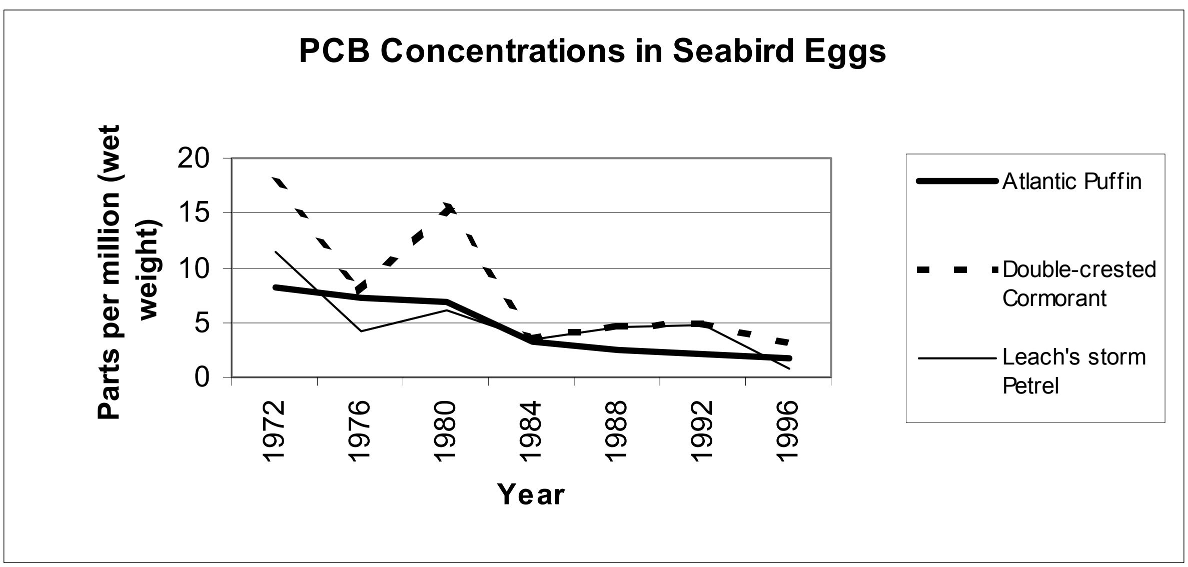
Blue mussels (*Mytilus edulis*) are recognized internationally as a good species to indicate local levels of contamination (Jones *et al*., 1998). They filter tremendous quantities of water as they feed and accumulate many of the contaminants contained in that water. These contaminants may occur naturally in the marine environment or they may come from land-based sources such as sewage or industrial effluents.

This report presents contamination data for Digby because it is currently the only location for which a significant time series is available. Contamination is often localized due to particular point sources and therefore the Digby information is not necessarily representative of contamination trends throughout the province.

Gulfwatch data provide valuable information on contaminant concentrations near Digby. The data demonstrate significant increases in carcinogenic PAHs, and fluctuations in concentration levels of PCBs and DDT (Figure 11). Iron, lead and mercury concentrations decreased somewhat between 1993 and 1997 , while other heavy metal concentrations appear to be relatively stable or changing only slightly [Figures 12(a) and 12(b)].

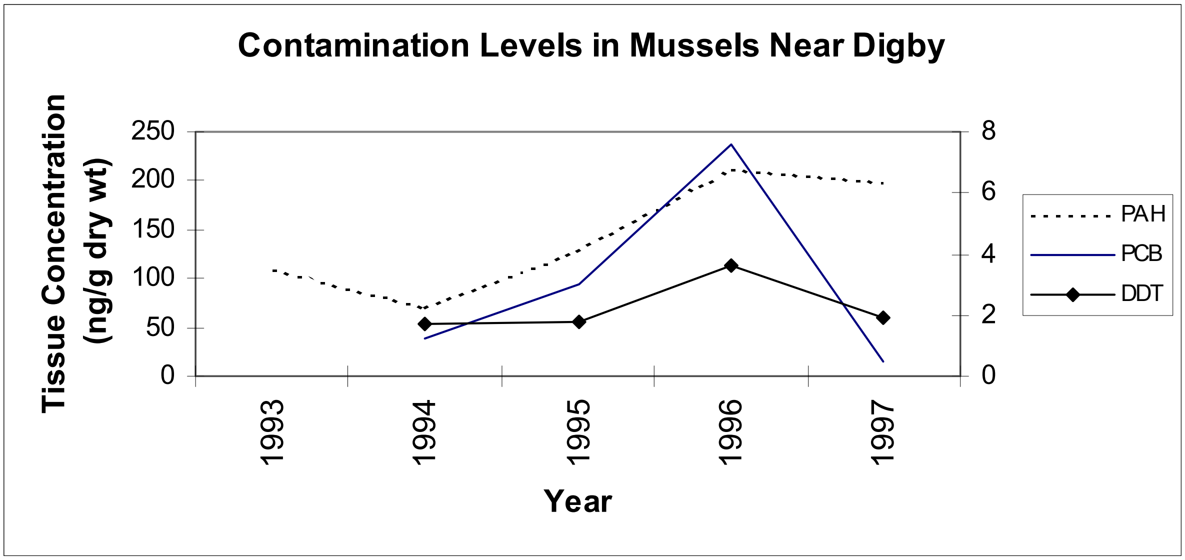
Given that cases of "sick, heavily contaminated fish have been documented in the region's coastal waters" (Scarratt, 1987), detailed contaminant information, such as the Gulfwatch data, can help to identify potential health risks for both local fish and human populations. Unfortunately, similar data are not available for the rest of the province. This is clearly a field in which expanded monitoring programs are required.

Figure 10. PCB concentrations in seabird eggs



Source: Canadian Wildlife Service (1999).

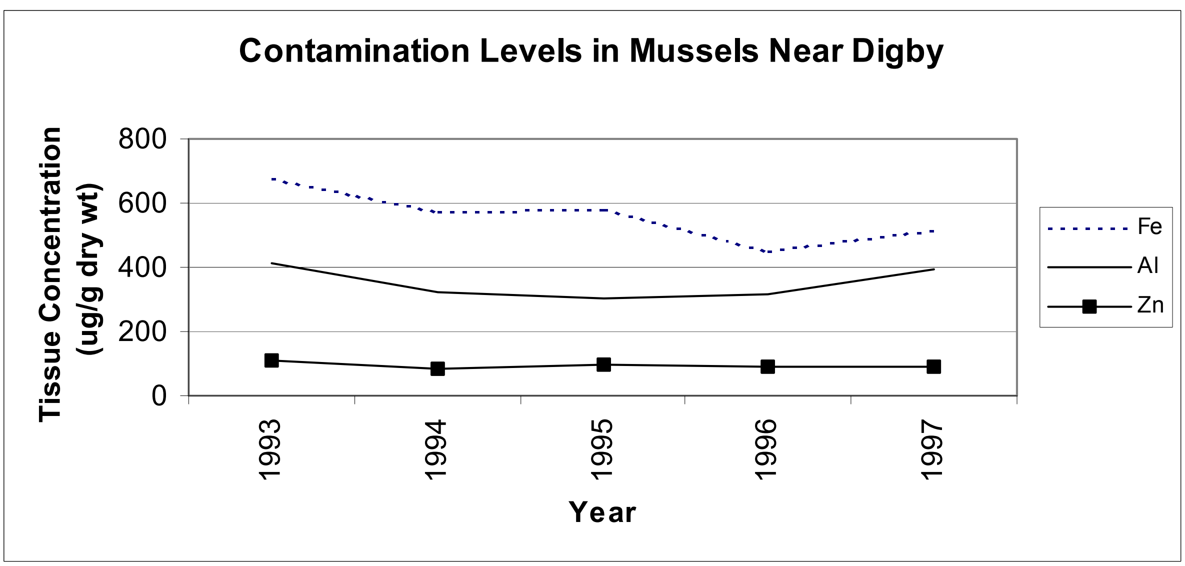
Figure 11. Gulfwatch monitoring concentrations of organic contaminants in mussels, Bay of Fundy



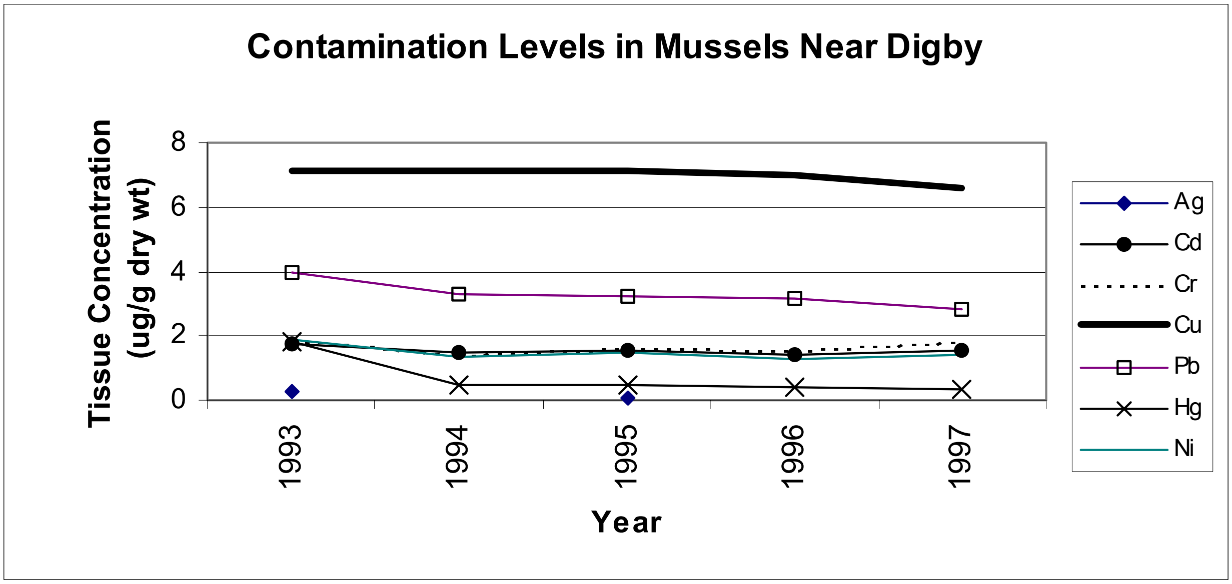
Sources: Chase *et al*., 1998, 1999; Jones *et al*, 1998

Figure 12. Gulfwatch monitoring concentrations of selected inorganic contaminants in mussels, Bay of Fundy

(a) Iron (Fe), aluminum (Al) and zinc (Zn) concentrations



(b) Silver (Ag), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and nickel (Ni) concentrations



Sources: Chase *et al*., 1998, 1999; Jones *et al*, 1998.

Shellfish Closures

Filter feeding organisms like oysters, mussels and soft shell clams live within provincial estuaries and mud flats. If the surrounding waters are contaminated, the shellfish tissue itself becomes contaminated. Consumption of shellfish from contaminated areas can cause serious illness, generating public health issues. Thus, in such cases, coastal areas are closed to shellfish harvesting.

While this situation can occur from natural causes, land-based agricultural or municipal run-off often causes the closures by adding nutrients to the water. With these additional nutrients, algae thrive, causing an algal bloom. Algal blooms may also be induced when marine contaminants toxic to algal grazers (such as zooplankton) enter the water and reduce the amount of algae that is grazed. Some algae produce toxins as a natural defense against grazing predators. Algal blooms can have a variety of impacts. For example, they can lead to die-off of eel grass beds, which are valuable fish habitat.

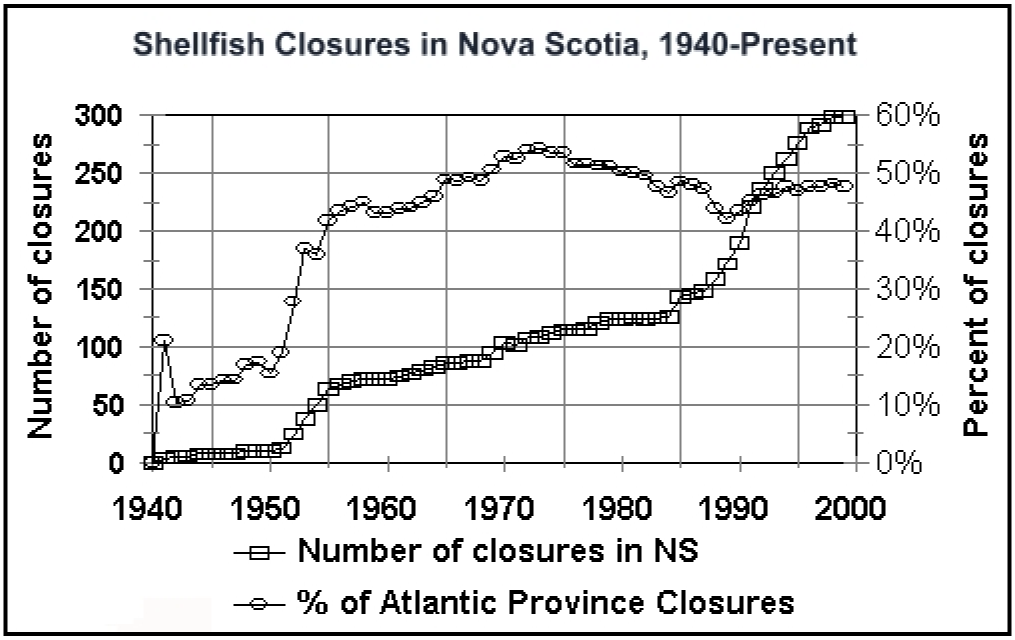
Closures due to toxins and bacterial contamination are good indicators of environmental quality, and often indicate the extent of land-based contamination. Closures directly affect the health of the shellfishery – the loss of market, recreational and subsistence harvests creates serious negative impacts and costs to the environment, the community, and the economy – and may also signal problems in the marine ecosystem as a whole.

For these reasons, analysis of shellfish closures is useful in Fisheries and Marine Environment accounts. The following analysis is taken from a recent **GPI***Atlantic* report, *The GPI Water Quality Accounts* (2000) by Sara Wilson:[1]

> *The State of the Nova Scotia Environment Report (1998) shows that Nova Scotia has the highest number of closed shellfishing areas in the Atlantic provinces, accounting for about half the region's total. However, the report does not record the relative size of the closures. The most recent data collected by Environment Canada (1999) assess the total size of shellfish beds closed annually to shell-fishing. From the perspective of sustainable development, the indicator "goal" is zero closed areas, the same as the "pre-impact" condition of the resource.*
>
> *According to the Nova Scotia Department of Environment, the number of areas closed to shellfish harvesting has increased steadily since the 1940s* [Figure 13]. *The number of shellfish closures has more than doubled in the last 15 years alone. In addition, the number of closures has increased since 1995, from 276 closures to 299 in 1999. In the most recent data, Nova Scotia still has the highest percentage of Atlantic Canada shellfish closures.*
>
> *Currently, Nova Scotia accounts for about 47% of the total number of closed areas in Atlantic Canada. The State of the Nova Scotia Environment (1998) reported that 700 sq. km. were closed to shellfish harvesting in 1995. It has been estimated that area closures have increased by approximately 34 sq km/year since 1975 (Menon, 1999). According to Environment Canada, this area has increased by 264 sq. km. (1999) over the past 4 years alone, a 38% increase in a very short period of time. This indicates that although the number of closures has not changed dramatically, the actual area closed (sq. km) has significantly increased. An increasing trend in closures signifies a decline in water quality in estuaries and coastal areas.*
>
> *This is an example of how the depreciation of natural capital can produce direct economic losses. Unfortunately, our conventional economic accounting system cannot elucidate this connection because the value of natural capital is not acknowledged and its depreciation, therefore, remains invisible. Even as a potential contribution to GDP, foregone revenues from shellfish harvesting are not recognized because our conventional accounts contain no benchmarks of sustainable resource use that allow current harvest levels to be assessed against original or potential stock levels. Integrated environmental-economic accounting, as proposed in the Genuine Progress Index, is essential if policy-makers are to understand the intimate connection between natural wealth and economic wealth, and to act wisely to protect and enhance both.*

[1] Wilson, Sara (2000) *The GPI Water Quality Accounts,* **GPI***Atlantic*, Halifax, section 7.1, pages 101-103. Data on shellfish closures were provided to **GPI***Atlantic* by Environment Canada. 1999. Environmental Protection Branch, *Shellfish Monitoring Program*, Environment Canada Atlantic Region Office, Amar Menon.

Figure 13. Shellfish closures in Nova Scotia, 1940-Present



Sources: **Figure**: Adapted from Wilson (2000); **Data**: Environment Canada.

Environment Canada is currently documenting areas of marine closures over the past decade; with new results expected to become available in December, 2001. This will allow more accurate updating of the data presented in this section.

However, it must be noted here that any time series showing the area of closures may also be affected by our ability to detect these events and by an increase or intensification in our use of shellfish resources (Craig, 2001). Strictly speaking, herefore, an uncorrected time series of closures may not properly reflect environmental quality. Until such corrections are made, the data given above should be regarded as provisional – although using these data is surely preferable to omitting consideration of lost shellfish values altogether. With appropriate formulation and further refinement, the indicator presented here will gradually become an ever more reliable component of a marine environmental quality assessment.

3. Socioeconomic & Community Indicators

3.1. Economic Valuation of Fishery Resources and the Marine Environment

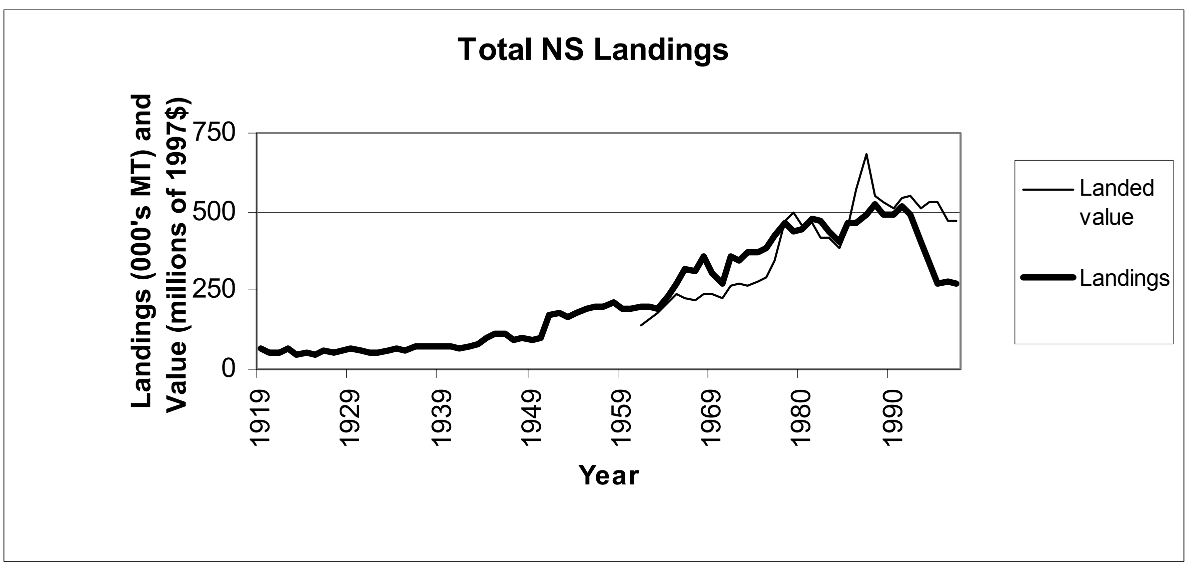
A wide variety of approaches can be used to measure the economic value of natural resources and their use. Some of these are conventional measures: in the fishery, these include the *landed value* (the gross income obtained by fishers from the sale of the fish), the *gross domestic product* (GDP – the total monetary value of the fish production), the level of *exports* (and the corresponding foreign exchange earnings), and the level of *employment* in the fishery. Recently, other valuation approaches have been proposed that relate particularly to the level of *natural capital* in the fishery system (e.g., Costanza, 1997). The latter are discussed later in this section.

Landed Value

The total weight of the catches obtained by Nova Scotian fishers increased through most of this century, peaking in 1988 at 522,000 metric tonnes (Figure 14). A notable decrease in total landings (by weight) occurred through the 1990s, reflecting the collapse of cod and other groundfish stocks. By 1997 the total weight of fish caught, 270 000 MT, was roughly half of what it had been in 1991 (DFO, 1999b).

The value of fish landed by Nova Scotians increased from the initial year for which data were available, 1961, through to its peak in 1987 at $701 million – even after adjusting for inflation (DFO, 1999a). Since 1987, however, the landed value of fish has decreased (though not nearly as dramatically as declines in the weight of landings) to a value of $482 million in 1997. Despite this drop, landed values in 1997 were double what they were in 1970. This can be explained by the increased effort in harvesting species, such as lobster, that command a high market value.

Figure 14. Historical catch of fish in Nova Scotia (all species combined)



Sources: DFO (1999a, 1999b).

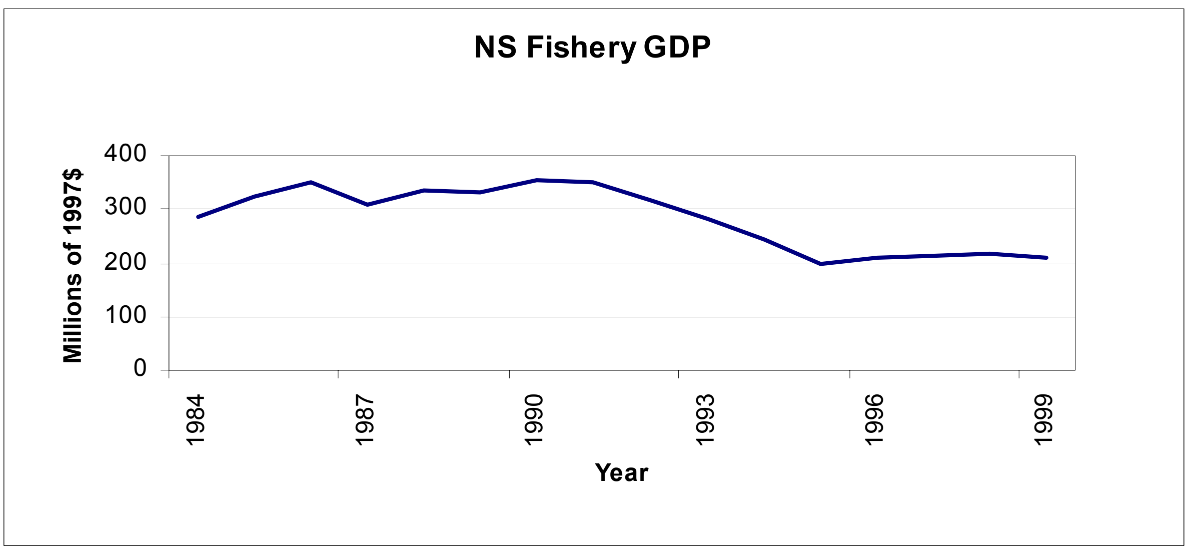
Gross Domestic Product (GDP)

Media reports on the "State of Nova Scotia's Fishery" traditionally focus on the annual quantity of fish caught, the total fishery revenue, and the level of fish exports. All of these factors are included in the fishery's contribution to the Gross Domestic Product (GDP), the conventional measuring stick of economic progress and prosperity. Between 1984 and 1991, the fishery GDP fluctuated between $285 and $356 million (in 1997 dollars) (NS Department of Finance, 2001). The fishery GDP declined during the early 1990s, to less than $200 million in 1995, but has since levelled outreaching about $210 million in 1999 (Figure 15).

Overall, therefore, the fishery GDP has declined by about one-third in the last decade, and its percentage contribution to provincial GDP has declined even more as total provincial GDP continued to grow. Note that these GDP figures are affected by the overall landings in the fishery, the species mix in that catch, and the prices involved.

These GDP values do not include the many non-market services that Nova Scotia's marine environment provides. For example, the essential value of nutrient cycling is not captured in the GDP and related economic growth statistics, even though each fish that we harvest relies on nutrient cycling for its development. Similarly, habitat structure and quality strongly influence the value of Nova Scotia's fisheries but are not incorporated into the GDP. Later in this section, these factors are considered in more detail. For the present, it is noteworthy that GDP and economic growth depend on non-market services and aspects of ecosystem health that are not explicit within their own statistics and accounting mechanisms.

Figure 15. Fishery GDP for Nova Scotia



Source: NS Department of Finance (2001).

Exports

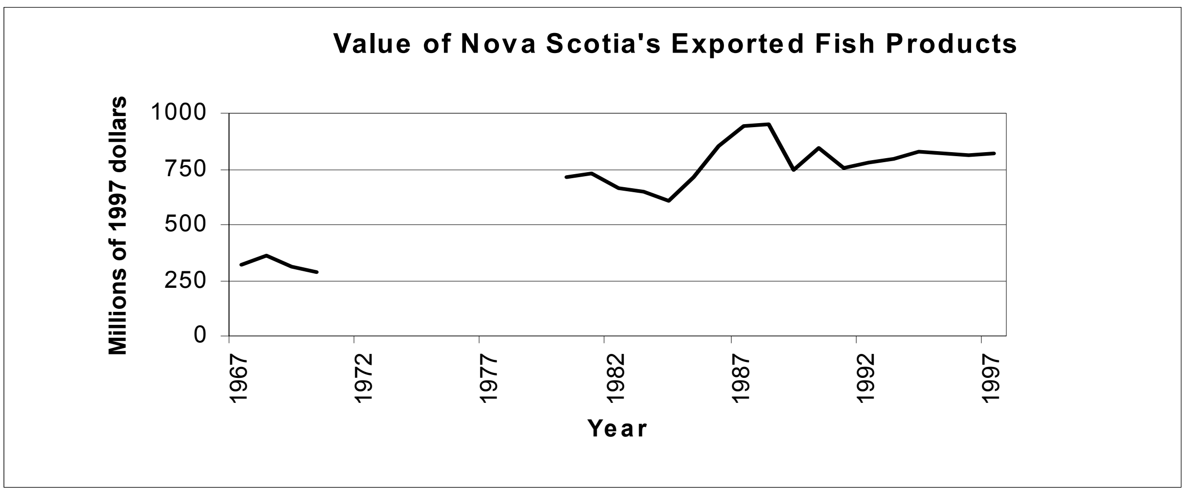
Exports have greatly increased since 1967 when they totalled about $317 million (Figure 16). Consistent data are available on Nova Scotian fish exports since 1980 (NS Voluntary Planning Board, Series), showing that the value of exports increased dramatically between 1984 and 1988, at which time the value peaked at $950 million. Nova Scotia's fish exports in 1997 amounted to $821 million, almost triple what they were in 1970.

An increase in exports is typically interpreted as a positive sign of progress because it represents an increased flow of foreign money into Nova Scotia's economy. Such an increase in export value is indeed a positive development if it comes from improved quality, perhaps due to careful harvesting techniques or from "value added" during processing.

However, increased exports may well reflect a simple increase in the volume of fish exported, in which case the *net benefits* of the higher exports depend on the impact such an increase has on the natural resource base. A greater flow of money into the economy today from exports may be at the expense of declining fish stocks and a loss of the stock of *natural capital* (see below) needed to support the fishery in the future.

The confusion as to whether increased exports signify an improved economy or a loss of natural wealth arises because we depend totally on a 'current accounting' mechanism that excludes capital assessments. By way of analogy, the owners of a factory may improve their temporary cash flow if they sell off their machinery, but obviously, if they do so, they will be unable to sustain the production of goods and services into the future.

Figure 16. The value of Nova Scotia's fish product exports

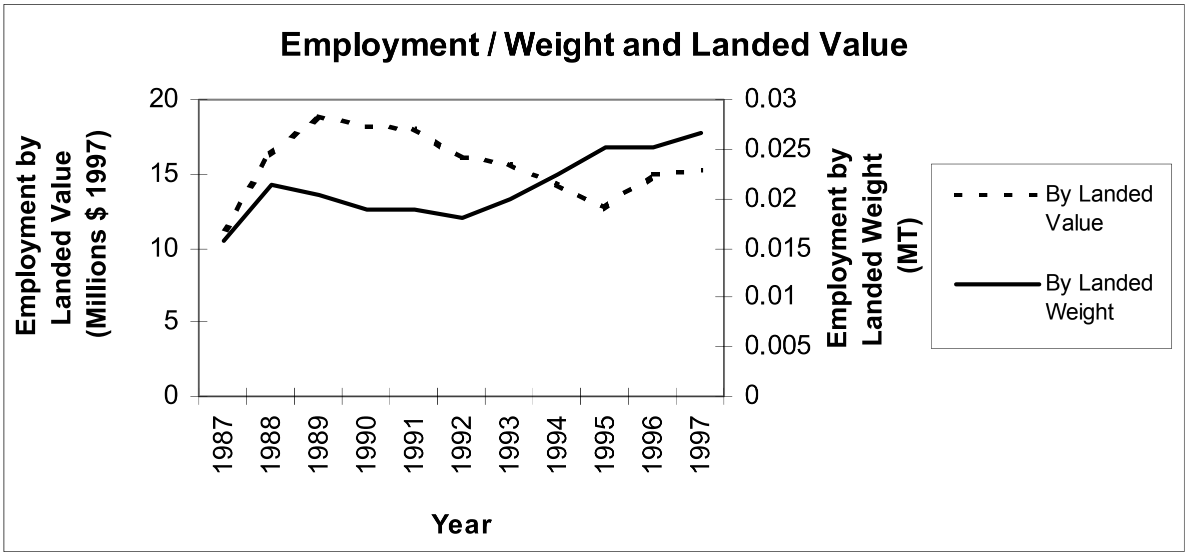


Source: Nova Scotia Voluntary Planning Board.

Employment

Employment can be measured as the number of people employed in Nova Scotia's fishing industry per unit of harvest (i.e. per metric tonne of fish caught), or per unit of landed value (i.e. per million dollars in landed value) (see Figure 17). These indicators assess the benefits obtained 'per fish' taken from the sea. The first of these has been increasing fairly steadily since the mid-1980s due largely to the decline in total landings by weight (figure 14 above), while the employment per unit of landed value declined in the late 1980s and early 1990s, and then began to increase in the late 1990s. This recent trend seems to reflect, in part, a shift toward lower-volume but higher value fishery products.

Figure 17. Number of fishers employed in Nova Scotia's fisheries per million dollars generated and per metric tonne caught.



Sources: NS Dept. Finance (2001), DFO (1999a, 1999b).

Natural Capital

The traditional measures of economic performance in a fishery – the landed value of the catch (gross revenue), the fishery GDP, and the level of exports – increase as more fish are harvested (measuring, as it were, the 'flow' of money out of the sea). Growing catches, growing fishery GDP and growing exports are translated as "progress" in these conventional accounting mechanisms.

Yet we have seen in Nova Scotia that a high landed value can be accompanied by, and indeed can be an indicator of, declining fish stocks. Monetary indicators can appear positive even if the harvests are not sustainable. Positive signals based only on fishery output can give a highly misleading sense of security and optimism if they are mis-used as indicators of progress and sustainability.

To fully account for the 'benefits' of a given harvest, measures of catches, landed value and exports must be accompanied by a measure of the change in value of the fish *remaining in the ocean* after the fishery has taken place. This latter indicator increases if there is growth in the value of the fish 'assets' and if there is a positive 'flow' of value into the resource stock.

This approach and understanding reflect the concept of *natural capital*, the natural assets that include not only the fish in the sea, but also the quality of the water, the ocean bottom habitat, and other elements of the marine environment. Some of the benefits that natural capital provides, for example the fish species that are harvested, are obvious, while others, such as the habitat provided for non-target species, may not be directly apparent to humans. Given the interdependence of all components of the marine ecosystem, it is prudent to recognize the indirect benefits as well. All of these assets clearly have significant and real value – they keep the fishery functioning, among other roles – and it is important to monitor changes to them if we are to assess accurately the actual economic health of the fishing industry.

It is noteworthy that the valuation of natural capital described here is a core feature of the Genuine Progress Index system of accounts. Just as the provision of fish is one service among many provided by the marine environment (the natural capital base of the fishery), so timber, for example, is one of many services provided by forests. Just as the marine environment provides many other services, such as nutrient cycling, on which the health of the fishery depends, so forests provide a wide range of services, including climate regulation, carbon sequestration and protection of watersheds, soils, and habitat, which in turn support timber productivity.

By valuing both the quantity and quality of a natural resource stock, the GPI can provide a far more accurate and comprehensive measure of resource industry strength and health than a current-income accounting system that mistakenly measures the depletion of the resource as economic gain. The GPI natural capital accounts in effect introduce a balance sheet of resource health into the accounting system – in a manner analogous to that used by all businesses to assess depreciation in capital value and to signal the need for re-investment.

Since renewable natural capital stocks have the capacity for natural regeneration, such reinvestment generally takes the form of conservation whenever stock declines are apparent. To that end, natural capital accounts can send early warning signals of resource decline or degradation to policy makers that allow conservation measures to be implemented before a catastrophic resource collapse occurs. By contrast, the signals received by policy makers from our current accounting system may signify maximum industry health on the very verge of a resource collapse, as occurred with the record fish landings that preceded the collapse of the Atlantic ground fishery.

To understand these concepts, it is helpful to compare natural capital with financial capital, which any economic activity needs to operate, and to physical capital, in the form of buildings, computers and equipment. Businesses must pay attention to the state of their physical capital, or their productivity will be threatened. These businesses have standard accounting procedures to keep track of both financial and physical capital. On the other hand, because the fishery sector does not pay for natural capital directly, natural capital has traditionally been regarded as "free" and has not received the accounting attention paid by other businesses to their capital assets.

We have now learned from hard experience in Atlantic Canada that if the extraction of natural capital in the form of fish catches is excessive, the value of the entire system may decline. Thus fishery management is needed in order to regulate resource harvesting and to maximize social benefits while ensuring that the productivity of the natural capital base of the industry is not compromised. Put in financial terms, the challenge is to maintain the value of the natural capital base (healthy fish stocks and a healthy marine environment) while living off the 'interest' (sustainable harvest levels). Furthermore, if levels of landings in a fishery indeed reflect 'living off the interest,' then any over-fishing, non-reporting, discarding and high-grading activities actually reflect a reduction in (and waste of) natural capital and show up in the resource accounts as a loss of value.

The above highlights the importance of taking natural capital into account, but leads logically to the next key issue: determining how to measure natural capital. To be complete, an assessment of natural capital should include a range of ecological assets, from fish stock biomass to habitat integrity and environmental quality. However, there is no general agreement on how to measure these assets, and indeed some natural assets are truly 'invaluable' and irreplaceable, and thus not conducive to 'valuation'.[2] These problems exist for valuation in physical or qualitative terms, but are even greater when one seeks to place *monetary* values on natural capital: a reliance on monetary measures is clearly inadequate to fully assess natural capital.

Nevertheless, the policy arena is so dominated by budgetary considerations that economic valuation is an essential strategic tool to ensure that the preservation of natural wealth receives the attention it needs when policies are being shaped so as to protect overall economic health. In other words, it is better to attempt some economic measurement of natural capital than to have changes in these assets ignored, as has been done in the past. Therefore, particularly to enable us to compare changes in natural capital with the dollar values of landings taken from the fishery, it is helpful to measure natural capital in monetary terms.

This being said, a comprehensive assessment of natural capital in Nova Scotia's oceans is beyond the scope of this preliminary report. The discussion in this section seeks to illustrate the idea of natural capital valuation by focusing solely on the natural capital within particular fish stocks. Of course, such stocks form only a limited part of the ecosystem, and the production of fish is only one function performed by the marine environment. For example, the oceans provide a critical service to human society by sequestering carbon from the atmosphere and thereby stabilizing the climate and slowing global warming. They also provide direct economic benefits to human society through waste absorption, transportation, recreation and other services. Therefore, a valuation of individual fish stocks as natural capital assets merely provides some elements of an overall assessment, which would also include vital ecosystem services that are not susceptible to direct economic valuation. With this crucial caveat in mind, we proceed with the valuation of fish stocks as marine natural capital, in order to illustrate the approach. (See section 2.1.7 below for an approach to assessing aggregate natural capital – in the form of ecosystem services within Nova Scotia's marine environment.)

Even the task of assessing natural capital within specific fish stocks is difficult, because there is no universally accepted methodology for quantifying the value of fish stocks in the ocean. The goal of such an analysis is to determine the total value of these natural 'assets' in the sea, and ideally this will take into account that an adult fish living today will, through reproduction, contribute to fish stocks into the future. Unfortunately, measuring this future contribution is difficult due to uncertainties about the dynamics of reproduction. For this reason, another major simplification is made here: the monetary value for the natural capital within a given stock in a given year is assumed to be given as the product:

$$\text{Value of natural capital} = (\text{estimate of fish biomass}) \cdot (\text{price of fish, in constant dollars}).$$

[2] For a discussion of the limitations of monetary valuation in natural resource accounting, see Walker et. al., *The Nova Scotia Greenhouse Gas Accounts for the Genuine Progress Index*, pp106-108.

Thus the proxy for natural capital used here is the current market value of fish in the sea – the total revenue that could theoretically be obtained if every fish were caught and sold that year. On the one hand, this over-estimates the market value of those fish to society, since the *costs* of catching the fish are not deducted. (The 'quota value' of the fish has been suggested as a better way to measure this.) On the other hand, as noted above, the above calculation also tends to under-estimate natural capital, in that it does not account for a fish stock's contribution to ecosystem services, nor its ability to reproduce and produce a flow of benefits over time.

If market prices do not change and if the biomass is maintained from one year to the next, a similar level of natural capital (as measured here) can be expected each year. Conversely, natural capital will decline if either of these components decreases. In general, natural capital will vary over time in response to variations in biomass and fish price, each of which is influenced by many factors. For example, biomass is affected by physical and chemical factors in the marine environment, by natural predation and by fishery harvesting. Market value can be influenced by factors such as the condition and size of the fish and by local and export market demands.

The following section attempts to illustrate some of the changes in natural capital (adjusted to 1997 dollars to account for inflation) for three Nova Scotia fish stocks, and to present some of the factors that influenced these changes.

Note that the discussion of natural capital here must be accompanied by simultaneous examination of the biomass itself, as an independent indicator, since an increasing or stable level of natural capital does not in itself demonstrate a positive ecological situation. It could reflect increasing prices that mask serious declines in biomass levels. Indeed, scarcity itself may raise prices, thereby maintaining the apparent economic value of the fish stock while the stock itself declines. In other words, each part of the equation (biomass and prices) must be examined in its own right, aside from the product of the two.

Cod

The biomass of cod stocks off the coasts of Nova Scotia rose steadily in the years leading up to the mid-1980s, then dropped precipitously for almost a decade (as depicted for the case of the 'fishable' biomass in Figure 2). Meanwhile, the price of cod (adjusted for inflation) remained essentially constant through the 1970s until around 1985, rose to a peak in 1987, then dropped temporarily before resuming a steady increase, to reach its highest recorded levels in the mid-1990s (Figure 18). Cod prices in the mid-1990s were more than twice as high as those in the early 1980s.

The product of these indicators, price and biomass, produces a measure of the natural capital embodied in Nova Scotia's cod stocks (Figure 19). The value of this natural capital increased between 1985 and 1988, but then exhibited a steady decline in value from 1988 to 1994, as the collapse of the cod stocks led to a historic low level of natural capital in 1994. Perhaps the most dramatic aspect of this is that the decline in natural capital occurred *despite* a considerable price increase.

Figure 18. Nova Scotia cod prices

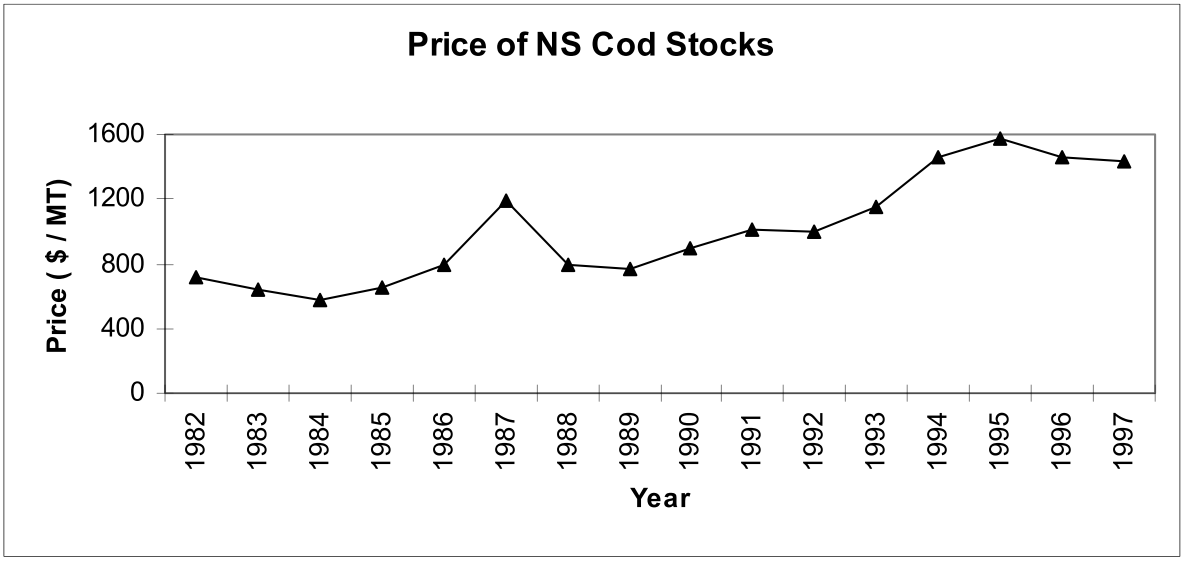
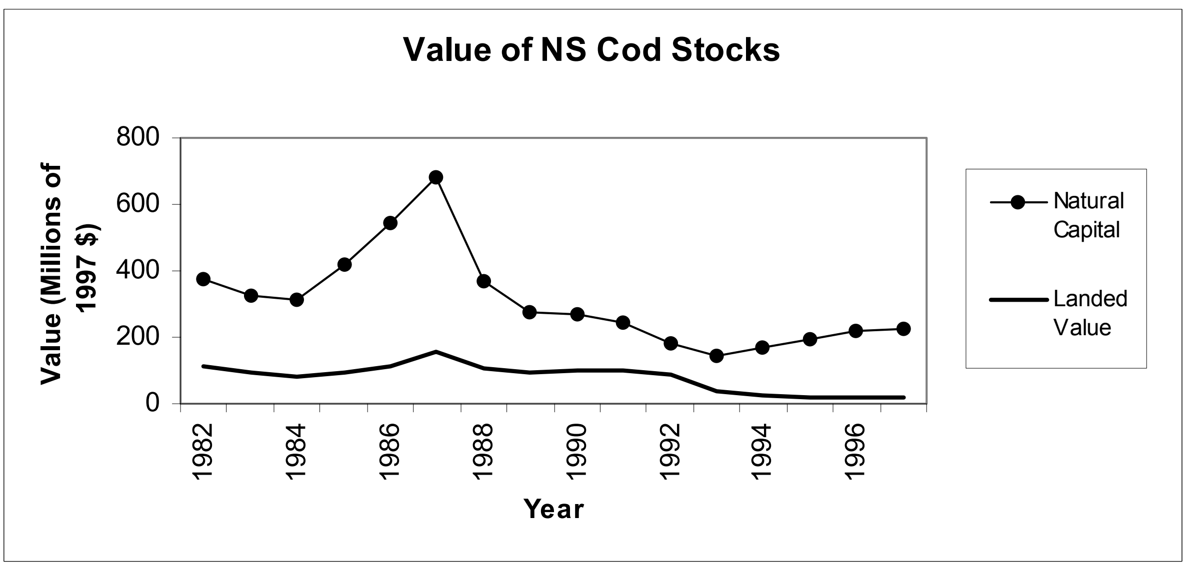


Figure 19. Value of Nova Scotia's cod stocks



Sources: DFO (1999a, 1999b).

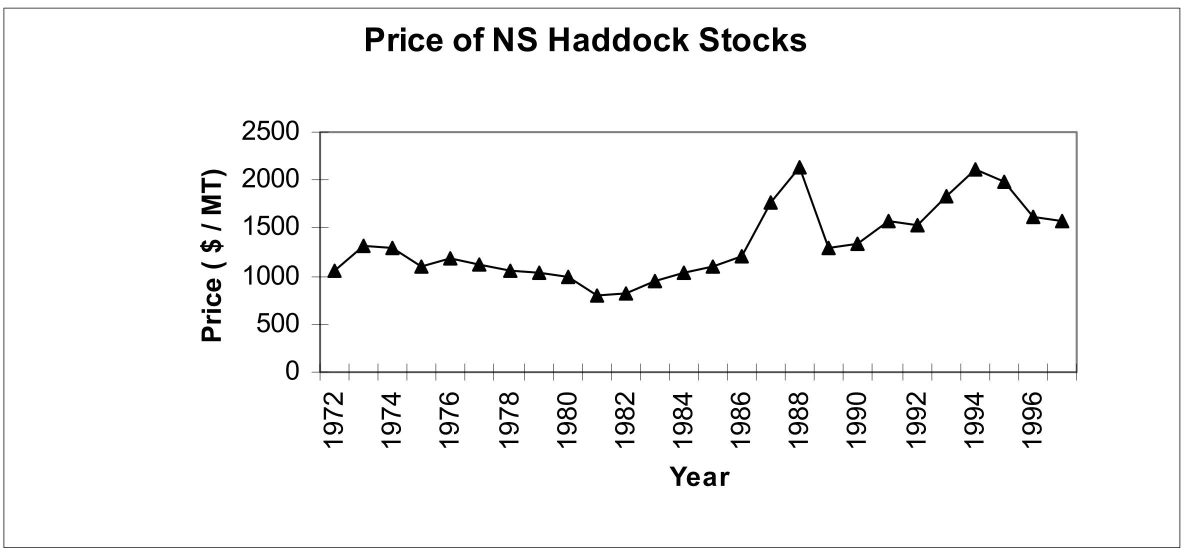
Since 1994, the value of Nova Scotian cod stocks has stabilized, because both price and biomass are slightly higher in 1997 than they were in 1993. Nevertheless, in 1997, the natural assets embodied in the cod stocks were about $74 million lower than they were in 1982. The landed value of cod has steadily declined since 1987 as catch levels have adjusted to the reality of a groundfish collapse. The future of the cod fishery is uncertain, with no assurance that the cod stocks will regain the abundance or value that they once had (Sinclair cited in Auld, 2000; Hutchings, 2000).

Had a publicly accessible set of natural resource accounts been available to policy makers as part of our core measures of progress in the 1980s, then timely conservation measures might have been taken to re-invest in our natural capital within the cod fishery before their collapse and before the closure of fisheries in the early 1990s became necessary. The sharp decline in stock value indicated in Figure 19 could have elicited a policy response to rebuild those stocks similar to that which we expect from policy makers when physical infrastructure like bridges or schools depreciates to the point of danger and requires rebuilding.

Haddock

The biomass of haddock increased from the mid-1970s through to the early 1980s, peaked in 1981, then declined until the mid-1990s (Figure 20). In contrast, over the period during which the biomass decreased, prices increased fairly steadily from a low in 1982 to considerably higher levels in the mid-1990s (with an exceptional peak in the late 1980s).

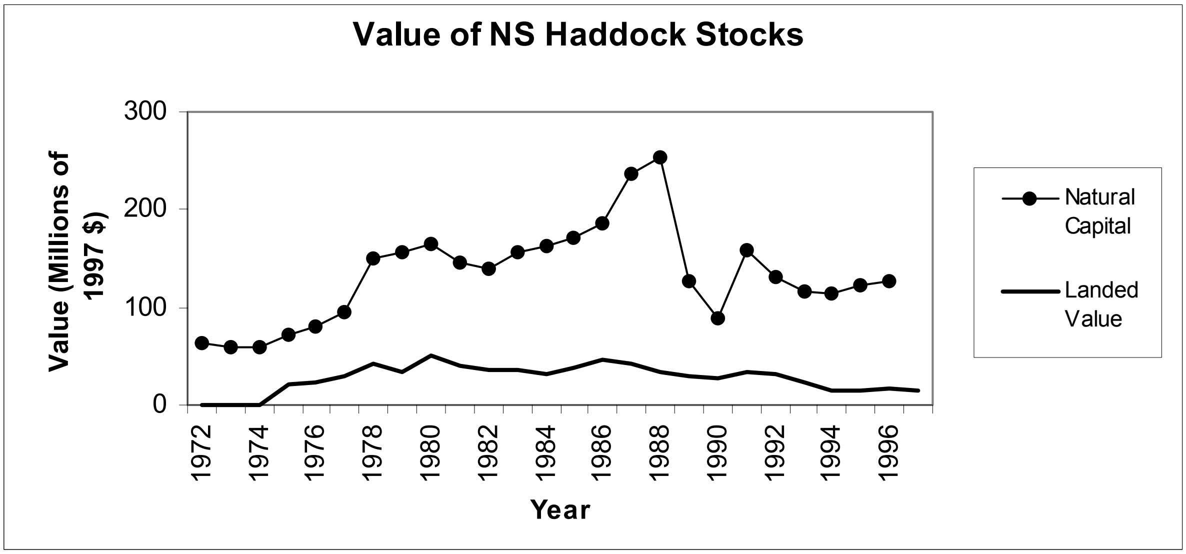
Figure 20. Nova Scotia haddock prices



For most of the 1970s and 1980s the increasing price more than compensated for a declining biomass, so that Nova Scotia's haddock stocks appreciated in value between 1972 and 1988 (Figure 21). This natural capital fell rather dramatically in the late 1980s and early 1990s, and despite price increases between 1989-1994 has not yet recovered to the high levels of the 1980s.

In 1997, Nova Scotia's haddock stocks had depreciated by about $53 million compared to the level in the early 1980s. The landed value of haddock catches did not respond immediately to the drop in natural capital in the late 1980s and early 1990s. The drop came several years later, reflecting a lack of timely response by management to major changes in the fish stocks. As in the cod fishery, if natural capital accounts had been available in the haddock fishery, their precipitous decline in value in the late 1980s could have sounded alarm bells in the policy arena earlier than occurred and possibly allowed remedial action that could have saved thousands of jobs.

Figure 21. Value of Nova Scotia's haddock stocks



Sources: DFO (1999a, 1999b).

Herring

The value of Nova Scotia's herring stocks, the natural capital, has peaked twice over the last two decades (Figure 23). The first peak, in 1980, was greatly influenced by the high price herring fetched in that year. The price of herring has declined quite steadily since then. The natural capital reached its maximum value in 1987, largely due to a high biomass level. Note that, in contrast to the case of cod, this increase in natural capital in the herring stocks came *despite* a declining price. A drop in both price and biomass between 1987 and 1995 contributed to a decline in the stock's natural capital over that period. A small rebuilding in natural capital levels occurred from 1994 to1996, apparently reflecting an increase in the price.

Figure 22. Nova Scotia herring prices

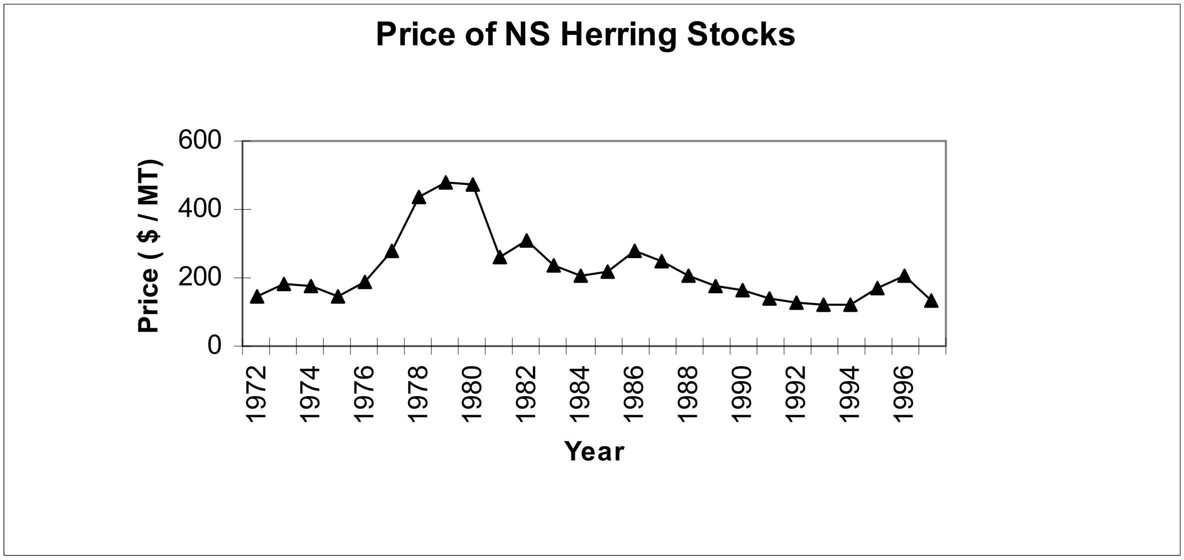
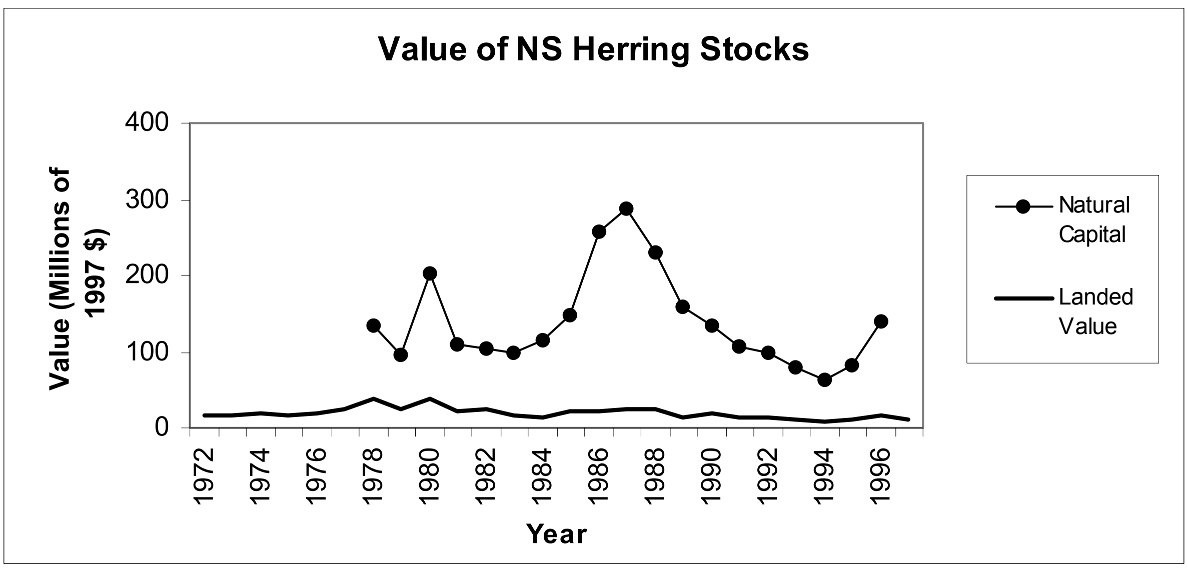


Figure 23. Value of Nova Scotia's herring stocks



Sources: DFO (1999a, 1999b).

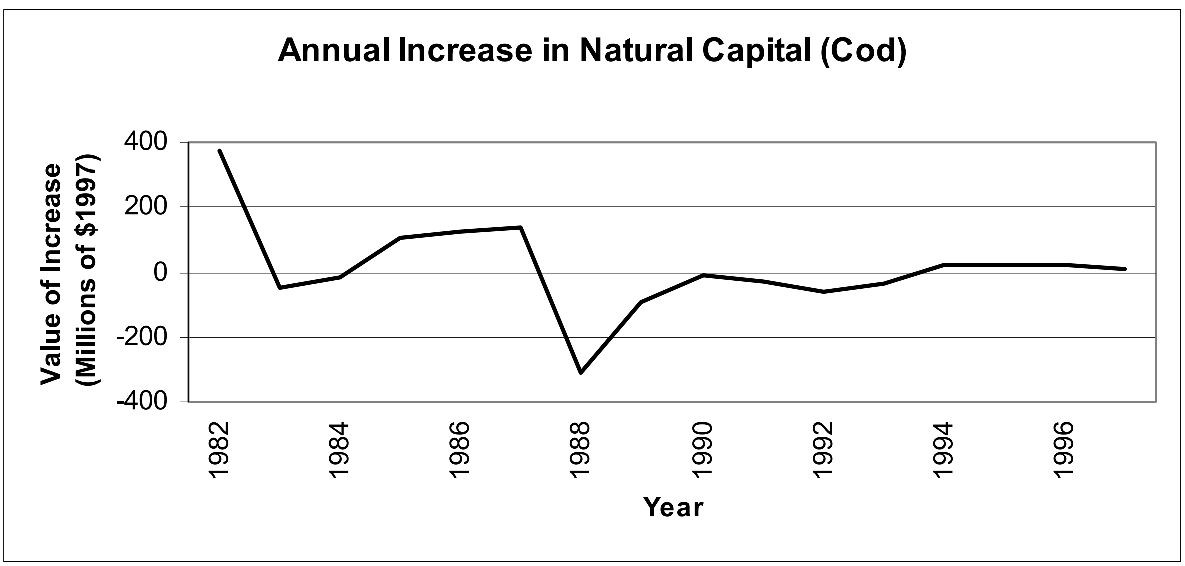
Resource Depreciation

Changes in natural capital are referred to as *resource depreciation* (for decreases in value) or *appreciation* (for increases). Over-harvesting leads to resource depreciation (loss of economic value) just as over-use of equipment without maintenance and replacement will lead to declines in the capital stock of a business (factories, equipment) over time. In contrast to machinery, however, fish stocks, being renewable, can naturally appreciate (grow) in economic value over time and regenerate of their own accord when harvested sustainably. A resource depreciation indicator permits the measuring of harvests and revenues in relation to changes in fish stock values over time.

Figure 24 provides an example of resource depreciation for Nova Scotia's cod stocks. (Similar graphs could be constructed for other species.) The horizontal line at 0 represents stability in the natural capital, so in any given year, if the graph lies above this line, this indicates appreciation (an increase) in the value of natural capital, while a point below 0 indicates depreciation of the fish stock value. Note that as with the measure of natural capital above, the indicator of resource depreciation here is based simply on the product of market price and stock biomass, each for the given year; this therefore does not completely capture all aspects of natural capital (again failing to account, for example, for future benefits that the resource can potentially provide). However, these estimates do help us to understand changes in the value of the resource.

Perhaps the key point in Figure 24 is in 1988-89, when depreciation of the stocks is evident. This depreciation – which occurred simultaneously with annual reports of fishery 'growth,' in terms of high catches, profits and exports – is analogous to the running down of physical capital in a manufacturing industry. Since that time, there has been relative stability in the natural capital stock, as depicted by points lying roughly along the zero level. Referring to Figures 18 and 19, it is apparent that any stability in natural capital is a result of price increases offsetting biomass declines.

Figure 24. Annual increase in the natural capital of Nova Scotia's cod stocks



Sources: DFO (1999b).

The above point, and more generally the appearance of Figure 24, is cause for some reflections on the approach used here to measure natural capital. Because resource declines happened to coincide with rising world prices, the monetary valuations of natural capital shown here are at odds with biomass levels. In other words, due to distortions created by market price changes, our measure of *economic* resource depreciation fails to show the dramatic nature of *physical* resource depreciation (biomass decline). This highlights the limitations of monetary measures in valuing natural resources and ecosystem services. Indeed, Figure 24 clearly shows that monetary valuations of natural capital cannot be relied on to signal *physical* resource depreciation. On the contrary, they may send completely misleading signals to policy makers.

Why, then, would monetary measures be used? First, as noted in the previous section, budgetary considerations so dominate policy discussions that *lack* of monetary valuation virtually guarantees that ecosystem services and physical resource values will not get the attention they deserve, thereby blunting essential conservation measures. Second, monetary valuation is useful in demonstrating the vital links between natural resource health and economic prosperity. The physical collapse of the ground fishery produced a massive loss of jobs and direct economic losses that *were* counted in monetary terms.

In other words, un-harvested natural resource stocks *do* have an economic value (albeit hidden in our current accounting systems), just as those that are harvested *are* currently given a value in the GDP and related statistics. Future jobs depend on the health of the un-harvested stocks as surely as present jobs depend on those that are harvested. Given the complete dependence of harvests on un-harvested stocks, the challenge is how to make the latter as explicit as the former currently are in our core economic accounts without producing the distortions evident in Figure 24 and in earlier charts.

Therefore, there are strong reasons to explore monetary measures. There is also a rationale for the method used here, based on fluctuating annual prices, since this does provide an indicator of the actual natural capital *as seen in a given year* (based on that year's biomass and fish price). In other words, the values shown indicate what would be *perceived* to be the natural capital (and the corresponding resource depreciation) in any given year.

However, the fact that the results shown above do not reflect fundamental changes in the resource base lead us to question the preliminary approach to economic valuation used here, and to invite further experimentation. It may be useful in future versions of these accounts to explore the possibility of using a constant price of fish, rather than one that varies with the marketplace. Such a constant price might, for example, be based on an average of market prices over the time period under consideration. A depreciation chart based on such a constant price, rather than on fluctuating annual prices, would produce trend lines identical to biomass levels, but simply with a dollar value attached. This would therefore provide a more accurate gauge of actual physical stock levels than our current valuation method. With such an approach, assessments of natural capital in a given year would be less closely tied to the economic situation in that year, which may better reflect the fact that un-harvested stocks have *future* monetary value rather than present market value.

Analysts will undoubtedly suggest other possible valuation methods, including the use of discount rates to assess the net present value of future marine resource benefits, also a highly controversial issue when choice of discount rates is considered.[3] In short, the necessity for

[3] Discounting is discussed at length and used for valuations in other **GPI***Atlantic* publications, including the *GPI Water Quality Accounts* (2000) and the *GPI Greenhouse Gas Accounts* (2001). In these valuations, **GPI***Atlantic* has

natural resource accounts and valuations of natural capital and resource depreciation is not in doubt, but the choice of valuation methodology is wide open.

Ultimately, it is clearly desirable to transcend monetary valuation altogether, but that will only be possible when environmental quality and natural resource health are automatically taken into account in their own right in all policy decisions. The native tradition of assigning a representative of the seventh generation hence to participate in policy deliberations may point a way forward towards this ultimate objective that goes beyond the monetary valuations currently required.

The Value of Marine Ecosystem Services

Nova Scotia's marine environment is invaluable. Our oceans provide recreational and cultural value as well as essential transportation and communication links, and the waters provide a multitude of services for our coastal communities. One of the ocean's most valuable roles is its contribution as a storage and processing centre for the nutrient cycles that form the basis of all biological processes. The ocean provides services and habitat for many organisms on which we rely and, of course, many of these organisms themselves, primarily our fish stocks, are important food sources (Costanza *et al.*, 1997).

Is it possible to place a monetary value on the 'invaluable' and essentially irreplaceable benefits of Nova Scotia's marine environment, and particularly on the services provided year after year by our marine ecosystems? On an international scale, this was the challenge undertaken – not without controversy, given its philosophical implications – by a team headed by ecologist Robert Costanza (Costanza *et al.*, 1997).

Drawing on a variety of ecological studies, and a variety of assumptions about monetary values of ecosystem services, this team produced estimates of the average annual value of such ecosystem services per square kilometre, for each of a series of ecosystem types. The team estimated, for example, what it would cost to replace such services through human engineering and other means. In particular, within the marine context, they calculated that, on average, the value of ecosystem services from open ocean (relatively far from the coast) is \$25,200/km^2/yr while the value of ecosystem services from coastal areas is \$405,200/km^2/yr (both in 1994 US dollars).

Note that these figures are global averages(calculated on a planetary basis) and that they are for a particular point in time. No trends can be deduced from the calculations to assess the maintenance or degradation of ecosystem services over time, or the appreciation or depletion of resource stocks. Nevertheless, assuming that the valuations apply reasonably well to the Nova Scotian situation, the value of marine ecosystem services is determined simply by multiplying each figure in the Costanza study by the total ocean area of the corresponding type, and summing up.

experimented with a wide range of discount rates and assessed the conceptual implications and results of different discount rate choices.

For the purpose of this calculation, the marine system included was restricted to the Scotia-Fundy management region, which extends from Bay St. Lawrence to the American border in the Gulf of Maine and includes the Bay of Fundy and all waters extending to the 200 mile Economic Exclusion Zone (including NAFO sub areas 4VWX within the 200 mile EEZ and the Canadian jurisdiction within sub areas 5Zej and 5Zem) (Whynot, 2001; DFO, 2001b). The approximate ocean area involved within this system is a total of 432,950 Km^2.

If we assume that this area is 3/5 coastal and 2/5 open ocean (DFO, 2001b), the resulting annual value of ecosystem services is calculated as:

$$(3/5)(432{,}950\ km^2)(405{,}200\ US\$/km^2/yr) + (2/5)(432{,}950\ km^2)(25{,}200\ US\$/km^2/yr)$$

= \$119,200,000,000 per year (in \$US 1997) – i.e. 119 billion US dollars per year.

While this is clearly a very approximate figure, its magnitude does highlight that the total value of ecosystem services provided by Nova Scotia's marine environment is clearly not captured in the fishery GDP. Indeed this total value, as calculated here, is more than 340 times the peak value of the fishery GDP given earlier in this report. The magnitude of this estimation, however approximate, suggests that it is vitally important to monitor trends in the contribution of Nova Scotia's marine environment to essential life-supporting ecosystem services.

3.2. Distribution of Fishery Access and Income

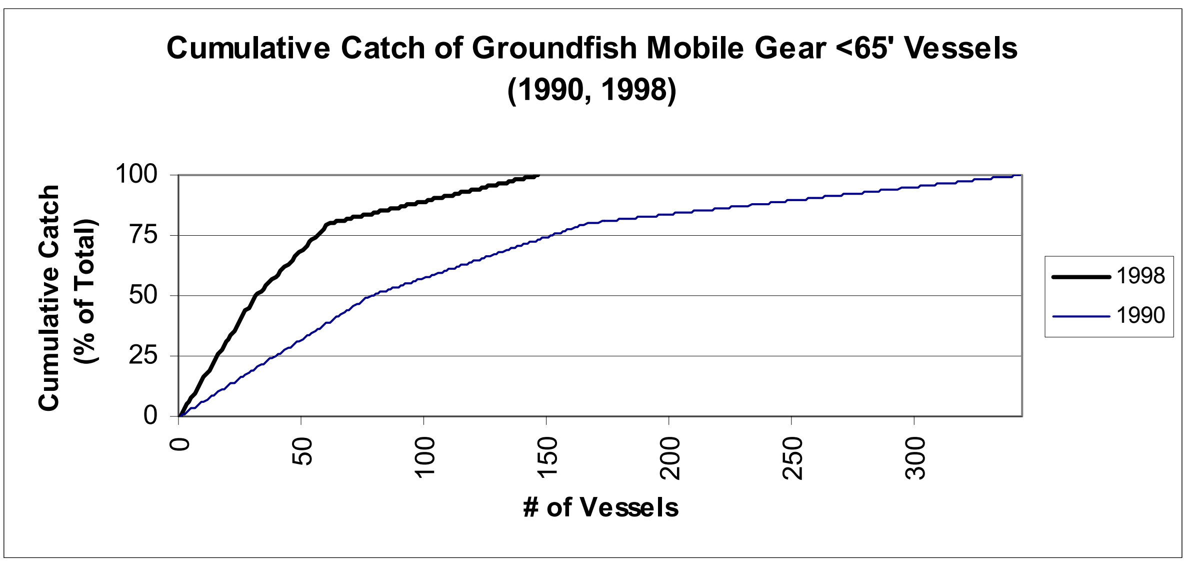
A fishery, and indeed any other part of society, is not likely to make "genuine progress" unless the benefits generated in that sector are equitably distributed (for example, among the fishers and the different fleets or gear sectors in the fishery, and between the harvesting and processing sectors). Indeed equity both within the present generation and between generations is part of the Brundtland Commission's core definition of "sustainable development" (WCED 1987.) Equity can be considered in terms of *access* to the fishery (a matter of who is allowed to fish) and in terms of the outputs (catches and income) obtained from fishing.

Fishing licences allow us to measure ***access*** to the fishery. Access is equitable if licenses are widely distributed among fishermen and across fishing communities. Such access to the fishery can become less equitably distributed if licenses, as they are bought and sold among fishers, are eventually bought up (or otherwise controlled) by a smaller number of individuals or companies. Such an increased level of concentration in access to the fishery would imply that fewer people have the opportunity to share in the wealth from the natural resource. This situation is widely understood to be evolving in parts of the lobster fishery, although this is apparently not yet documented.

Some information is available, however, for access to fisheries managed through individual transferable quotas (ITQs). These personal fishing quotas, which are bought, sold and 'owned' by individuals (and companies), provide the right to catch a certain proportion of the Total Allowable Catch (TAC). Theoretical studies of ITQs suggest that, relative to fisheries with other management approaches, an ITQ system leads to concentration of fishery access, as quotas accumulate in fewer hands. Experiences with ITQs in Canada and other countries have verified this tendency in practice, as fishers or companies with the capability to do so (perhaps in the form of wealth or financial backing) are able to buy quota from other fishers.

For example, in the ITQ-managed fleet in the Scotia-Fundy inshore mobile gear groundfish fishery, ownership of quota holdings – representing effective access to the fishery – became concentrated in fewer and fewer hands between 1990 and 1998. This was due to two factors. First, as shown in Figure 25, the total fleet size declined from roughly 350 vessels to under 150 over that period – so that fewer vessels are sharing the total catch. Second, within the fleet sector, the distribution of the catches became less even. In 1990, about 45% of the fleet (somewhat over 150 of 350 vessels) shared three-quarters of the catch, while by 1998, that proportion of the catch was controlled by only 35% of the fleet (just over 50 of around 150 vessels). Overall, these changes mean that a smaller fraction of a smaller fleet now controls the catch quota; 50 vessels now catch a proportion of the harvest that had been shared among 150 vessels previously.

Figure 25. Cumulative catch of groundfish mobile gear <65' vessels for 1990 and 1998



Source: Liew (1999).

This result has led to widespread discussion of concentration in ITQ-managed fisheries (cf. Liew, 1999; Burke, 1994; Annala, 1996.) Indeed, depending on one's perspective, the increased concentration is either seen as an advantage (reducing the number of participants in the fishery) or a disadvantage (reducing equity in the fishery and harming communities.)

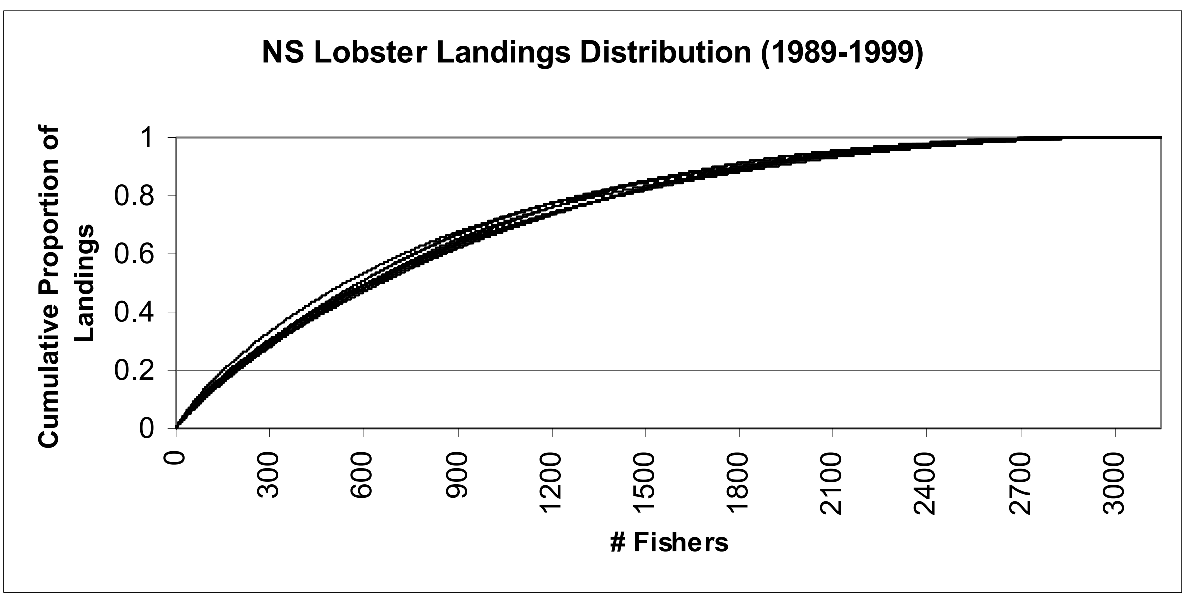
While the groundfishery is subject to regulations meant to limit concentration – a limit of 2% quota per quota holder (Burke, 1994) – the use of legal individual contracts has enabled a small number of companies to accumulate quota to bypass this regulation. Apostle *et al*. (1997) estimate that 60-70% of the 'licenses with quota' in the mobile gear ITQ groundfishery are 'processor-owned or –controlled.' Landings in this ITQ fleet were also concentrated within fewer and fewer ports between 1990 and 1998 (Liew, 1999), a move that may also be detrimental to the well-being and sustainability of coastal communities.

Consider now the distribution of the ***results*** of fishing activity – catches and incomes – as illustrated by the Nova Scotia lobster fishery. Figure 26 shows a set of curves, each depicting for a specific year the distribution of landed value across all lobster fishers. If the curves were in fact straight lines, this would indicate perfect equity with 50% of fishers receiving 50% of the landed value, 75% receiving 75% of the value, and so on. On the other hand, the steeper the curves at the start (left-hand side), the greater a proportion of the value goes to a small number of fishers.

Figure 26 indicates that benefits from the lobster fishery are not distributed entirely equitably, but the key point concerns the trend, or lack thereof, in the results over time. Because the curves lie close to one another in Figure 26, the picture has not been further complicated with labels showing the corresponding years, but in fact there is no pattern over time. We can conclude from this that the distribution of benefits from the lobster fishery has remained roughly constant over time.

It is important to note, however, that this does not capture the point noted earlier concerning *access* to the fishery, namely that there is apparently a recent trend toward the buying up of control over lobster licenses by processors, through legal contracts. This results in an increase in effective ownership concentration, which – over time – is likely to affect the catch distribution shown in Figure 26.

Figure 26. The distribution of lobster landed value across all Nova Scotian lobster fishers, by year (1989-1999)

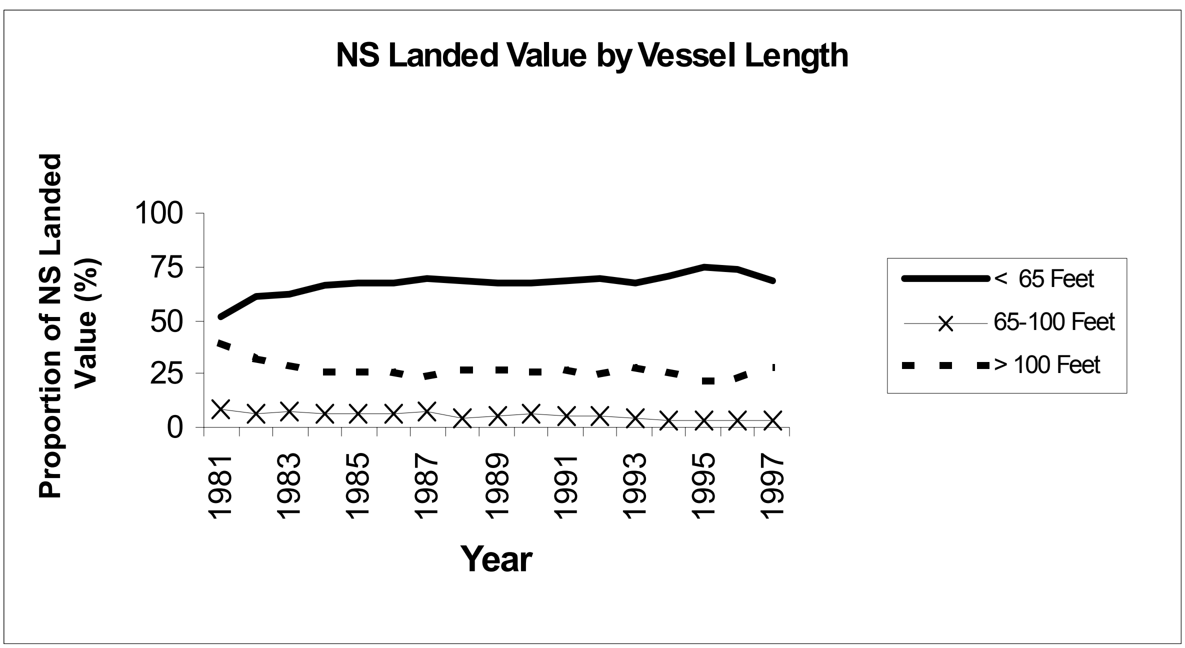


Source: Based on data from DFO Scotia-Fundy, Economics Branch (personal communication, Jim Nelson, 2001).

The distribution of income among fishers is another indicator of equity and well-being in Nova Scotia's fisheries. Ideally, such a measure would assess the distribution of *net earnings* on an *individual* level. However, data on the income of individuals in Nova Scotia's fishing industry were not available for this study, nor were data on *net* income (profits, or taxable income from fishing) at either an individual or group level. Therefore, in lieu of a more appropriate measure, data detailing the gross income of groups of fishers were used. Concentration of incomes can be analyzed relative to various classification schemes including vessel length, gear sector, fishery, or region. As illustrations, this report describes concentrations of the landed value of fish caught by different fleets.

Figure 27 illustrates the trends in each fleet's contribution to Nova Scotia's total landed value from fishing over time. The contribution by offshore vessels (>100 feet) has declined slowly, by 11% since 1981. The nearshore fleet (65-100 feet) contributed less than 10% to Nova Scotia's landed value 20 years ago and this contribution decreased quite steadily until 1997 when it comprised roughly 3% of the landed value. The inshore fleet (under 65 feet, including midshore vessels 45-65 feet) contribute the most to the landed value and this contribution has increased, proportionally, over the past twenty years. A recent focus on more lucrative fisheries, such as the shellfish fisheries, may be contributing to the trend. In any case, since the vast majority of Nova Scotian fishers work on boats that are less than 45 feet in length (the 'true inshore'), this trend may be seen as positive from a distributional perspective.

Figure 27. Value of Nova Scotia's landings by vessel length (fleet) category



Sources: DFO (1999c), DFO (1999f).

3.3. Resilience

As noted in the previous section on ecological indicators, resilience is a key concept and a highly desirable attribute in natural systems. Resilience reflects the ability of a system to 'bounce back' from shocks and to maintain its integrity. This applies both to ecological systems, in which genuine progress is assessed by the capacity of an ecosystem to maintain its 'health' over time, and to human systems in which socioeconomic structures and communities are able to 'bounce back' from dramatic changes in the natural resource base or in the overall economic system.

What is required of a fishery to make it resilient is by no means clear, but in this section, some factors that may contribute to socioeconomic and community resilience are explored. These include: debt levels (a negative indicator), diversification of total fishery landings across multiple species, access of individual fishers to multiple fisheries (rather than a specialization in just one fishery), diverse age structure of the fishers, economic (livelihood) diversification among fishers, and the extent of community economic development initiatives (all positive indicators.) Just as biodiversity is recognized as a key indicator of ecosystem resilience, so diversity is also clearly a key to resilience in human communities. Each of these indicators is explored briefly here.

Debt Levels

If fishers face excessive levels of debt, and consequently particularly high annual payments on that debt, this is likely to reduce the fishers' capability to adapt to changing circumstances. This is not to suggest that debt is necessarily negative, but rather that a useful indicator of economic resilience may be that of *excessive* debt levels (or excessive reliance on governmental subsidies, employment insurance or other transfer payments).[4] Indeed, from a relative perspective, the burden of debt is assessed according to capacity to make payments, while the ultimate problem with debt is that of bankruptcy.

Debt among Nova Scotian fishers can arise both from capital spending (e.g. boat-building) and from purchase of individual licenses and individual quota (e.g. ITQs). There is no systematic tracking of debt levels, so any measure is but a rough estimate. The only sources available for this study are ones based on data sources solely for capital spending and only for a time period ending in the early 1990s. These indicators cannot therefore be considered to reflect current reality, but are presented here as examples of the type of information that, if more comprehensive and up-to-date, could be of considerable use in a set of fisheries accounts.

The first measure considered here is the total amount outstanding to the provincial Fisheries Loan Board. The Loan Board has historically been an important source of financial support for Nova Scotian fishers, providing 60-80% of money borrowed by fishers for capital spending between 1984 and 1994. Thus debt owed to the Loan Board might be a useful indicator, subject to the above caveats and to the fact that the relative role of the Loan Board versus other financing approaches such as banks is unknown. The analysis indicates that debt owed to the Loan Board

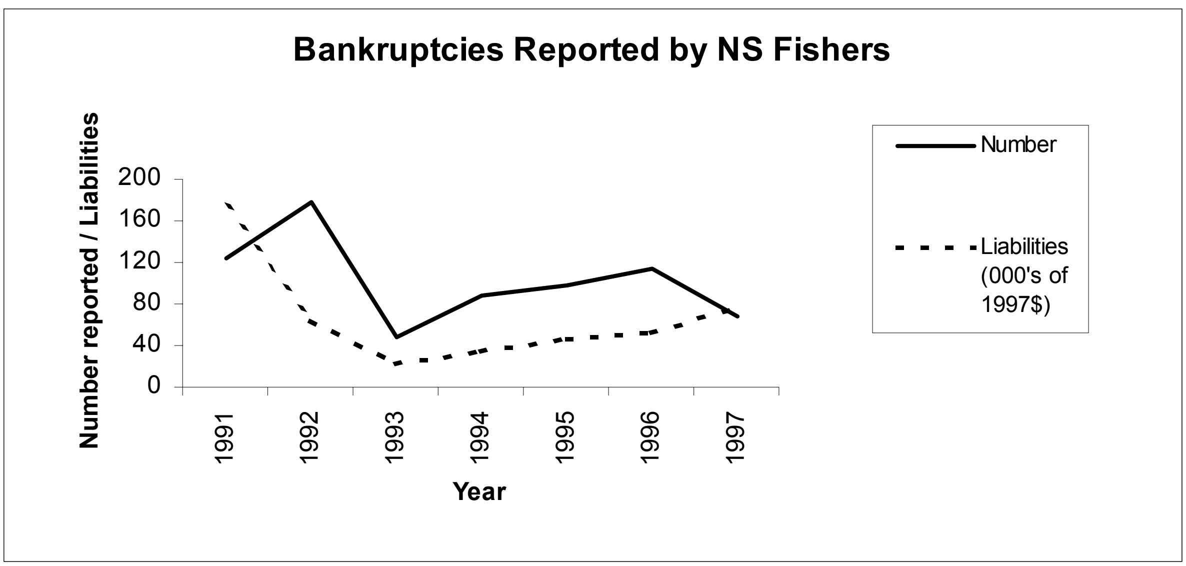
[4] For analogous indicators in the *GPI Soils and Agriculture Accounts,* see Scott (2001), "*Farm Viability and Economic Capacity in Nova Scotia,*" **GPI***Atlantic*, Halifax, April, 2001.

increased in the early 1980s but is currently at the lowest levels since that time. Specifically, by 1996, the average amount owed per loan and the total amount owed to the Fisheries Loan Board had both decreased to approximately half of 1985 levels.

A second measure on debt is based on the set of DFO Scotia-Fundy 'cost and earnings' studies, published by the economic analysis division, each of which surveyed a specific sector of the fishery. Overall, there was considerable variability in the debt load of fishers across sectors, with debt loads in the groundfishery increasing by 50% between 1988 and 1991, while other fisheries were experiencing a decline in debt. Following 1991, however, the groundfishery experienced a significant decrease in new debt, falling into line with the apparent trend to decreasing debt in more recent years within all the fisheries studied.

Turning to bankruptcies (Figure 28), data are available since 1991, indicating that the time leading up to the groundfish collapse in the early 1990s (1991-92) produced the peak in total bankruptcies. Given that levels are surprisingly low in 1993, when many groundfisheries were cut back severely, it is possible that this indicator played the role of a predictor of the groundfish crisis: – its peak occurred before the cod collapse attracted attention in 1993. While both the number and financial liability of bankruptcies increased between 1994 and 1996, these levels did not reach those of 1991 or 1992. The number of reported bankruptcies dropped between 1996 and 1997 but during the same period, the total amount of liabilities continued to increase. Overall, then, there seems to be a declining trend in the number of bankruptcies but an increasing trend, since 1993, in the financial magnitude of those bankruptcies.

Figure 28. Bankruptcies reported by Nova Scotian fishers



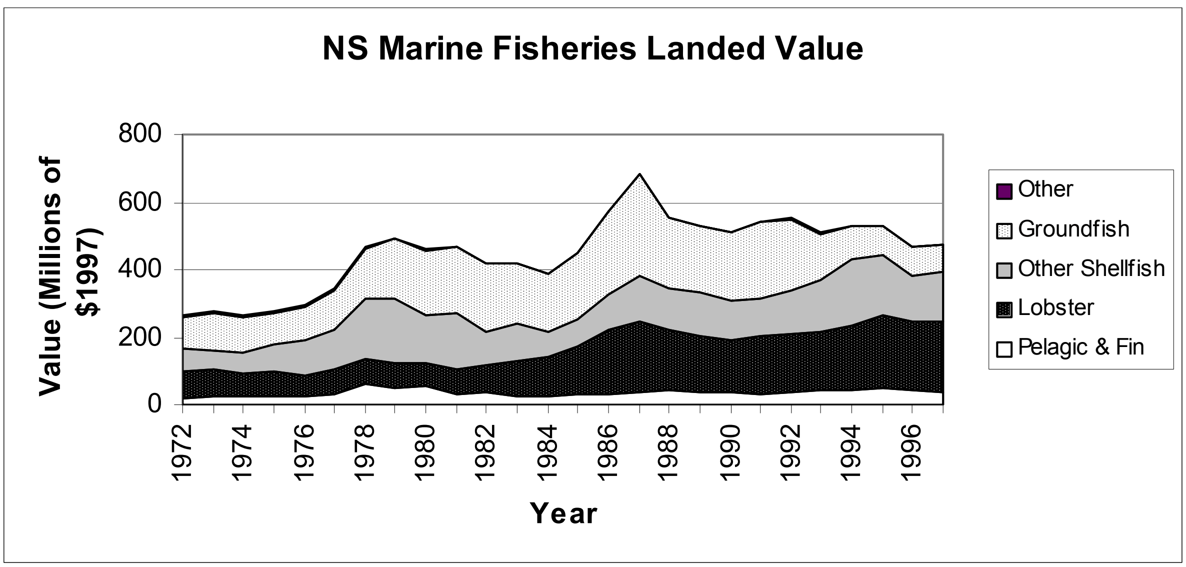
Source: NS Voluntary Planning Board.

Diversified Landings

Figure 29 shows that the dependence of Nova Scotian fishers on the various sets of marine species has varied over the years. Examination of a longer time series of data (not shown here) suggests that the Nova Scotian fishery has reduced its reliance on single fisheries over the past century. From the human perspective in the fishery, this suggests that fishing communities may now have a more diverse set of fishery livelihood options than historically, and therefore greater resilience.

On the other hand, the steadily increasing dependence on the shellfish fishery following the groundfish collapse in the early 1990s (Figure 29) may be a danger signal of reduced resilience in the future. Should the shellfish fishery be threatened for ecological reasons, it is hard to see what fishers would rely on in the absence of a significant groundfish recovery.

Figure 29. Species contribution to Nova Scotian fisheries' landed values



Source: DFO (1999a).

It must be noted, however, that while a diversity of landings in a fishery system would seem to be beneficial, in terms of economic and community resilience and as a mechanism to reduce fishing pressure on healthy stocks, diversification may have negative ecological repercussions if it is pursued carelessly. Complex interactions between various species in an ecosystem make it difficult to predict the impact that fishing a new species can have on traditional target species.

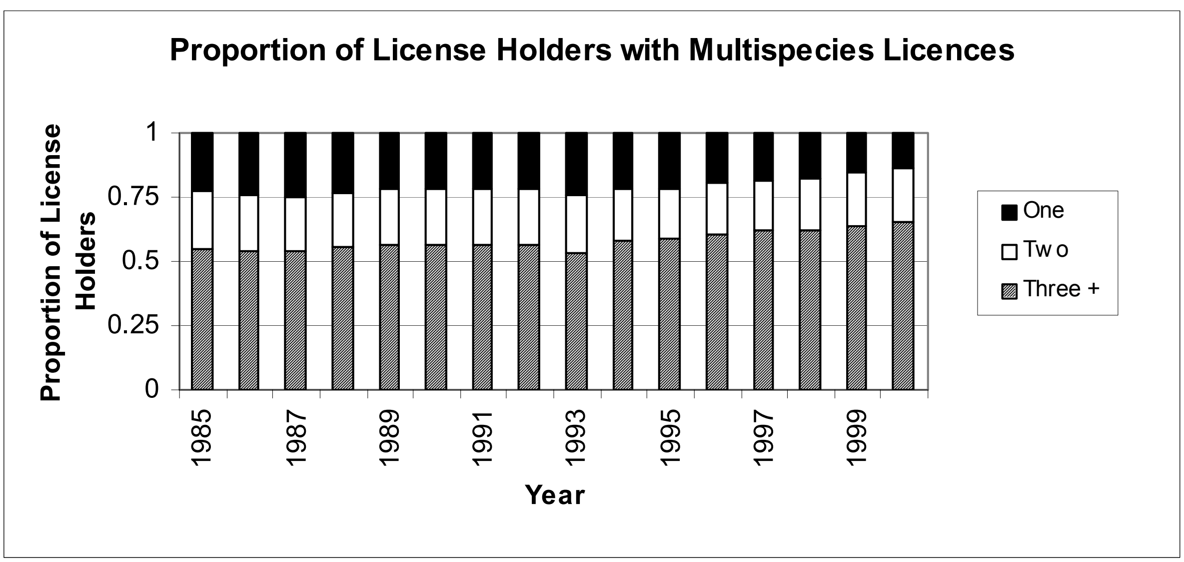
Some scientists are concerned, for example, about a possible global trend in which fishers are harvesting species lower and lower on the food chain, because the traditional target species populations have already been over-fished (Pauly *et al*., 2000). Certainly in recent years, since the groundfish collapse of the early 1990s, there has been considerable attention placed on diversifying fishing activity into 'previously under-utilized' species – which may well be lower on the food chain. In short, even apparently positive trends like increased diversification of landings, must be carefully examined to assess their qualitative impacts on other key indicators.

Multi-Fishery Access

Fishers holding more than one species license are able to switch between fisheries in response to changing abundances and profitability. In particular, fishers can redirect toward other fisheries when faced with a collapse of one fishery (as was the case with cod), and can thereby maintain their livelihood from fishing. From both an individual and a community perspective, multi-fishery access enhances the resilience of the overall fishery situation – as long as redirection of fishing is not such as to serially deplete fish stocks. Thus, the extent to which fishers hold multiple licenses to harvest a range of species is an indicator of socioeconomic and community resilience.

In Nova Scotia, most fishers have legal access to harvest fish from more than one fishery. There was little change in the proportions of fishers holding single, double or multiple species licenses between 1985 and 1993 (Figure 30). However, there appears to be a gradual positive trend towards greater multi-species licensing between 1993 and 2000, with the proportion of fishers holding licenses for at least 2 species rising from below 76% in 1993 to above 86% in 2000. This increase in the proportion of multiple species license holders may be due to an increased interest in harvesting a greater diversity of species, but it could also occur if more of Nova Scotia's single species license holders were leaving the fishery than were multi-species license holders.

Figure 30. Proportion of license holders with multispecies licenses 1985-2000



Sources: DFO (1999e), DFO (2001c).

Many fishers maintain licenses even though they are not utilizing them. This may have been partly as a result of DFO efforts to encourage specialization in the fishery. As a result, the proportion of fishers with multiple licenses should be interpreted here as an indicator of *potential* resilience, while *actual* resilience depends on the fishers' capability to use their licenses at some point in the future. Other factors, such as appropriate gear and physical health, may affect fishers' ability to make use of their licenses for access to the fishery. Nevertheless, it is widely accepted that when the groundfisheries declined dramatically, the fact that many fishers held and were able to return to using lobster licenses provided a crucial fall-back position in the fishery sector.

Age Structure of Fishers

It is well accepted in ecology that age structure can be an important factor in the health and resilience of fish stocks as in other natural resource stocks.[5] A fish stock should have a broad age spectrum that is relatively evenly distributed, rather than containing fish of only a narrow age range. Resilience on the human side might be considered similarly. A well-distributed age spectrum among fishers is desirable both from a human perspective – for example, to ensure a range of social interactions within the fishery and continuity within fishing communities – and from a management perspective, perhaps to avoid abrupt increases or decreases in harvesting capacity over time. Of course, as with fish populations, this is not to suggest that all ages must always be equally represented.

Figure 31 shows that between 1931 and 1990 in Nova Scotia, there have been decreases of approximately 5% in both the proportion of young fishers (15-24 years) and the proportion of older fishers (45-65 years), while the proportion of middle-aged fishers (25-44 years) has increased by roughly 10 %. Since the latter is historically the major age group, it could be argued that the spread in age structure among fishers has diminished. However, the significance of this trend is unclear. For example, it may simply reflect a trend over time to a lower participation rate in the fishery among the particularly young and perhaps the earlier retirement of older fishers.

Diversified Employment

The incomes of Nova Scotian fishers tend to be more variable from year to year than those of their non-fishing counterparts (Cashin, 1993). Between 1981 and 1990, self-employed fish harvesters' incomes were twice as variable as the incomes of people working outside of the fishing industry. This highlights the importance of economic diversification for enhancing resilience in fishing communities (see below), and illustrates the fishing industry's vulnerability to economic difficulties.

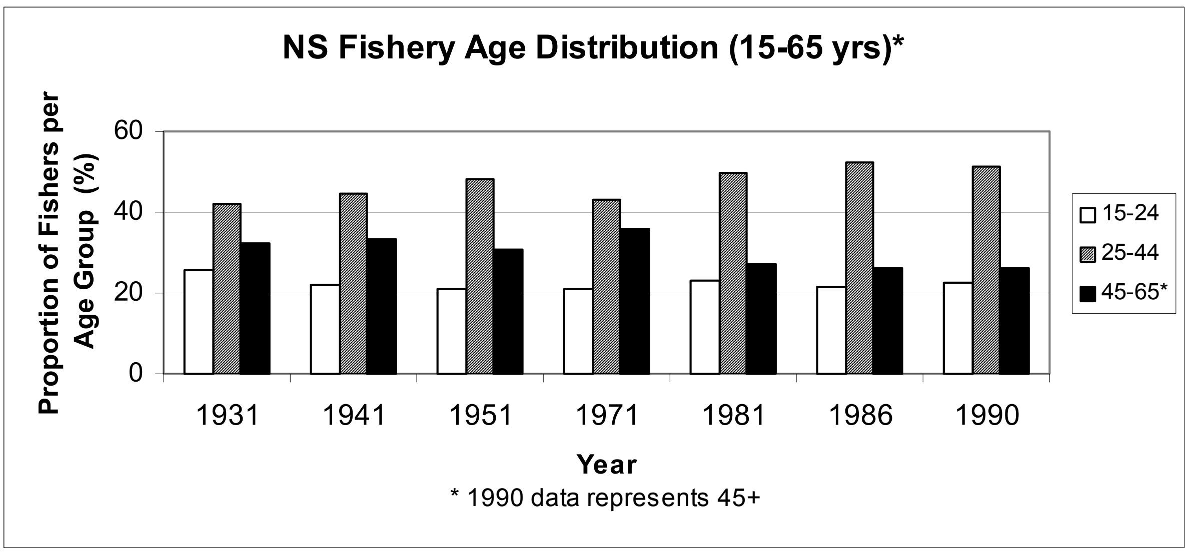
On the positive side, individual fishers in Nova Scotia are more diversified in their own employment than the average Nova Scotian. In both 1981 and 1990, an average fisher earned approximately 18% of his or her employment income outside the fishing industry while an

[5] For example, age structure is also a key indicator of forest health and resilience in the *GPI Forest Accounts* (2001).

average Nova Scotian earned only 3% of employment income through secondary employment (Cashin, 1993).

By comparing income levels it appears that an average fisher may have a greater economic incentive to diversify his or her income because the average income from fishing is well below the provincial average income outside the fishing industry. (For example, the analysis in Cashin, 1993, indicates that for the year 1990, the average fishing income for self-employed fishers in Nova Scotia was $14,900 while the average income across all economic sectors was $20,200.) Extra income and/or work time may also be important to increase the prospect of eligibility for employment insurance during economic downturns. For all these reasons, a greater level of livelihood diversification may increase overall fishery resilience.

Figure 31. Age distribution of Nova Scotian fishers from 1931 to 1990



Source: Statistics Canada, Census (multiple years).

Community Economic Diversification

A resilient fishing community is one that can continue even during very difficult times and 'bounce back' from disruptions. Many components of a community's structure, including economic and age structure, can contribute to its level of resilience. In particular, a diversified economy increases community resilience. Communities with diversified economies are less vulnerable to variability and market fluctuations within a single industry, because other industries within the community are able to provide some economic stability. On the other hand, communities that primarily rely on a single industry are economically vulnerable and will be affected by the variable success and difficulties within that industry (Lamson, 1986).

The importance of economic diversification in human communities is not unlike the importance of biodiversity in marine ecosystems. Resilience, in both cases, results when more than one component of the system can perform similar critical functions within that system (Lamson, 1986). An apt analogy might be carrying a spare tire in one's car – if one component is not functioning in a way that supports the system, there are other components that can support the system until it has time to regain its former status or to adjust to the new situation. Thus fishing communities increase their resilience by participating in economic activities that are not directly related to the fishing industry. On the other hand, they can endanger resilience if there is great reliance on few, large vessels compared to more smaller ones – since large capital-intensive vessels are less able to respond to "dynamic variability" within fish stocks and fish markets (Lamson, 1986).

The issue of community resilience in fishing communities was very apparent in the early 1990s with the collapse of many groundfisheries. The groundfishery was the focal point of the economy in many Nova Scotian fishing communities. Communities that had a more diversified economy, whether this involved the fishing of multiple species by local fishers or engagement in economic activities outside the fishing industry, were better able to manage in the face of the groundfish-related difficulties.

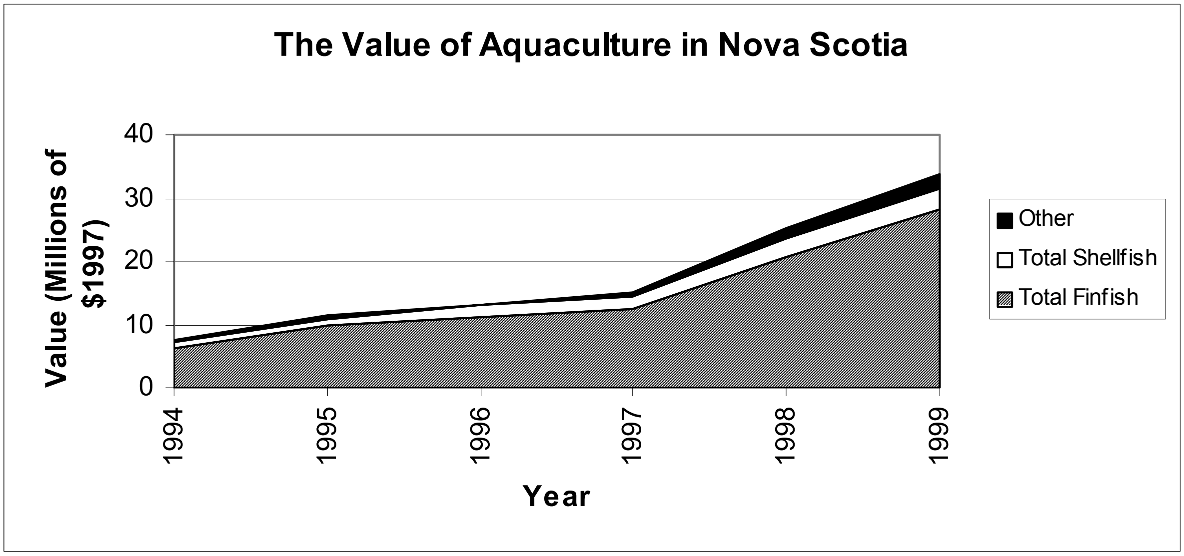
Several Nova Scotian fishing communities were able to diversify their economies to ease the impact of the groundfish collapse. For example, Isle Madame, an island community in Richmond County, is known for its efforts to diversify its economy into tourism and aquaculture. Tourist attractions, such as whale watching tours, have helped the economy in Digby Neck. Shelburne, among other communities, initiated a program for coastal resource mapping to identify options that region may have for economic diversification. Diversification carried out within the fishing industry has helped other communities, with economic diversity enhanced by increasing the variety of fish the fishers harvest while decreasing the emphasis on any particular fishery.

3.4. Aquaculture

While this report focuses principally on capture fisheries and the marine environment, the growing importance of aquaculture in Nova Scotia must be noted here, both in terms of its particular socioeconomic effects, and the impact it has on fisheries and marine ecosystems. With respect to socioeconomic effects, Figures 32 and 33 depict recent trends in the value of aquaculture production and the employment created in the aquaculture sector. There have been upward trends in the produced value of each component of aquaculture (shellfish, finfish, and other), as well as in the generation of full-time employment. It is clear from Figure 33 that finfish – notably salmon – dominate in value terms, although it must be noted that shellfish production generates an important source of employment in many parts of the province.

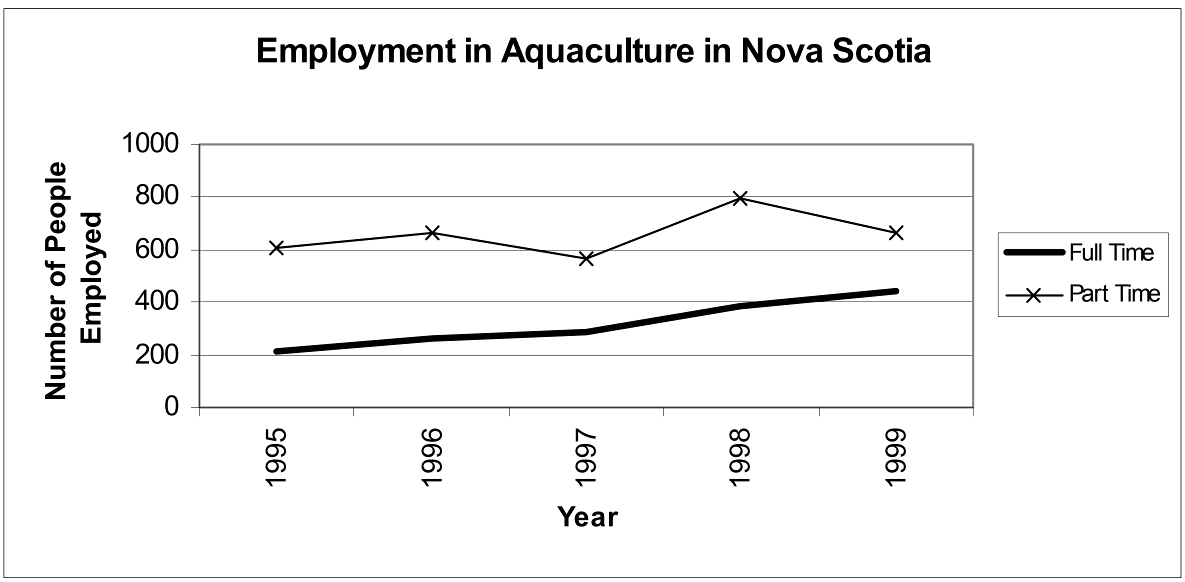
Negative impacts of aquaculture can occur both on the ocean habitat (through pollution, disease transfer, etc.) and on fisheries, whether through habitat impacts, ocean space conflicts, or market interactions. A detailed examination of these impacts is beyond the scope of the present report, but should be included in future updates of these accounts.

Figure 32. The value of aquaculture in Nova Scotia, 1994-1999



Source: NS Department of Agriculture and Fisheries (2001).

Figure 33. Employment in aquaculture in Nova Scotia, 1995-1999



Source: NS Department of Agriculture and Fisheries (2001).

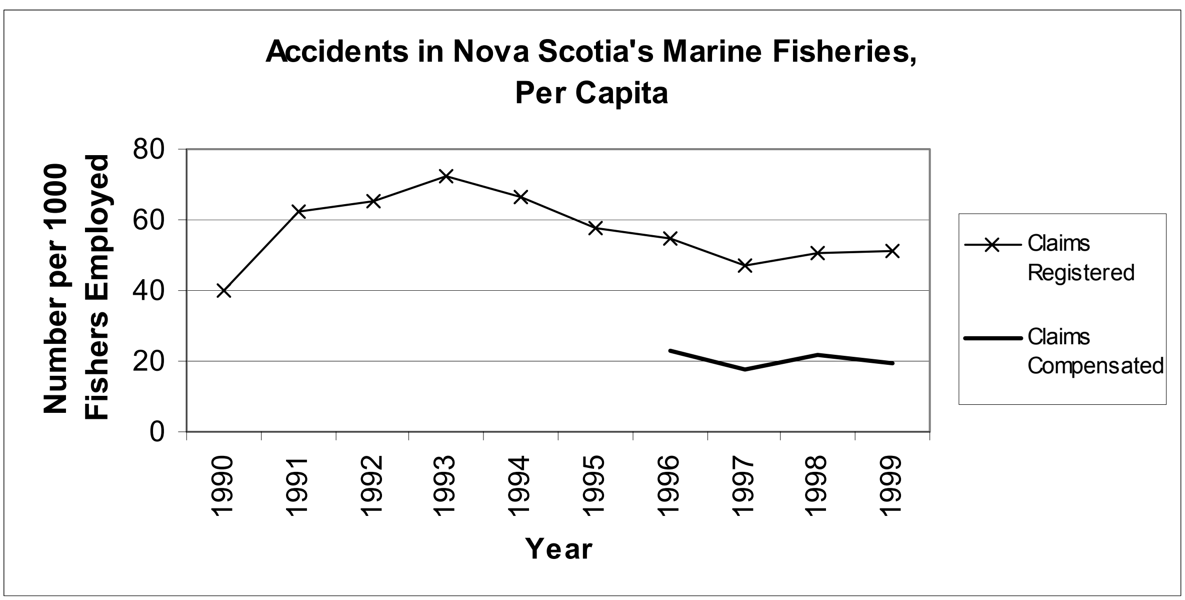
3.5. Workplace Safety

Safety is an important factor when considering the "progress" of an industry. As with money spent cleaning up environmental disasters, funds spent dealing with safety emergencies actually increase the GDP – a misguided sense of progress. The GPI recognizes that a safe workplace is a measure of well-being, and that when people are healthy and secure at work, the economy as a whole can benefit. Thus the GPI accounts for accidents and safety violations as costs rather than gains to the economy.

There is no comprehensive source of information documenting the safety of fishers in Nova Scotia. As an illustration of a safety indicator, this report uses an estimate of accidents in Nova Scotia's fisheries, as measured by the proportion of marine fishers who registered claims at the Nova Scotia Workers Compensation Board (NSWCB) each year. There is no consistent trend in the data that would suggest that the Nova Scotia fisheries are becoming more or less safe overall, but the current average of 50 accident claims per year for every 1,000 fishers employed (5%) remains high. One item of interest was an increase in accidents reported in the early 1990s coinciding with the collapse of the groundfishery.

A more consistent measurement of safety could be the number of these claims that were compensated by the NSWCB. However, due to changes in the compensation regulations through the Worker's Compensation Act in 1996 (NSWCB, 2001) recent data are not comparable to older data, so data for actual claims compensated can only be shown here from 1996 onward. No particular trend was apparent since 1996, but continued monitoring of these data may prove useful for future assessments.

Figure 34. Accidents in Nova Scotian fisheries



Source: NSWCB (2001).

4. Institutional Indicators

In the pursuit of sustainable development, *institutional sustainability* is an essential and generally overlooked ingredient. Efforts to enhance overall sustainability are unlikely to succeed unless sufficient attention is paid to maintaining or enhancing long-term financial, administrative and organizational capabilities – the essence of institutional sustainability. However, these aspects are often rather hidden; it is common to see sustainability discussed in a 'disciplinary' manner, based only on biological, social and economic components, without explicitly including such institutional aspects. This needs to be rectified in the future.

For example, in a fishery context, there is a need for indicators that assess the set of *management rules* by which the fishery is governed, and the *organizations* that implement those rules. These organizations comprise the bodies and agencies that manage the fishery, whether at the governmental, fisher or community level, and whether formally (e.g., the legal system and governmental agencies) or informally (fisher associations and nongovernmental organizations).

In general, two key requirements for institutional sustainability are (a) the manageability and enforceability of regulations, and (b) the match between the level of resources that society wishes to allocate to management, the level required to perform the desired management functions effectively, and the actual level of resources available. Together, these relate to the *effectiveness* of the institutions and to the inherent sustainability of those institutions – as assessed perhaps by the *capability* of the institution to manage, and the *acceptance* of the institution by its stakeholders and those funding it.

It is important to assess the infrastructure that manages and regulates the marine system from all these angles – relating both to the inherent sustainability of the infrastructure itself and to its contribution to the sustainability of the marine system. These aspects are linked as well: If a management system is *effective* in successfully maintaining a healthy and sustainable ocean system, this will presumably lead to greater acceptance of management efforts, and potentially greater resources devoted to those efforts – i.e. to greater institutional sustainability. Conversely, there is a natural tendency in the wake of a negative event, such as a fishery collapse, for a public feeling to develop that financial resources are being wasted on a management system that is unable to do its job.

An illustration of the importance of institutional sustainability, and of examining institutional indicators, may be seen within the conflict that has been so prominent between Mi'Kmaq communities and the federal government over fishing in the Maritimes. There are clearly major problems arising with both the themes described earlier: the set of *management rules* by which the fishery is governed, and the *organizations* that implement those rules. Indeed, the conflict is largely over which entity (the Mi'Kmaq communities or the federal government) has the 'right to manage' the fishery, i.e. to set the management rules. The conflict itself also illustrates how a lack of institutional stability can influence other aspects of the fishery, notably its ecological, socioeconomic and community sustainability. In the discussion of institutional indicators below, several indicators examined are relevant to the matter of native involvement in marine resource management.

Unfortunately, compiling indicators that cover the range of areas noted above is much easier stated than accomplished. The discussion in this section is very brief and preliminary, reflecting the fact that the authors have not been in a position to obtain the data or carry out the new research necessary to fully develop indicators along the lines described above. Indeed, data on the indicators described here are rarely published, even though an assessment of institutional sustainability may be a crucial component of any measure of 'genuine progress.' Thus, collection and analysis of quantitative data on these indicators is highly recommended for future studies.

In this section, some possible institutional indicators are described, and two of these, for which minimal data are available, are examined briefly. A number of possible indicators are shown in Table 3, each reflecting a certain criterion of institutional sustainability. These are all likely to be subjective in nature, but measures might be derived quantitatively through survey approaches. The right-hand column suggests what the situation might look like if the given indicator is at its minimum possible level.

Table 3. Some Possible Institutional Indicators

Criterion:	Indicator:	Indicator at minimum if:
Management Effectiveness	Level of Success of Stated Management and Regulatory Policies	Existing management structures are insufficient to control exploitation levels and regulate resource users
Use of Traditional Methods	Extent of Utilization	Traditional resource and environmental management methods not utilized
Incorporating Local Input	Extent of Incorporation	Management/planning activity does not incorporate local socio-cultural factors (community decision-making, tradition, ecological knowledge)
Capacity Building	Extent of Capacity-Building Efforts	Lack of capacity-building within relevant organizations
Institutional Viability	Level of Financial and Organizational Viability	Management organizations lack long-term financial viability or suffer from a lack of political support

The above are but a few of many possible institutional indicators. Others that might be explored include:

- the sufficiency of institutional resources to enable effective management;
- the acceptability of institutional resources by the public and stakeholders;
- the relative level of resources allocated for marine science and conservation;
- the priority placed on sustainability within the management system;
- the ability of a management plan to pass an environmental assessment;
- the degree of co-operation and sharing of power with fishing communities;
- the degree of stakeholder co-management (sharing of power with governments);
- the degree to which marine protected areas have been formally established..

The first two of this latter list are discussed in further detail below.

4.1. Sufficiency of Institutional Resources

This indicator deals with a fundamental issue in any management system: Are the financial and personnel resources sufficient to do the job required? Ideally, the indicator would measure total personnel and budget levels, relative to 'required' levels necessary to accomplish the goals of the fisheries management institution. However, it is unclear how to assess 'necessary' levels, except perhaps through valuation surveys.

The graphs in Figure 35 and 36 below simply depict trends over the period 1987-1993, within the Scotia-Fundy region, in (1) total expenditures by DFO, and (2) expenditures for specific activities. (Unfortunately, while data must surely exist on these variables for more recent years, the authors were not able to obtain that data within the time frame of this study.)

Note that in the three years leading up to the early 1990s groundfish collapse, expenditures decreased significantly on basic scientific work (such as ecosystem and ocean science studies), and on the surveillance and enforcement of regulations. This suggests, without being conclusive, that there may have been a lack of institutional resources for these key areas of management work at a critical point in time.

Other factors, in addition to monetary aspects, also are relevant in this regard. For example, just as the age structures of fish and of fishers are important indicators of resilience (as discussed earlier) so too might one examine the age profile of government staff. A lack of recruitment into the federal DFO has presumably led to a skewing of the age structure over time, which may have a bearing on the sufficiency of institutional resources.

Figure 35. DFO total expenditures in the Scotia-Fundy region

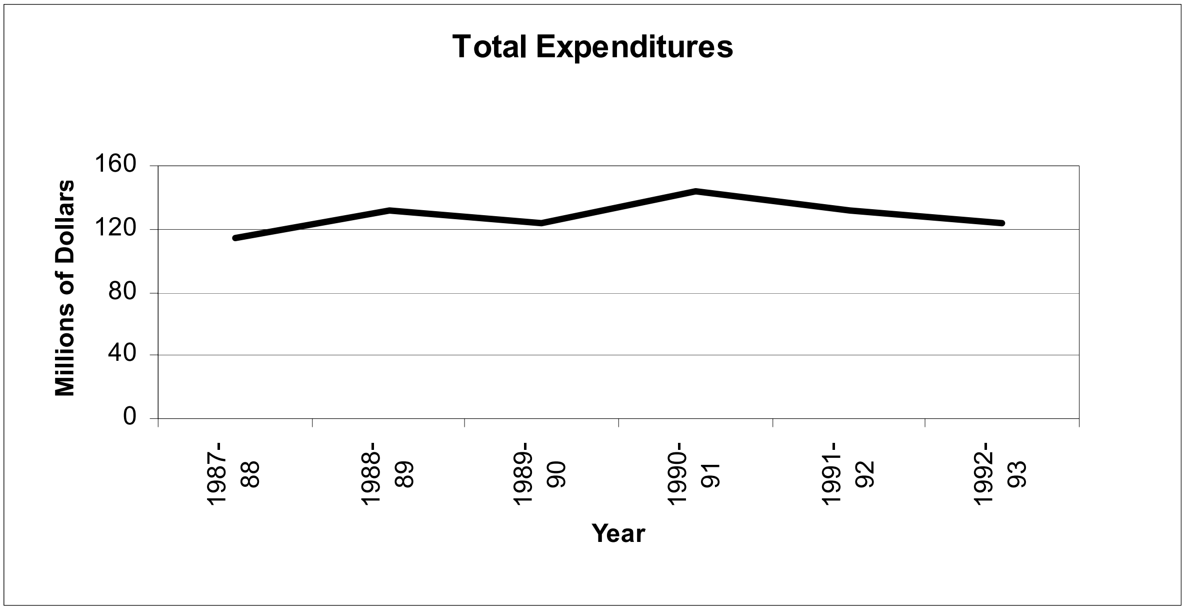
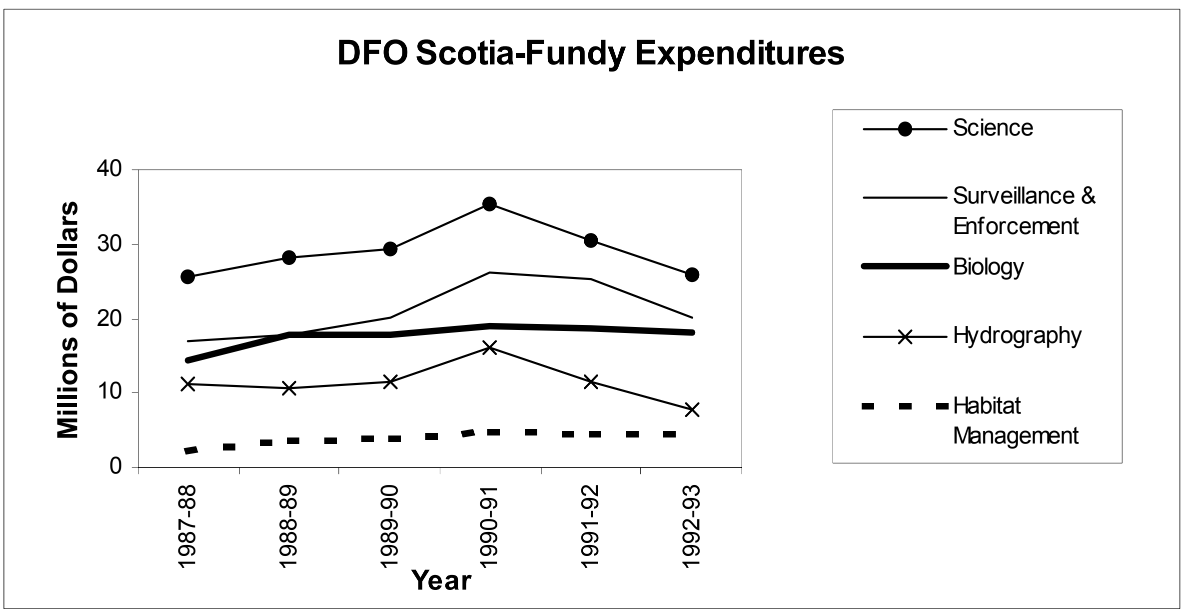


Figure 36. DFO expenditures by category, in the Scotia-Fundy region

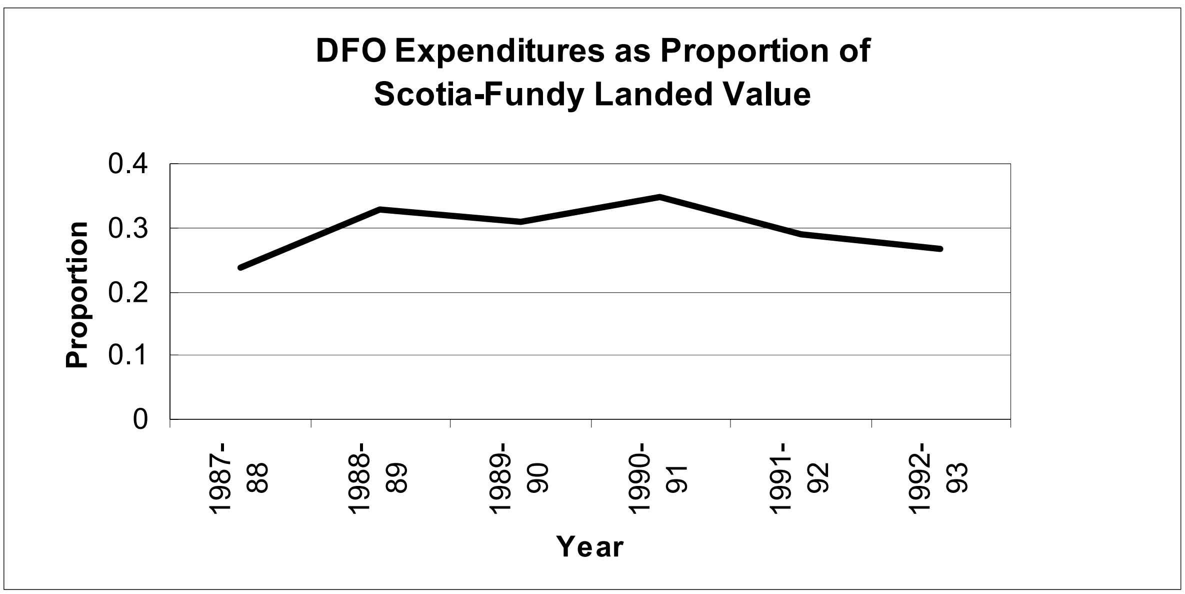


4.2. Acceptability of Institutional Resources

A certain level of institutional resources allocated to fishery management may be seen as acceptable if it produces 'good value' from a societal perspective. From a monetary point of view, this might be assessed as the ratio of total (or better, net) fishery revenue to the fishery management budget. The higher the ratio, the more 'efficient' is each dollar spent by government in producing economic benefits. However, monetary measurements alone do not account for society's intrinsic interest in learning about and protecting the ocean. Thus a more inclusive measure of the 'benefit-cost ratio' that incorporates social and environmental benefits and costs would be preferable.

The graph below – Figure 37 – provides a simple, and rather dated, view of governmental spending on fisheries and oceans, as a proportion of the total landed value of fish in the Scotia-Fundy region. Figure 37 illustrates, for example, that DFO expenditures in the Scotia-Fundy region amounted (at the time) to about 30% of the total landed value of the region's fishery. However, this is not a desirable indicator as such, both because the expenditure data represented here do not precisely match the spending on management and scientific activities, and because landed value does not fully reflect the wide range of benefits obtained from the fishery or the marine environment. Furthermore, changes in the ratio shown have at least as much to do with changing fish prices as changes in the operation of fishery management. Nevertheless, this indicator provides a preliminary sense of the more complete indicators that might eventually be developed for future monitoring of institutional sustainability.

Figure 37. DFO expenditures in the Scotia-Fundy region as a proportion of the region's fishery landed value



5. Conclusions

What we measure is a sign of what we value. Assessing how "well off" we are solely by economic growth measures, as has been the tendency in the past, omits social and environmental values from our core measures of progress. Traditional economic measures, such as fishery revenues, exports and employment remain relevant but, considered in isolation, a preoccupation with these indicators has misled us in the past, sent inaccurate and misleading signals to policy makers, and even contributed to the collapse of the Atlantic groundfishery.

By failing to include such important factors as ecosystem health, fishery resilience, and resource depreciation in past calculations, conventional accounting has given these vital factors an implicit value of zero. This failure to account for natural capital values and resource depreciation can have devastating economic consequences, as the groundfish collapse demonstrated.

While not all desirable indicators are measurable quantitatively, ecological, social, economic, community and institutional variables that enhance sustainability and promote long-term prosperity at least deserve qualitative valuation if we are to preserve our natural wealth and maintain a viable fisheries sector and a healthy marine environment.

Assessing and predicting the well-being and sustainability of fishery and marine environmental systems is an important challenge for society, particularly in a region like Atlantic Canada. This report describes one approach to this challenge, the creation of a set of quantitative indicators that can be monitored and used on a regular basis to assess progress toward the sustainable development of the fisheries and the marine environment.

While the original (naïve) goal of this effort may have been to produce an ideal set of such indicators, the reality of limitations of time, financial resources and access to data altered the objective. The goal ultimately became one of providing an admittedly imperfect prototype to indicate what might be achieved if government departments, academic institutions, NGOs and users of the ocean environment were to work together to develop and maintain a set of 'Fishery and Marine Environment Accounts' – a comprehensive set of indicators to monitor our 'genuine progress' in the marine sector.

What, then, was produced in this process? A very wide-ranging set of ecological, socioeconomic and institutional indicators has been examined in this report. For most of these, time series are available, giving trends over time in each of the indicators. For others, quantitative information was available only for a single point in time, or not at all, in which case the indicator has been discussed in qualitative terms. The full set of indicators discussed in this report is listed below.

Ecological Indicators

Primary Commercial Species
- Fishable Biomass
- Catch Levels
- Size at Age
- Condition Factor
- Age Structure

Non-Target Species
- Discard Rates
- Right Whales: Population and Reproduction

Resilience and Biodiversity
- Shannon-Weiner Index
- Area of Bottom Habitat Impacted

Marine Environmental Quality
- Organochlorine Contaminants in Seabird Eggs
- Contaminants in Mussels
- Area of Shellfish Closures

Socio-Economic / Community Indicators

Economic Valuation of Fishery Resources and the Marine Environment
- Total Landed Value
- Fishery Gross Domestic Product (GDP)
- Value of Fishery Exports
- Employment per unit of Landed Weight
- Employment per unit of Landed Value
- Market Price
- Natural Capital (Fish Stock Value)
- Annual Depreciation (or Appreciation) in Natural Capital
- Value of Marine Ecosystem Services

Distributional Indicators
- Distribution of Access and Catch among Fishers within a Fleet Sector
- Distribution of Catch among Fishers within a Fishery
- Distribution of Landed Value by Vessel Length

Resilience
- Debt Levels among Fishers
- Reported Bankruptcies
- Bankruptcy Liabilities
- Distribution of Landed Value across Species
- Proportion of Fishers with Multiple Licenses
- Age Distribution of Fishers
- Diversification of Employment Sources

Value of Aquaculture Production

Employment in the Aquaculture Sector

Workplace Safety
- Accident Claims Registered per 1000 Fishers
- Accident Claims Compensated per 1000 Fishers

Institutional Indicators

Sufficiency of Institutional Resources
- Total Expenditures
- Distribution of Expenditures by Category

Acceptability of Institutional Expenditures
- Expenditures as a proportion of Landed Value

What can we conclude about Nova Scotia's fisheries and marine environment from the above set of indicators? First, it does not seem possible to draw a simple conclusion about the current situation – one cannot conclude that all is healthy, or in crisis. The results present a picture of complexity, with some indicators at low levels, while others are stronger, and many others showing no clear trend over time. This reinforces the need to look at each indicator individually and to understand its particular nuances, and it highlights the hazard of merely ‘summing up’ to aggregate a set of disparate measures. (For that reason, too, the Nova Scotia GPI is developing each component of the index separately, with no attempt to rush towards a “bottom line” GPI.)

As suggested at the outset of this report, most readers will likely have found by this point that one or more of the above indicators may not have been handled in this report as might have been desired. Perhaps existing data sources were not located, or data were misinterpreted, or there was some other shortcoming. That is bound to be the case in a new initiative such as this.

In addition, there are various indicators that, while potentially of considerable use in assessing fisheries and the marine environment, were not addressed in this report. For example, indicators that may be useful to examine for possible inclusion include (a) the harvest level relative to conservationist levels, (b) the spatial extent of protected areas (refuges from harvesting), (c) the concentration of wealth in the fishery, (d) the level of priority placed on sustainability in management institutions, and (e) the level of co-operation and sharing of power with fishing communities.

These shortcomings and limitations (which arise as well in the other components of the Genuine Progress Index) reflect the fact that any set of indicators can only be proposed on a tentative basis; the set in this report is certainly of a preliminary nature. Further work is needed to determine what constitutes a ‘sufficient’ set of indicators, and to determine the feasibility of measuring each indicator under varying circumstances. The effectiveness of any measure of well-being and sustainability must be judged over the course of time. This is an ongoing process that requires a participatory and interdisciplinary approach, one that includes as broad a base of contributors as possible.

It is hoped that this prototype set of accounts can be further developed through such a process, and implemented on a regular basis in the very near future. To this end, **GPI***Atlantic* invites feedback and improvements in methodologies, data sources and indicator selection. Indeed, there is an open invitation to add new indicators to the list discussed in this report. Despite the considerable work that remains to be done in the development of natural resource accounts and of the GPI as a whole, the exclusion of vital social and environmental realities from our core measures of progress leads to far greater problems and policy failures. There is no reason not to begin measuring what we value and to bring these measures into the policy arena without delay. A carefully formulated GPI analysis can assist decision-makers greatly in distinguishing between the real costs and benefits of different management options. Surely this is a key policy goal – to ensure that our natural resources are used in a sustainable manner that benefits citizens, their communities, and the natural environment both now and in the future. The GPI fisheries and marine environment accounts are intended as a starting point in that endeavour and as a contribution to that process.

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APPENDIX A
SUSTAINABILITY INDICATORS: BACKGROUND AND METHODOLOGICAL CHALLENGES

The indicators described in this document address both well-being and sustainability of the fishery and the marine environment. While perhaps all the indicators relate to well-being, not all are 'sustainability indicators.' The latter is a term that has become popular based on the great worldwide interest in measuring and assessing the nebulous aspects of 'sustainability.' This appendix discusses some of the underlying issues relating to such *sustainability assessment*, and examines what actually constitutes a sustainability indicator.

One of the most fundamental ideas underlying discussions of fisheries is the *sustainable yield* – a harvest that can be taken today without being detrimental to the resource available in future years. In many fisheries world-wide, there has been a focus on determining a sustainable yield in the form of a Total Allowable Catch (TAC). One option is to choose the 'maximum sustainable yield' (MSY) – the most fish that can be caught each year, year after year – although lower catch levels may be chosen in practice to balance the variety of fishery objectives better. Fishery science has evolved as a *science of sustainability*, with a focus on determining sustainable yields.

However, it has become apparent, particularly in recent times, that a focus on sustainable yield has a major shortcoming in its sole focus on the physical *output* from the fishery. While the calculation of an MSY harvest level can provide a useful indicator of the upper limit that must be placed on fish stock exploitation, through balancing of present and future catches, there is more to a healthy future than simply a large fish stock. This realization has led to the broadening of fishery discussions to examine what is needed for *sustainable fisheries* (National Research Council 1999). This broadened perspective implies that attention must be paid to the health of the aquatic ecosystem, to the integrity of ecological interactions, and to the state of the human system.

Such a holistic approach also fits within the framework of *sustainable development*. This implies the need to view sustainability in a broad and integrated manner, including ecological, economic, social and institutional aspects. Sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987) or as "the persistence, over an apparently indefinite future, of certain necessary and desired characteristics of the socio-political system and its natural environment" (Robinson *et al.* 1990).

The concept of *resilience* is critical to meaningful discussions of sustainability. A resilient system (Holling 1973) is one that can absorb and 'bounce back' from perturbations (shocks) caused by natural or human actions. The idea of resilience was first formulated with ecosystems in mind, but is just as relevant elsewhere in the fishery. For example, resilience is important to fishing communities, where it implies a capability to persist in a healthy state despite changes in the state of the natural system and the socioeconomic environment. The management system must be designed with resilience in mind so that if something unexpected happens (as is bound to be the case from time to time), the management system can still perform adequately.

A key element of progress toward sustainability and resilience is the development of quantitative methods for assessing and predicting these attributes. Despite much discussion on how these can be measured, very little has been applied in practice in an integrated manner to fishery and marine systems. That is a key motivation for the present report.

Methodological Challenges

A "Bottom Line" Index of Sustainability?

Suppose that a set of indicators has been developed for a fishery and/or marine system. Certainly, these indicators provide some insight into whether sustainability seems to be present or absent, where the conditions seem 'healthy' or otherwise. But can we determine from this whether or not the system as a whole is sustainable? Is it possible to summarize in a single number the 'level' of sustainability for the fishery, or the 'health' of the marine environment? To accomplish this, it would be necessary to aggregate the indicators into an overall 'bottom line' index. Assuming a quantitative value has been determined for each indicator, *weights* might be selected for each, and the weighted values combined in a suitable manner to form a single number, the desired "index."

But is this reasonable? Such a single index would need to reflect a judgement of the balance among the components, yet ecological, socioeconomic, community and institutional sustainability are fundamentally different items driven by different and sometimes contradictory forces. While sustainability assessment does provide a means to examine the implications of inescapable trade-offs between criteria, it seems reasonable that the trade-offs should be a *political* matter, not one to hide within a single bottom line index.

Indeed, a single bottom line number has limited utility for policy makers, who cannot use that number to assess relative strengths and weaknesses in the fisheries sector or to determine where action is needed. Instead, a disaggregated index, in which the different components are clearly identifiable, allows policy makers to identify priorities and needs more readily. For all these reasons, the Nova Scotia Genuine Progress Index and its components focus on fleshing out the complex details and making transparent the individual indicators rather than attempting to aggregate the results into a single number or "bottom line."

Validation of Sustainability Indicators

To what extent is a set of quantitative sustainability indicators useful in practice? This question relates to the task of *validation*. Unfortunately, it is not possible, given the nature of sustainability, to prove *a priori* that a given set of indicators will properly *predict* whether or not a given system will be sustainable. The best we can hope for is that the set of indicators is widely regarded as reasonable and "indicates" or "points towards" underlying realities. In any case, there will always be some uncertainty about the utility of sets of indicators, since quantification of sustainability inherently requires projections into the future. Indicators are by definition a simplification of complex and interconnected realities and must therefore always be used with caution.

Sustainability versus Stability

A key difficulty in assessing sustainability lies in differentiating between apparent stability and long-term sustainability. Given natural cycles and environmental influences, it is difficult to determine whether a fishery is 'stable.' But it is even more difficult to assess sustainability, since we cannot conclude that an apparently stable fishery is sustainable. Equilibrium is not a sufficient condition for sustainability.

Furthermore, stability is not necessarily a desirable situation. More important is the system's *resiliency*, as discussed above. Thus a key element of sustainability assessment is to understand the consequences of change, and to assess whether essential characteristics of the current system will survive that change.

Sustainability versus Non-sustainability.

It is likely more straightforward to assess a fishery system's 'non-sustainability' than its sustainability. A non-sustainable system tends to display high levels of stress on certain aspects of the system, such as a precipitous drop in fish biomass, a decay in the infrastructure within fishery-dependent communities, or an inability of the management institutions to cope with pressures upon them. There may be sufficient resilience in a stressed system to overcome these problems, but in general, the greater the stress, the greater the tendency to non-sustainability. In contrast, if a fishery system has reached a sustainable state, it is less likely to be under significant stress. This implies that it may be more feasible in practice to develop indicators of non-sustainability than of sustainability, and then to infer the latter indirectly from an examination of the former.