MEASURING SUSTAINABLE DEVELOPMENT

APPLICATION OF THE GENUINE PROGRESS INDEX TO NOVA SCOTIA

FISHERIES AND THE MARINE ENVIRONMENT IN NOVA SCOTIA: SEARCHING FOR SUSTAINABILITY AND RESILIENCE

by

Anthony Charles*
Chris Burbidge*
Heather Boyd
Amanda Lavers

*Saint Mary's University
Halifax, Nova Scotia, B3H 3C3
Canada

January 2009

A. Charles, C. Burbidge, H. Boyd and A. Lavers. 2009. *Fisheries and the Marine Environment in Nova Scotia: Searching for Sustainability and Resilience*. GPI Atlantic. Halifax, Nova Scotia. Web: http://www.gpiatlantic.org/pdf/fisheries/fisheries_2008.pdf

TABLE OF CONTENTS

Executive Summary

While conventional measures of marine resource industries, such as Gross Domestic Product (GDP) and employment, have been used as the basis for making decisions about management of fisheries and other marine uses, these measures overlook important aspects of fishery systems and the marine environment. The danger in relying too heavily on these measures is that they can send misleading signals to managers and policy makers. Atlantic Canada was 'ground zero' for what is perhaps the most widely used example of the shortcomings of traditional economic measures in renewable resource industries; the collapse of the once lucrative groundfish fishery (for cod and similar bottom-dwelling species) in the 1990s. The stability and high value of the fishery GDP through the 1980s (see Figure 1), along with the growing employment levels in the industry during this period (see Figure 15), did not warn of the declining health of the groundfish stocks and the impending collapse of the fishery.

Resilience reflects the ability of a fishery or a marine ecosystem to bounce back from shocks and to maintain its healthy state. It is, thus, a highly desirable attribute – both in ecological systems (in which genuine progress is assessed by the capacity of the ecosystem to maintain its "health" over time) and in human systems (in which resilient socioeconomic sectors and communities are able to bounce back from dramatic changes in their natural resource base, the economy, and social conditions). Multiple attributes are required to make a fishery resilient. Indeed, *diversity* in the larger sense has been identified by observers as key to resilience in human communities, just as biodiversity is a key indicator of ecosystem resilience.

If we are to have sustainable and resilient fisheries and a healthy marine environment in Nova Scotia, we require a more in-depth understanding of their ecological, socioeconomic and institutional components and the interactions between them. This report, part of the *Nova Scotia Genuine Progress Index (GPI) Fisheries and Marine Environment Accounts*, helps to fulfil this need by offering indicators that can and should be monitored and applied on a regular basis to evaluate the wellbeing and sustainability of fisheries and the marine environment.

Nine key indicators that measure ecological, socioeconomic and institutional aspects of Nova Scotia's fisheries and marine environment are highlighted in this report. The majority of the indicators presented here appeared in the original (2002) *GPI Fisheries and Marine Environment Accounts* report, but have been updated to illustrate recent trends. This report also includes newly developed indicators designed to measure additional aspects of Nova Scotia's fisheries and marine environment.

Ecological Indicators

The ecological indicators in this report measure various aspects of Nova Scotia's fisheries and marine environment ranging from the health of commercial fish stocks and of non-fished species to the state of marine food-webs and water quality. Some key findings from these ecological indicators are presented here.

- Groundfish stocks in the Eastern Scotian Shelf region off Nova Scotia are used as an indicator of fish stock size and value. Overall, fish abundance has decreased substantially since the 1980s. The cod biomass shows no sign of recovery, while the haddock and pollock stocks show limited recovery. Furthermore, the value of the groundfish stocks in the Eastern Scotian Shelf region has decreased since the late 1980s, signifying a depreciation of natural capital. Despite modest increases in the value of the haddock and pollock stocks in the 1990s and 2000s respectively, the value of all groundfish stocks in the region remains low compared to the historically high levels of the mid- to late-1980s.

- Lobster landings have increased nearly five-fold since the 1970s. This leads to a perception that lobster stocks are healthy, but increased levels of fishing effort on lobster may have contributed considerably to the increased catches since 2001. Most recently, in 2007, lobster landings in Nova Scotia suddenly dropped to 70% of the 2006 record level, returning to the lower levels of the 1990s.

- The size of fish, at a given age, for some finfish stocks around Nova Scotia has remained relatively stable over time, while other stocks show either increasing or decreasing trends over the past 10–15 years.

- There has been a steady decline in the mean trophic level of the species landed in Nova Scotia's fisheries since the mid-1980s. As species at the top of the marine food web have been depleted, lower trophic level species (those lower on the food chain) are now the primary target and source of revenue in Nova Scotia's fisheries.

- Two species groups, marine mammals and sharks and rays, have experienced substantial population declines in Atlantic Canada. The mortality rate and the birth rate of the highly endangered North Atlantic right whale population have both increased since the previous (2002) report. The increased birth rate is insufficient to counter the rate of population decline, and the population is now in even greater jeopardy.

- The number of shellfish closures in Nova Scotia has increased steadily since 1940, and has more than doubled since 1985, indicating a decline in marine environmental quality.

Overall, the results are cause for concern with respect to the state of Nova Scotia's marine ecosystems. Unsustainable fishing practices have depleted fish stocks, some of which show little or no sign of recovery. The structure and function of marine food-webs have been altered and populations of many large predators at the top of the food chain have been severely depleted. Marine biodiversity in the region is under threat from human activity, with some species facing extinction. Finally, marine water quality has deteriorated. With Nova Scotia's fisheries and marine environment being the backbone of many of the province's largest industries, bringing in millions of dollars in revenue for the province each year, a deterioration in the ecological health of the marine environment will undoubtedly have a negative impact on the province's economy and society as a whole.

Socioeconomic and Institutional Indicators

The socioeconomic indicators in this report include conventional measures of the social and economic conditions related to fisheries and the marine environment, such as employment and GDP. As previously noted, these measures can be used to identify broad socioeconomic trends, but overlook many important social and economic aspects that are fundamental to building sustainable and resilient communities. In response, this report highlights the importance of *resilience and diversity indicators* and provides an example of one such indicator, the age structure of Nova Scotia fishers. Some key findings from the socioeconomic indicators include:

- The number of fishers employed in Nova Scotia decreased greatly from the highs experienced in the late 1980s and early 1990s to much lower levels later in the 1990s following the collapse of the groundfish fishery. After 2001, the number of fishers rose somewhat, then fell again, and certainly has not returned to the pre-collapse levels.

- Nova Scotia's fishery GDP was steady at high levels for several years up to the time of the groundfish collapse (thereby masking the underlying decline in the ocean's natural capital). Between 1992 and 1995, following the collapse, the fishery GDP decreased by almost half. After 1995, the fishery GDP increased again and by 2006 it had grown to nearly 80% of the 1992 level.

- In considering the age profile of the province's fishers, the proportion of middle-aged fishers has remained relatively stable, but the proportion of older fishers has increased since 1931, while the proportion of younger fishers has decreased.

The results for the conventional socioeconomic measures, fishery employment and GDP, require careful interpretation. As noted above, high GDP levels can easily mask underlying problems in the ocean's fish stocks and natural capital. With regard to fishery employment, the key is to compare current levels not only to the higher levels of the late 1980s and early 1990s, but to sustainable levels. It is possible that to a certain degree, lower levels of employment today are desirable because they represent an adjustment in the fishery to a more sustainable level. On the other hand, lower employment can also come as the result of mis-guided policy measures that shift the fishery away from a more labour-intensive small-boat fleet. Thus it is important to carefully assess employment trends. The other indicator in this category, the age structure of Nova Scotia fishers, suggests an aging fishery – a worrisome trend that brings into question the socioeconomic resilience of the fishery.

Good governance of fisheries and the marine environment provides the foundation for resilient ecosystems and communities. Governance institutions must be able to adapt to changing economic, social and environmental conditions to remain viable in the long-term. However, it is very difficult to obtain the data to properly assess the effectiveness of fishery institutions. In this report, we use a simple measure – changes in the annual expenditures by institutions responsible for fisheries and oceans governance in Nova Scotia – as a preliminary indicator. This is not an ideal indicator, as it is not even clear whether a downward or upward trend in such expenditures is desirable, and certainly monetary measures alone are unlikely to provide an adequate measure of good governance. This being said, the results are as follows:

- Expenditures by the federal Department of Fisheries and Oceans in Nova Scotia declined in the second half of the 1990s, jumped substantially in 2000, and then decreased steadily in the subsequent years covered in this analysis (2000–2003).
- Provincial Department of Fisheries and Aquaculture expenditures show an overall increasing trend since 1996.
- Both federal and provincial government expenditures as a proportion of the landed value of Nova Scotia fisheries have decreased over time.

As noted, the results of this indicator are difficult to interpret. There is a clear need to develop additional measures that provide a comprehensive picture of progress towards good governance of Nova Scotia's fisheries and marine environment.

What, then, is the "bottom line" message about the current state of Nova Scotia's fisheries and marine environment arising out of the key indicators described in this report? Before drawing some conclusions, we note that each indicator tells a story, and there is a need to assess and understand the particular nuances of each story; it makes no sense to merely "sum up" results across all of the indicators. Furthermore, we cannot expect that all the indicators will point in the same direction—for example, as we have seen, what is true of one fish stock does not necessarily hold for all. Some indicators point to low or no levels of sustainability, others illustrate a strong trend in the right direction, and many others show no clear trend over time. Thus, the overall picture is a complex one, and we must be cautious in interpreting the results.

Having said this, there are some crucial features in the results here that raise significant concerns. First, consider the ecological perspective. For the particular fish stocks examined, the indicators show clear examples in which biomass, natural capital (value) and fish condition (size) do not reflect sustainable management. Furthermore, in marine ecosystems, (1) ecological resilience is threatened as Nova Scotia "fishes down the food chain" with the catch focusing on decreasing trophic levels, (2) several marine species at risk remain in danger of extirpation or extinction, and (3) deterioration in marine environmental quality is illustrated through increasing shellfish closures. This is not a positive situation in terms of ecological trends.

From the socioeconomic perspective, there are also some negative signals concerning resilience of Nova Scotia's fishery, with a major shift in the age structure of the fishing population (fewer young, more older fishers). There are also concerns about equity in the fishery, as indicated by a comparison of two indicators: a decrease in employment and a rising fishery GDP. This means fewer Nova Scotians are sharing the growing monetary output from the fishery.

Finally, we note that producing a multi-dimensional indicator framework such as this can help identify fisheries and marine concerns in a comprehensive way that can lead to timely policy and action. This points to the need to institutionalize a regular monitoring system that incorporates a wide variety of indicators such as those in this report. This is imperative if we are to move toward genuinely sustainable and resilient fisheries and marine environments in Nova Scotia.

For the original (2002) GPI Atlantic report on fisheries and the marine environment, please see the following:

The Nova Scotia GPI Fisheries and Marine Environment Accounts (2002)
http://gpiatlantic.org/pdf/fisheries/fisheries.pdf

Acknowledgements

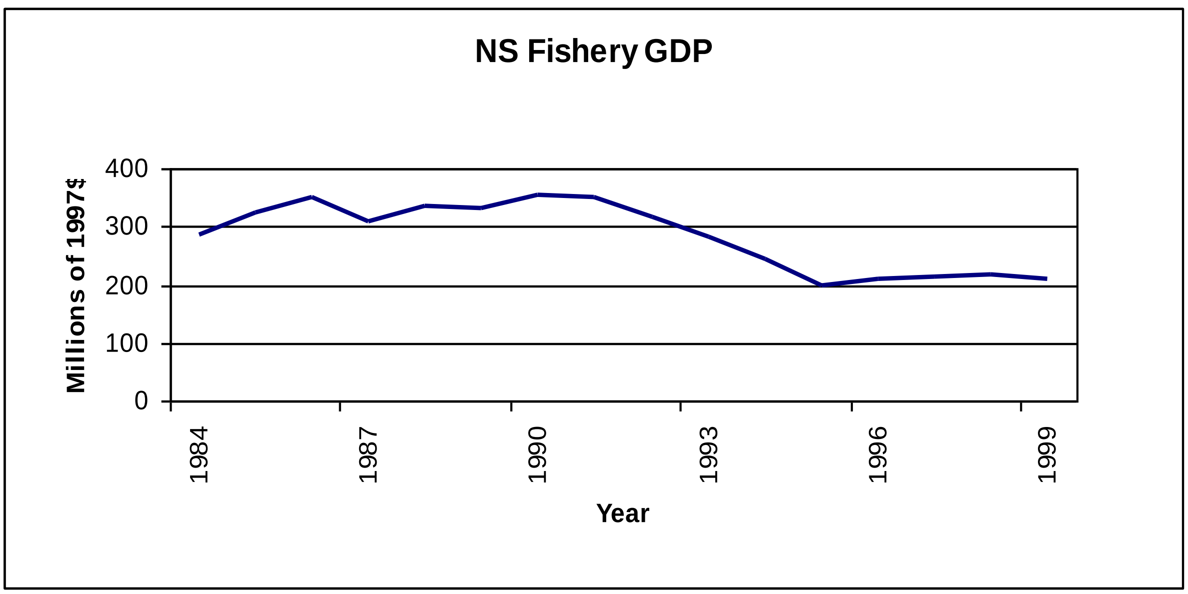
The authors of this report are grateful to Ronald Colman, Director of **GPI***Atlantic*, for his support for this work and for providing helpful comments on earlier versions. We also thank Cheryl Benjamin, Karen Hayward, Vanessa Hayward, Ryan Patey and **GPI***Atlantic* for help in preparation of this report. Charles and Burbidge acknowledge financial support from the Natural Sciences and Engineering Research Council of Canada. Any errors or misinterpretations, and all viewpoints expressed, are the sole responsibility of the authors and **GPI***Atlantic*.

1. Introduction: why we need new indicators for fisheries and the marine environment

In the late 1980s, Nova Scotia's fishery for cod and other groundfish seemed to be booming. The media reported steadily large catches, high exports, and strong contributions of the fishery to the province's Gross Domestic Product (GDP), the conventional measuring stick of the economy. Figure 1 shows that, between 1984 and 1991, the fishery GDP appeared strong and relatively stable, at values between $285 and $356 million (in 1997 dollars) (Nova Scotia Department of Finance 2001).

However, over that time period, 'behind the scenes', fish stocks were dropping, and by 1992–1993, many fisheries were collapsing, and the fabric of coastal communities began to unravel. The fishery GDP, which had stayed at high levels right up to the time of the collapse, dropped to around $200 million by 1995 (in 1997 dollars). Our conventional economic measuring sticks, notably the fishery GDP, but also other measures such as catches and exports, did not warn of the impending disaster. These measures counted only what we took out of the sea but gave no value to what we left behind. 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, a healthy ecosystem, strong fishing communities, and a sustainable fishing economy.

Figure 1. Fishery GDP ($1997 millions), Nova Scotia, 1984–1999



Source: Nova Scotia Department of Finance (2001).

Note: This graph, which appears in Charles et al. (2002), is shown here to illustrate Nova Scotia's fishery GDP up to the fishery collapse. More recent trends in Nova Scotia's fishery GDP are shown in Figure 16 below.

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 (if we use conventional measures), because cleaning up the mess causes money to be spent, producing an overall positive effect on economic indicators such as GDP. Yet, as with the collapse of fish stocks, we know that oil spills really represent a decline in wellbeing and sustainability, not an increase in prosperity as our conventional measures imply.

If healthy fisheries and protection of the marine environment are important to us, we clearly need a set of measures that better reflect the reality of what we value and that assess the wellbeing 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 would also send early warning signals to policy makers that could trigger timely remedial action, thus potentially avoiding disasters like the collapse of the groundfish stocks.

Such genuine indicators of fishery and marine environmental health 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 wellbeing of the communities that depend on the ocean for their livelihood, and the effectiveness of the institutions that govern fishing activities and ocean use. In other words, an appropriate set of indicators will allow us to assess more comprehensively the entire fishery and marine "system" (Garcia and Charles 2008).

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. This is particularly so for a region like Atlantic Canada, given the area's historical dependence on the ocean, and given the region's recent hard experience. Perhaps more directly than in other parts of the country, Atlantic Canada has learned the hard way—through the 40,000 jobs that were lost when the groundfish stocks collapsed in 1992—that the conventional "jobs versus environment" debate is a myth, and that when our natural resource health declines, we lose jobs. We urgently need measures that properly account for the value of our natural, human, and social capital (and that monitor their depreciation), just as we presently account for produced capital.

The *Nova Scotia GPI Fisheries and Marine Environment Accounts* have been developed as a response to this challenge. The GPI accounts and their corresponding indicators can and should be monitored and applied on a regular basis to evaluate wellbeing and sustainability of fisheries and the marine environment. Indeed, each indicator in the accounts is selected to measure one of the fundamental components of wellbeing and sustainability that must all be simultaneously achieved in a process of sustainable development (Charles 2001). Together, the indicators cover crucial aspects of the marine system, including ecosystem health, socioeconomic progress, the wellbeing of coastal communities, and the institutional integrity of fishery and ocean management. Together, the indicators demonstrate clearly that these environmental, economic, social, and institutional dimensions of sustainability and wellbeing are inextricably linked.

The preparation of this report was motivated by **GPI***Atlantic*'s *2008 Genuine Progress Index for Nova Scotia*, which presents the most recent available information on all 20 components of the Nova Scotia GPI - from trends in health, crime, education, wealth, income, economic security, employment, and volunteer work to greenhouse gases, air pollution, fisheries, forests, transportation, energy, waste management, agriculture, and water quality.

This report, therefore, presents a set of key indicators that highlight crucial aspects of the GPI fisheries and marine environment accounts, and that include ecological, socioeconomic, community, and institutional indicators. The majority of the indicators presented here appeared as well in the original *GPI Fisheries and Marine Environment Accounts* report (Charles et al. 2002) but have been updated to illustrate recent trends. In addition, this report includes newly developed indicators designed to measure novel aspects of fisheries and the marine environment.

Although the indicators in this report represent the most current set of salient measures that has been developed to date on Nova Scotia's fisheries and marine environment, it should be noted that a full and more comprehensive suite of indicators is actually required to measure all of the multiple dimensions that contribute to sustainable use of marine resources, healthy ecosystems, and resilient coastal communities. Therefore, the present report can be read in conjunction with the previous report (Charles et al. 2002), which contains additional sets of indicators that could be included in a full monitoring program.

2. Fish in the sea: measuring the quantity and value of fish stocks

The benefits of fisheries have traditionally been accounted for using measures of catches, landed value, and exports. 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 while 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 misused as indicators of progress and sustainability. Therefore, to fully account for the benefits of a given harvest, these measures must be accompanied by a measure of the change to the fish stocks *remaining in the ocean* after the fishery has taken place. Here, we examine these changes from both biological and "ecological economics" perspectives. The former is addressed through biomass trends in commercial fish stocks, while the latter is examined by translating biomass into monetary values, for comparison with traditional economic measures.

This approach and understanding reflects 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, such as the fish available for harvesting, are obvious, while other benefits, such as the habitat provided for non-target species, may not be directly apparent to humans. Given the inter-dependence of all components of the marine ecosystem, however, it is prudent to recognize the indirect benefits as well. All of these marine assets clearly have significant and real value—they keep the fishery functioning, among other roles, and it is important to monitor how they change over time if we are to assess accurately the actual economic health of the fishing industry.

By valuing both the quantity and quality of a natural resource stock, the GPI accounts can provide a more accurate and comprehensive measure of fishery strength and health than a current income accounting system that mistakenly counts 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.

Although, for this analysis, natural capital has been expressed in monetary terms, it must be acknowledged that there is no general agreement on how to measure these assets accurately. Indeed, some natural assets are truly "invaluable" and irreplaceable, thus, not conducive to quantitative valuation.[1] Nevertheless, the policy arena is so dominated by budgetary considerations that valuation—particularly in monetary terms—is an important strategic tool to ensure that attention is paid to the sustainability of our natural wealth as economic policies are being shaped, and in particular, to ensure that changes in natural capital are not ignored, as has happened in the past.

[1] 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,* GPI Atlantic. Halifax. August, 2001, pp.106-108. (http://www.gpiatlantic.org/pdf/greenhouse/ghg.pdf). Accessed 8 October, 2008.

The task of assessing the value of 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. In particular, while determining the total value of natural assets in the sea should take into account how an adult fish living today will (through reproduction) contribute to fish stocks in the future, measuring this future contribution is difficult due to uncertainties about the dynamics of reproduction. For this reason, a major simplification is made here: we measure the monetary value of natural capital in a given year simply as a product of the estimated fish biomass and the price of fish (in constant dollars).

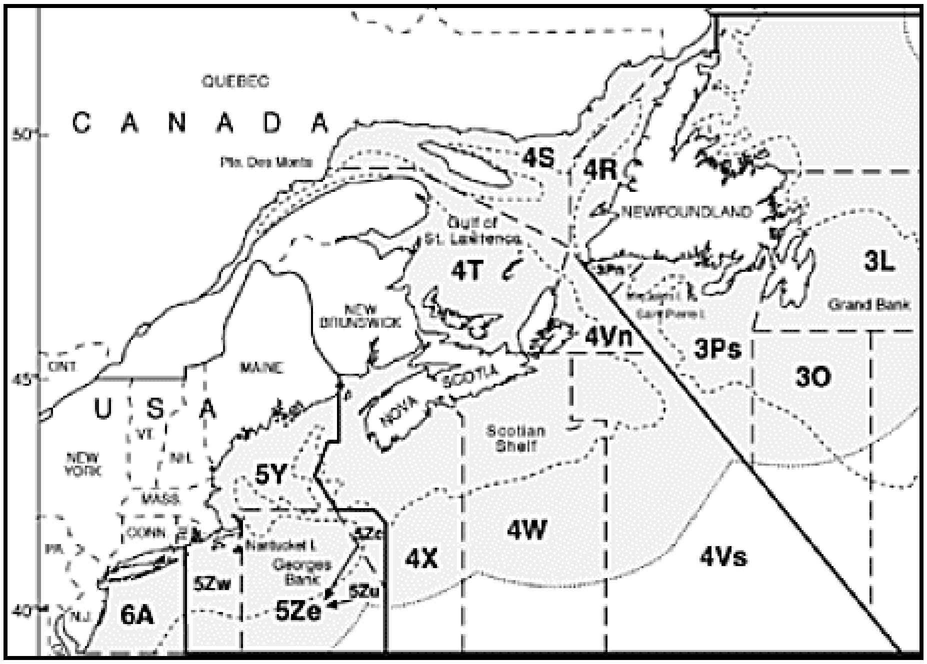
Thus, the proxy for natural capital used here is the current market value of fish in the sea—the total revenue that could theoretically be obtained if every fish were caught and sold that year. On the one hand, this over-estimates the market value of those fish to society, since the *costs* of catching the fish are not deducted. On the other hand, as noted above, this method of calculation also tends to seriously under-estimate natural capital in that it does not account for a fish stock's contribution to ecosystem services, or its ability to reproduce and thus produce an ongoing flow of benefits over time beyond its own immediate value.

If market prices do not change, and if fish biomass is maintained from one year to the next, a similar level of natural capital (as measured here) can be expected each year. On the other hand, natural capital will decline if either the price or the biomass decreases. In general, therefore, natural capital will vary over time in response to both 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, local and export market demands, and scarcity.

Here, we examine the stocks of two groups of commercially valuable species that inhabit the waters around Nova Scotia. The first group consists of bottom-dwelling (benthic) fish known as "groundfish"—specifically cod, haddock, and pollock. The second species examined is lobster, a highly valuable benthic shellfish.

Before the value of the fish remaining in the ocean can be measured, we first must know their abundance. 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 stocks. The federal Department of Fisheries and Oceans (DFO) annually publishes biomass estimates for many marine species in the waters surrounding Nova Scotia. Fish stocks in Nova Scotia are defined using the fishing zones designated by the Northwest Atlantic Fisheries Organization (NAFO) (Figure 2).

Figure 2. Partial map of Atlantic Canada, focused on Nova Scotia, showing fishing zones based on Northwest Atlantic Fisheries Organization (NAFO) statistical areas



Note: Throughout this report, indicators refer to the fishing zones shown on this map. For example, the notation 4VsW refers to fishing zones 4Vs and 4W on this map.

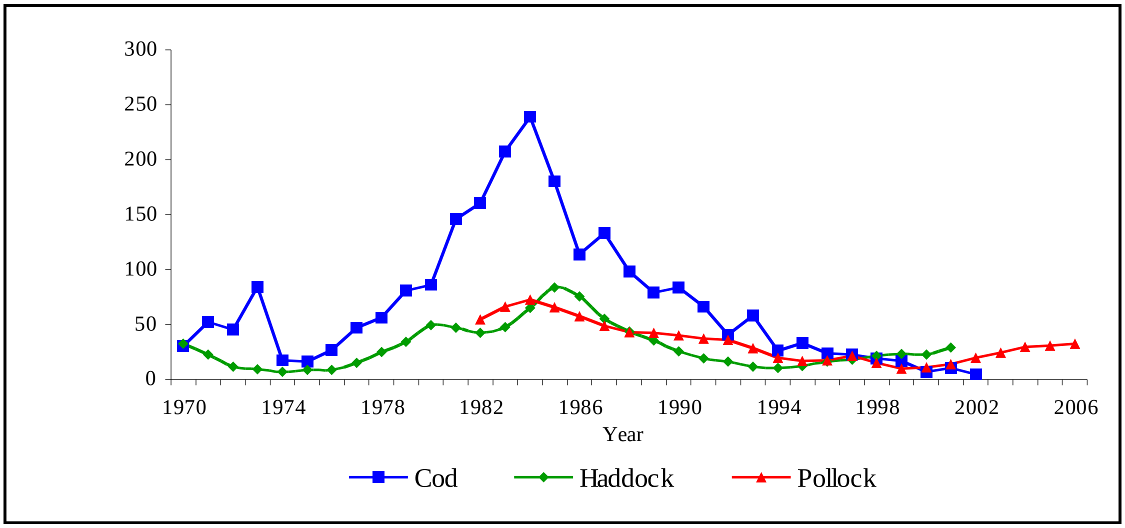
It must be noted that, while the accuracy of biomass estimates has presumably improved over time, reflecting advances in the study of marine ecology, in technological tools, and in sampling and estimation techniques, there remain many sources of uncertainty in the biomass estimates (de Young et al. 1999; Lassen and Halliday 1997). These arise due both to technical problems in the estimation process, and to variability in the biomass levels themselves, which, in turn, 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.

2.1 Groundfish

Figure 3 illustrates the declines in biomass (age 3+) for the selected groundfish species—cod, haddock and pollock—in the Eastern Scotian Shelf region since the mid-1980s. This region was chosen as a good example to illustrate groundfish biomass trends, but it must be noted that such trends vary across Atlantic Canada.

For groundfish on the Eastern Scotian Shelf, it is notable that the early 1970s was a time of very low stocks, reflecting the overfishing that took place prior to the 200-mile limit coming into effect with the Law of the Sea Convention. With what was thought to be better control over the fishery, combined with a lucky increase in recruitment of fish to the population, the biomass of the cod stock recovered rapidly into the mid-1980s. But all was not well with the cod stock, and the most recent collapse began in 1985, continuing into the 21st century. So far, the cod stock shows no signs of recovery (Hutchings 2000; Thorne 2000).

Figure 3. Biomass (age 3+) of cod, haddock, and pollock (000s of metric tonnes), Eastern Scotian Shelf, 1970–2006



Sources: Fanning et al. (2003); Mohn et al. (1998); Mohn and Simon (2002); Stone et al. (2006)

Notes:

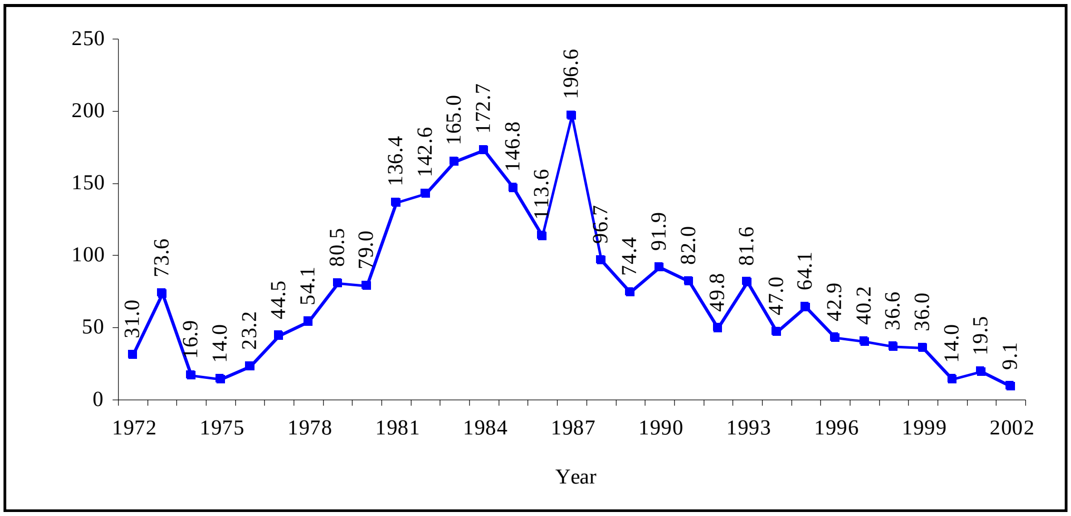
- This includes NAFO statistical areas 4V and 4W. However, data for the Cape Breton portion of this stock (4Vn) are included for years 1981–1997 only.
- See appendix for the data table.

The corresponding monetary value of natural capital embodied in the Eastern Scotian Shelf cod stock is estimated in Figure 4 below by multiplying (in each year) these biomass estimates by the price of cod (adjusted for inflation). The latter 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 level in 1999. Cod prices in the late 1990s were more than twice as high as those in the early 1980s, and have remained at these high levels (around $2,000 per metric tonne) throughout the last decade (see Appendix table 1).

The value of natural capital for cod in the Eastern Scotian Shelf region off Nova Scotia (Figure 4 below) increased through the 1980s to a peak of $200 million ($2007)[2] in 1987, but then exhibited a steady decline in value from 1987 to 2002, as the collapse of the cod stock led to historically low levels of natural capital in 2002 (the most recent year in our data). By 2002, virtually the entire $200 million value that had been present in the Eastern Scotian Shelf cod stock had been wiped out—what was left amounted to only an estimated $9 million in 2002. Perhaps the most dramatic aspect of this trend is that the decline in natural capital in cod, to the lowest on record, occurred *despite* a considerable price increase.

[2] Throughout this report, and unless otherwise noted, all dollar figures are given in 2007 constant dollars.

Figure 4. Value of cod stocks ($2007 millions), Eastern Scotian Shelf, 1972–2002



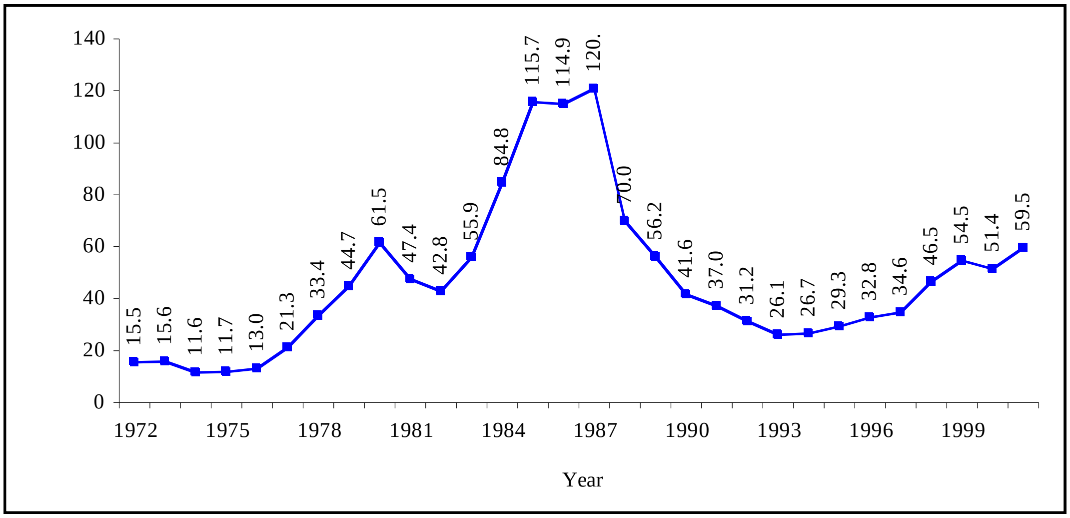
Sources: DFO (2008a); DFO (2008b); Fanning et al. (2003); Mohn et al. (1998).

For haddock, the biomass generally followed a similar path to that of cod—with a decline in the early 1970s, a recovery to a peak in 1985, and another decline to low levels by the mid-1990s (see above for an explanation of this). Thereafter, the haddock stock has followed a different path from that of cod, with a slight increase into the early 2000s (Figure 3 above), up to the end of our available data series.

Over the period during which the biomass of haddock decreased, prices increased fairly steadily from a low point in 1982 to considerably higher levels in the mid-1990s (see Appendix table 2). Since 1999, haddock prices have decreased steadily to the lowest levels (in 2004/2005) in two decades.

The haddock stock of the Eastern Scotian Shelf appreciated sharply in value from the late 1970s to an estimated value of $120 million in 1987. As haddock biomass dropped after 1985, steadily increasing haddock prices partially and temporarily compensated for this, keeping the natural capital measure high. However, the value of haddock natural capital fell dramatically in the late 1980s and early 1990s, losing 78% of its value by 1994, before beginning a slow recovery in the mid- to late 1990s. Despite continuing price increases for haddock between 1989 and 1999, however, the value of this natural capital did not recover to the high levels of the mid-1980s, and in 2001 (the most recently available data), it remained at half the level (about $60 million) of the 1987 peak year (Figure 5 below).

Figure 5. Value of haddock stocks ($2007 millions), Eastern Scotian Shelf, 1972–2001

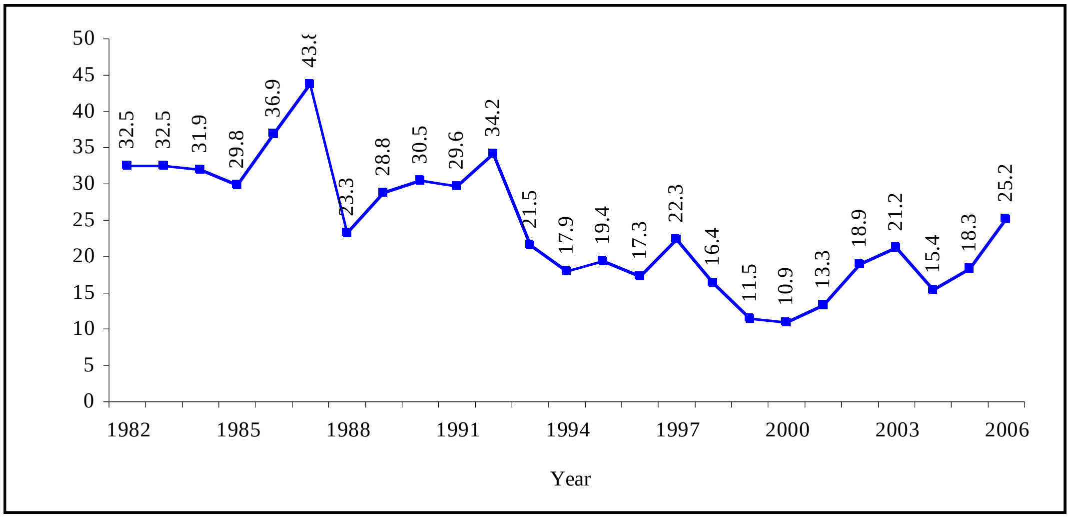


Sources: DFO (2008a); DFO (2008b); Mohn and Simon (2002).

Turning to pollock, the biomass of the Eastern Scotian Shelf stock, like those of cod and haddock (see above), was heavily depleted prior to the mid-1970s and the 200-mile limit coming into place. From then through the mid-1980s, there was an increasing biomass, followed by a long and fairly steady decline until 1999, after which the stock experienced a modest increase (Figure 3 above). As the biomass of pollock decreased between the mid-1980s and 1999, the price steadily increased (see Appendix table 3), peaking in 1999 just as the biomass reached its lowest recorded level. The price of pollock then dropped sharply between 1999 and 2004 (by more than half, or over $600 per metric tonne), coinciding with some recovery in the fish stock. Since 2004, the price of pollock has increased to about $800 per metric tonne, or about two-thirds the peak 1999 value.

Figure 6 shows the estimated natural capital value of the Eastern Scotian Shelf pollock stock—which again is the product of both biomass and price levels. Overall, there is a remarkable long-term depreciation in the value of the pollock stock between 1987 and 2000—coinciding with the declining stock biomass, though with increasing prices over the same period helping to counter and ameliorate the effects of decreasing stock biomass on the stock's overall value. The increased stock biomass since 2000, in tandem with the increased price of pollock since 2004, has resulted in recent increases in the value of this stock. Thus, the stock value plummeted from an estimated peak value of $44 million in 1987 to a 2000 low point of $11 million, before partially recovering to $25 million in 2006—reflecting a loss of $19 million in value compared to the 1987 peak.

Figure 6. Value of pollock stocks ($2007 millions), Eastern Scotian Shelf, 1982–2006



Sources: DFO (2008a); DFO (2008b); Stone et al. (2006).

While many groundfish stocks around Nova Scotia have declined since the mid-1980s, many other species, especially shellfish, have not. Shrimp, for example, appear to have increased in biomass since 1995 (Koeller et al. 1999). As well, if the steady increase in lobster landings is any indication, as seen in Figure 7 below, lobster biomass from Nova Scotia appears to have increased remarkably since 1980, with 2006 landings four to five times the levels of the 1970s. However, this apparent conclusion is subject to some serious caveats, as indicated below.

2.2 Lobster

In contrast to groundfish, for which there are fairly regularly monitored and maintained estimates of stock abundance, regular biomass estimates for lobster have not been available. This means, as well, that time series of natural capital values cannot be found for lobster stocks around Nova Scotia, since these require quantitative biomass estimates.

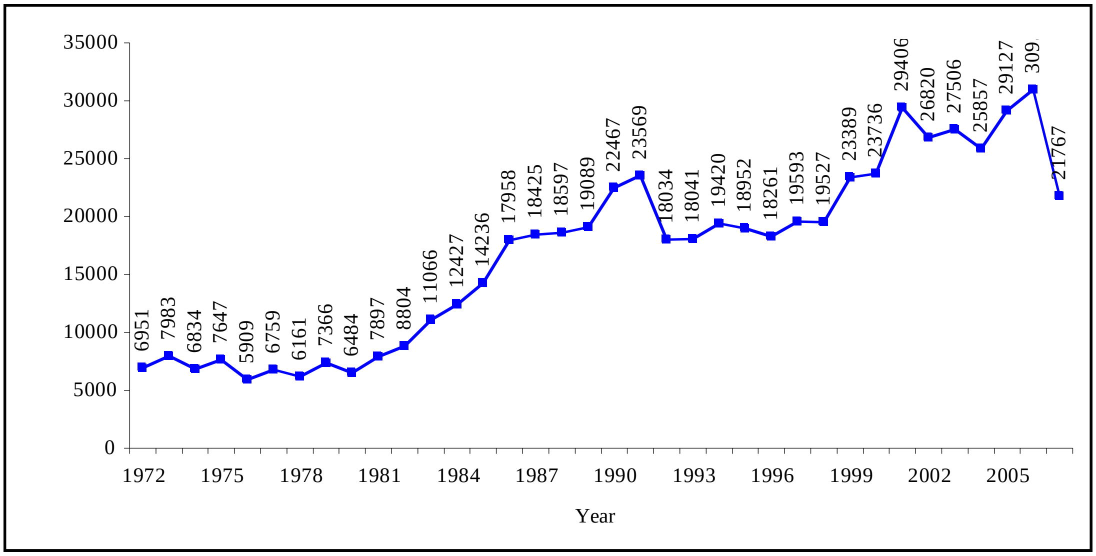
Lobster catch levels are available, but we must recognize that, in many fisheries, the use of catch data as an ecological indicator, or as an indicator of the health of a fish stock, can be dangerous. Catch levels can send highly misleading signals about biomass because many variables other than biomass, 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 with sophisticated mechanized fishing gear could seek out and catch fish even as stocks declined.

Despite these limitations, lobster fisheries, unlike many others in Canada, are managed by keeping the amount of fishing effort fixed. This implies that catches should—theoretically at least—reflect the abundance of lobster in the sea; in other words, catch levels may provide a rough indicator of lobster biomass. However, there is evidence that over time, even if the number of fishers and lobster traps remains the same, the intensity of fishing and technology can rise, thereby leading to increased landings. Therefore, while the use of catch data in the lobster fishery may better reflect abundance than it would in, say, the groundfish fishery, even here, catch data must be carefully interpreted.

Figure 7 below is a time series of lobster landings in Nova Scotia extending back to 1972. Five time periods are apparent from the figure:

- Prior to the 1980s, catch levels in Nova Scotia remained stable at between 6,000 and 8,000 metric tonnes a year. Since there was no apparent change in the effort devoted to lobster fishing during the 1970s, this seems to support an interpretation of stable stocks in a relatively sustainable fishery.
- From the early through mid-1980s, there was a period of rapid increase in catch levels, perhaps due to some combination of higher biomass (due perhaps to environmental conditions or predator–prey changes) and/or increased fishing activity.
- Between the late 1980s and late 1990s, there was little variation in Nova Scotia's lobster landings, which again suggests that lobster stocks were relatively stable (although the total catch landings are aggregated over a number of lobster stocks, thus hiding some variations among them).
- Catch levels increased again beginning in 2001 before reaching a record high of more than 20,000 metric tonnes in 2006 at four to five times the levels of the 1970s. This increase might suggest a high stock biomass. However, the latest stock status reports explicitly note that changes in fishing effort have not been accounted for and could be a possible explanation for the increased catch levels (DFO 2007a; DFO 2007b; FRCC 2007).
- Most recently, in 2007, lobster landings in Nova Scotia suddenly dropped to 70% of the 2006 record level, returning to the lower levels of the 1990s. It is too early to determine the cause of this sharp decrease—in particular, what it says about the sustainability of the high catch levels of the previous few years. The concern, of course, is that lobster stocks could be in potentially serious trouble—possibly for the first time in recorded history.

Figure 7. Lobster landings (metric tonnes), Nova Scotia, 1972–2007



Source: DFO (2008a).

3. Fish size: a measure of health and quality of individual fish

While scientists have traditionally focused on the total biomass of fish stocks, it is also important to monitor another fundamental indicator of the health of the stock—the wellbeing of individual fish. Two key measures of this are 1) size at age—the average length or weight of a fish of a given age, and 2) condition factor—which essentially tells us whether the fish are growing well—for example 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). Such adverse trends, in turn, may warn of potential problems with fishery sustainability.

The health of individual fish may also 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 Engelstoft 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. Finally, these indicators also reflect the general GPI accounting principle that natural capital, like produced capital, may depreciate in value due to both quantitative depletion (e.g., fewer fish or trees) and qualitative degradation (the quality of a fish population or a forest). While declining fish stock biomass indicates the former, as seen in the previous section, assessments of fish size and condition point to qualitative factors that also influence natural capital value.

Figure 8 below provides 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 off Nova Scotia (areas 5Z and 4X), including the George’s Bank area, are larger at age 3 than cod living in the colder waters on the Eastern Scotian Shelf (4VsW) and in the Gulf of St. Lawrence (off northern Cape Breton and in Nova Scotia’s northern waters—area 4TVn). Figure 8 also indicates changes over time in average size at age for each of the cod stocks assessed. Fishing zones are as indicated in Figure 2 above.

The average size at age of cod stocks in the Gulf of St. Lawrence has decreased slightly since the 1960s, while that of cod in the neighbouring Eastern Scotian Shelf area (4VsW) has fluctuated up and down over time with no clear trend. Overall, size at age in the Eastern Scotian Shelf waters remained relatively stable between the early 1970s and the late 1990s, but between 1998 and 2001, it began to increase rapidly.[3]

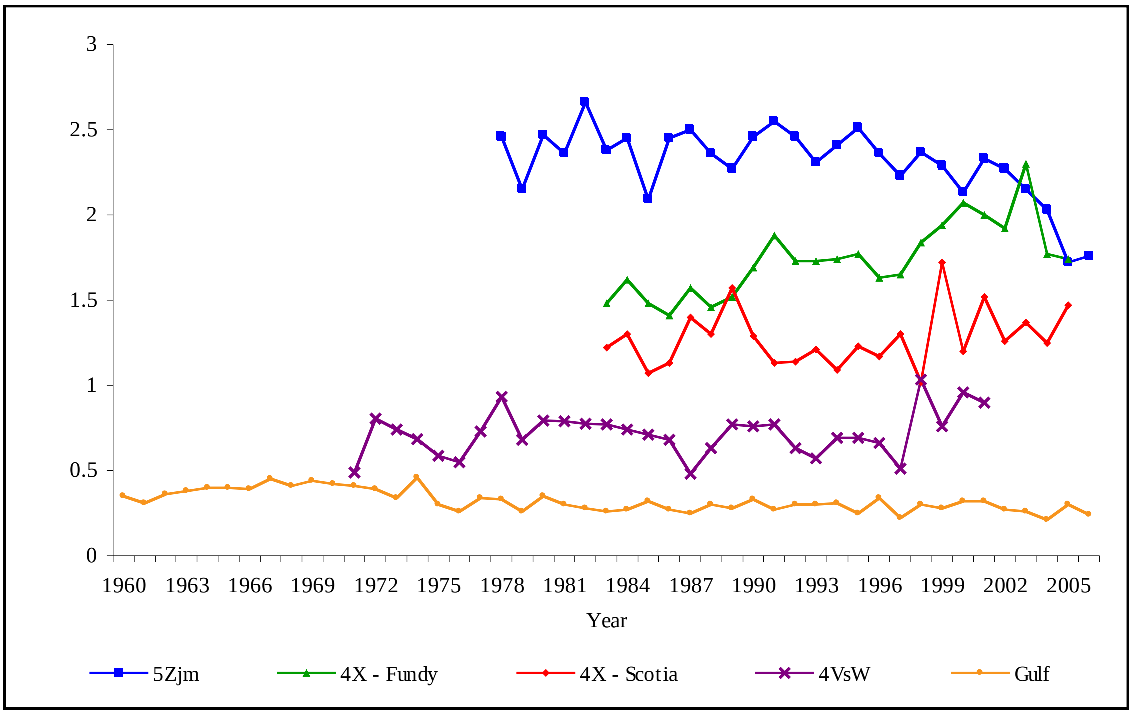
The average size at age of cod stocks in the eastern portion of Georges Bank has been declining rapidly since 1995 and reached a record low in 2005/2006. Although the reason for the decline is

[3] Note that recent estimates of the size at age for the 4VsW cod stock may be unreliable because the fishery moratorium implemented in that area in 1993 has made estimation difficult and the type of gear used to catch the cod has also changed (Fanning et al. 2003).

unclear, this size decline is believed to be hampering recovery of this stock (Gavaris et al. 2007). Cod stocks in the nearby Southwest Nova Scotia (4X) area have shown an increase in their average size at age, although in the Bay of Fundy, size at age increased rapidly in the late 1990s and then declined sharply after peaking in 2003.

These changes, and the different trends in the various cod stocks, are not well understood. It is possible that the recent changes in the size at age for these different cod stocks may be an indication of larger changes occurring in marine ecosystems and the marine environment.

Figure 8. Size trends across cod populations (kilograms) in waters around Nova Scotia, 1960–2006

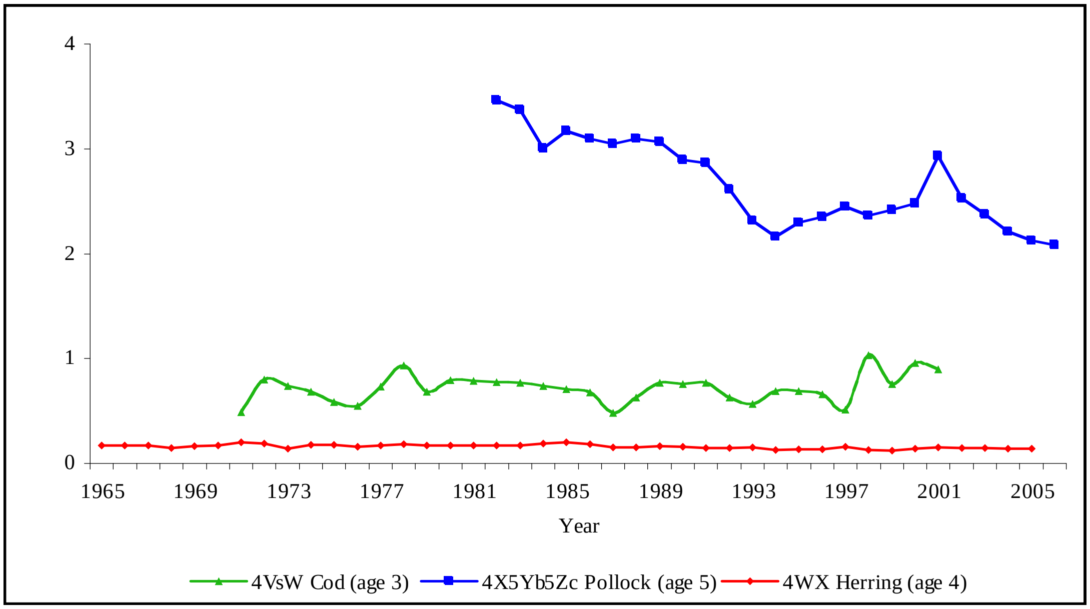


Sources: Clark and Perley (2006); Fanning et al. (2003); Gavaris et al. (2007); Swain et al. (2007).

Note: See appendix for the data table.

Figure 9 below 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 overall size at age and in trends over time. While there has been no overall trend in size at age for herring or cod since the early 1970s (despite some fluctuations up and down), the average size of pollock decreased considerably between the early 1980s and the mid-2000s—with a weight decline at age 5 of about 40% during this 20-year period. This suggests a significant change, and one that may indicate a potential decline in the value of that stock.

Figure 9. Fish size trends for cod, pollock, and herring (kilograms) in waters around Nova Scotia, 1965–2006.



Sources: Fanning et al. (2003); Power et al. (2006); Stone et al. (2006).

Note: See appendix for the data table.

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 strategy lies in ensuring that enough fish have an opportunity to spawn before being captured. An 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 measures are used such as "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 GPI fisheries and marine environment accounts.

4. Mean trophic level of harvested species: are we fishing down the marine food web?

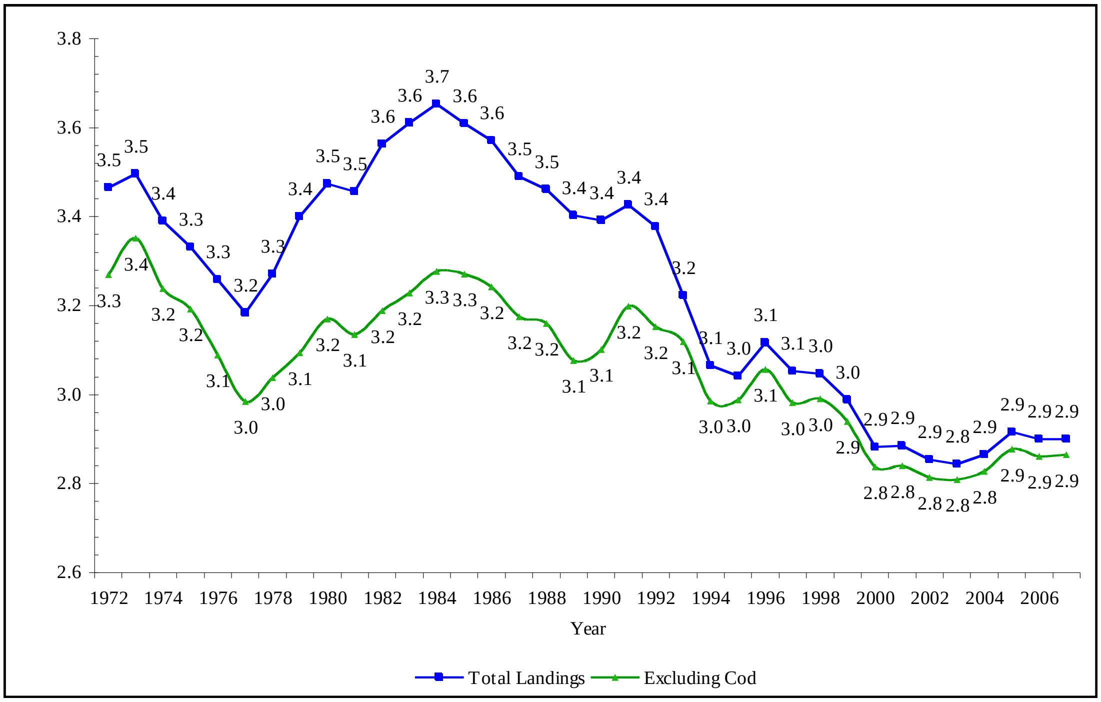
Conventional fisheries management has focused on maximizing the catch from single-species fisheries without consideration of the effects of fishing on non-target species and marine ecosystems. There is growing recognition of the need to move away from this single-species focus to consider the cumulative and indirect effects of fishing on marine ecosystems (Botsford et al. 1997; Preikshot and Pauly 2005). Fisheries can alter the structure and dynamics of marine food webs by changing the relative abundance of species at different trophic levels. Substantial reductions in the population of a single keystone species (a species whose impact on its community is larger than its biomass would suggest) in a marine food web can result in trophic cascades that disrupt predator–prey interactions among species at various trophic levels (Preikshot and Pauly 2005).

Pauly et al. (2001) point out that, in fisheries where both large and small species are targeted, the large, long-lived species will decline more rapidly than the smaller, shorter lived species because of fundamental differences in their life history strategies. Therefore, over time, species at the bottom of the food web will comprise an increasingly larger portion of the total catch in a given fishery as stocks of species at the top of the food web become depleted. This phenomenon has been called "fishing down marine food webs (Pauly et al. 1998)."

A number of studies have demonstrated this phenomenon by calculating the mean trophic level (TL) of all species landed in a particular region's fisheries over time (Pauly et al. 1998; Pauly et al. 2001; Pauly and Palomares 2005). Figure 10 below shows the mean TL of harvested species, weighted by their respective landings, in Nova Scotia fisheries over the period 1972 to 2007. Following Pauly et al. (2001), the mean TL is shown first for all landed species, and then for the same set of species but excluding cod.

Figure 10 shows an initial decline in the mean trophic level of Nova Scotia fisheries followed by a period of increasing mean TL beginning in the late 1970s, which can be traced to growth of the fisheries for groundfish in the waters around Nova Scotia. After peaking in 1984, the mean TL then began a period of steady decline, despite the fact that landings of cod and other groundfish remained high throughout the 1980s. The initial cause of the decline in mean TL after 1984 was not due to decreased landings in the groundfish fishery but rather to increased landings of lobster (a lower TL species). The rapid decline in the mean TL in the early 1990s, however, clearly marks the collapse of the groundfish fishery in Atlantic Canada and the shift toward targeting species at lower trophic levels, mainly lobster and other shellfish. Lobster landings continued to increase through the mid-1990s, causing the mean TL to decrease even further. Since 2000, the mean TL has remained relatively stable at historic lows.

Figure 10. Mean trophic level (weighted by landed weight) in Nova Scotia Fisheries, 1972–2007

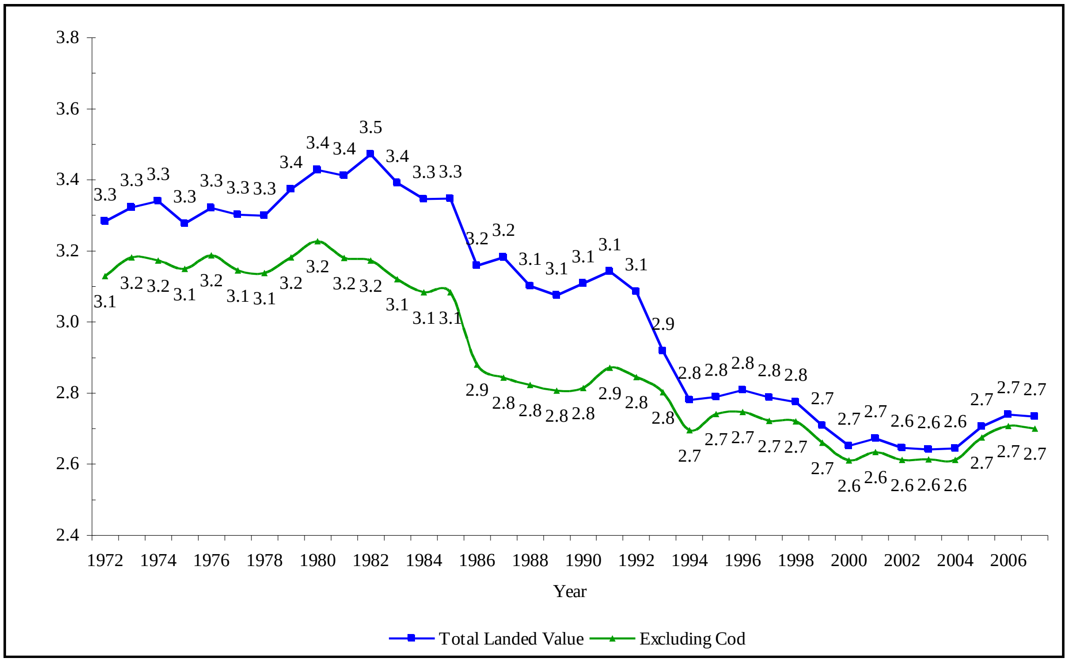


Sources: DFO (2008a); Froese and Pauly (2008); Pauly and Christensen (1997); Pauly et al. (2001).

Figure 11 below provides a different way of looking at the trophic level of catches in Nova Scotia fisheries, this time weighted by landed value. This indicator can be interpreted as telling us which fish species (in terms of trophic levels in the ecosystem) are contributing most to Nova Scotia's fishing economy at any point in time.

Since, in a Nova Scotia context, commercial marine species at the bottom of the food web, such as lobster and other shellfish, are typically worth more per unit weight than species at higher trophic levels, we see that the mean trophic level in Figure 11 is less than that in Figure 10. However, trends in the indicators, from the early 1980s to the present, are the same in both graphs, and Figure 11 highlights the fact that Nova Scotia's fishery economy has become increasingly dependent on species toward the bottom of the food web.

Figure 11. Mean trophic level (weighted by landed value) in Nova Scotia Fisheries, 1972–2007



Sources: DFO (2008b); Froese and Pauly (2008); Pauly and Christensen (1997); Pauly et al. (2001).

This clear reality that Nova Scotia's fisheries have been increasingly fishing down the marine food web is particularly disturbing for two reasons. First, it is an indication of the extent to which fisheries have altered the marine ecosystems around Nova Scotia and depleted populations of important predators at the top of the food chain (notably, the cod stocks). Such populations may have been reduced to the point at which they are no longer able to perform their traditional ecosystem functions.

Second, the increased reliance on species at the bottom of the food web has made Nova Scotia's fisheries less resilient from both a biological and socioeconomic perspective. A healthy, more biologically diverse marine ecosystem is more likely to recover from shocks or perturbations than a severely degraded and less diverse one (Preikshot and Pauly 2005). This is a key consideration given the potential impacts of climate change on marine ecosystems.

Furthermore, if the lobster fishery were to collapse biologically or to become unprofitable (as happened in Fall 2008 with a dramatic drop in lobster prices globally), there are few remaining options within the fishery sector. Following the collapse of the cod stocks, some fishers were able to adapt to the crisis by entering the growing lobster fishery, but now, with Nova Scotia fisheries already dependent on species at the bottom of the marine food web, there is less room to manoeuvre. It will not be possible to continue to fish down the marine food web indefinitely, so a collapse in the lobster fishery has the potential to cause even greater socioeconomic devastation than the collapse of the cod.

5. Marine species at risk

Fishing and other human activities in the marine environment have seriously impacted the populations of some marine species, including both target species in the fishery and other, non-target species. Although fisheries agencies have long monitored the status of populations of commercially harvested species, little effort was directed at determining the status of non-target marine species. In 1977, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created to assess the status of wildlife species in Canada (COSEWIC 2004). Since its creation, COSEWIC has assessed the population status of a number of marine species in Atlantic Canada. Table 1 below lists all marine species that have been designated by COSEWIC as species at risk in Atlantic Canada.

Table 1. Marine species at risk, waters around Nova Scotia

VULNERABLE / SPECIAL CONCERN	THREATENED	ENDANGERED	EXTIRPATED	EXTINCT
• Atlantic cod • American eel • Atlantic wolffish • blue shark • fin whale • harbour porpoise • roughhead grenadier • Sowerby's beaked whale • winter skate (Georges Bank—Western Scotian Shelf—Bay of Fundy)	• cusk • Northern wolffish • shortfin mako shark • spotted wolffish • striped bass (Southern Gulf—Bay of Fundy) • winter skate (Eastern Scotian Shelf)	• Atlantic salmon • blue whale • leatherback sea turtle • North Atlantic right whale • Northern bottlenose whale • porbeagle shark • white shark • winter skate (Southern Gulf)	• Atlantic walrus • grey whale	• eelgrass limpet • sea mink

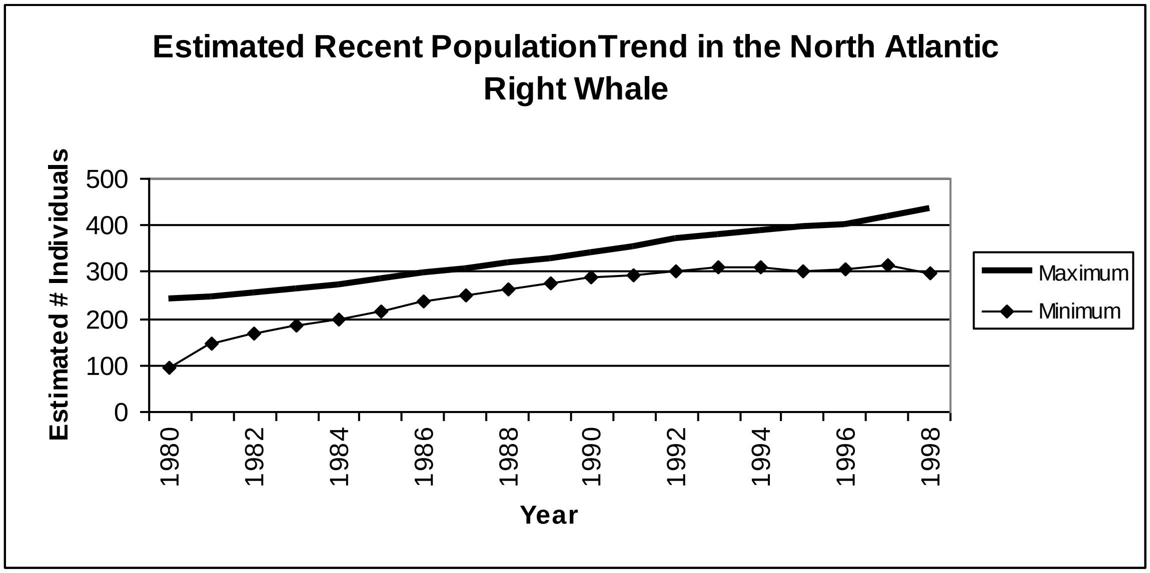
Sources: COSEWIC (2005); DFO (2008c).

Non-target species of critical importance in Nova Scotian waters include various species of marine mammals. As of 2008, a total of six different species of marine mammals have been designated by COSEWIC as being at risk (Table 1 above). Perhaps none is more closely monitored at present than the endangered 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 worldwide.

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 somewhat over 1,000 right whales, but place many caveats on this estimate. They also estimate that the population may have fallen to less than 100 by the time 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 estimate is reinforced by the analysis of Kraus et al. (2000), indicating that the population was around 100 in 1980 before rising to just under 300 in 1998 (Figure 12 below). In summary, then, despite the uncertainties involved, there is general agreement that, while the North Atlantic right whale population size is now above what it was at its lowest, it still remains far below levels present prior to exploitation.

Figure 12. Estimated population trend in the North Atlantic right whale, 1980–1998



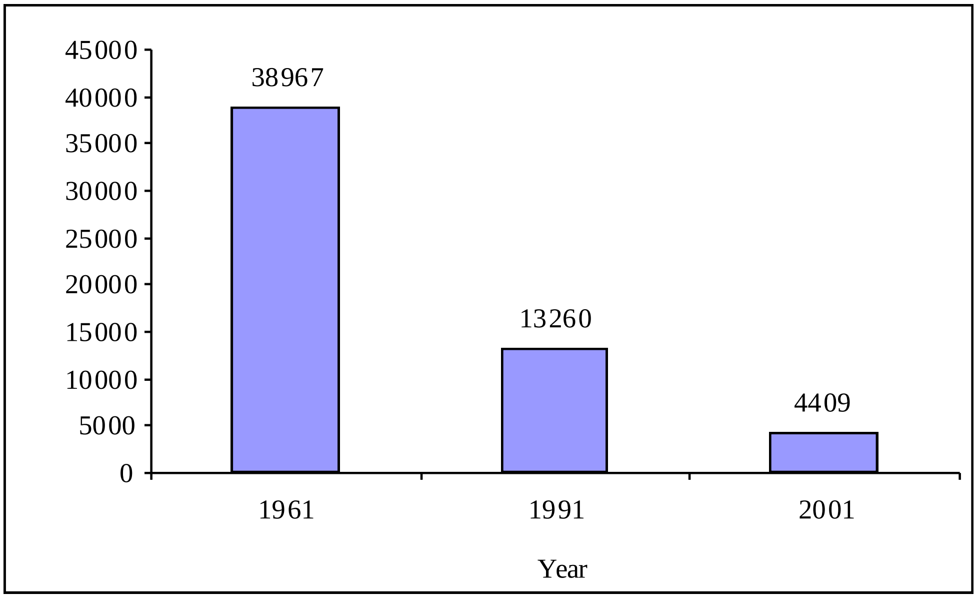
Source: Kraus et al. (2000).

Since the last *GPI Fisheries and Marine Environment Accounts* report (Charles et al. 2002), Kraus et al. (2005) have reported two major changes in the right whale population trend. First, there has been a significant increase in the mortality of the population. In 2004 and 2005, over a period of just 16 months, there were eight reported deaths, including six adult females and a young calf. These deaths represent a large reduction in the reproductive potential of the right whale population. Kraus et al. (2005) estimated that this increase in mortality would reduce population growth by between 3.5% and 12%.

Second, there has been an increase in the population's birth rate. Between 2001 and 2005, the number of calves born each year was higher than the average of 12 per year prior to 2000. A total of 31, 21, 19, 16, and 28 calves, respectively, were born in each of the years between 2001 and 2005. According to Kraus et al. (2005), while this increased birth rate translates to an increased population growth rate, it is not sufficient to counter the estimated 2% annual decline of the population.

Sharks and rays are a second group of species well represented in Table 1 above, with five of these species having been designated as “at risk.” One of these, the porbeagle shark, spends the majority of its time in Atlantic Canadian waters (Campana et al. 2003). After two periods of heavy exploitation in the 1960s and 1990s, the estimated biomass of porbeagle declined by 89% between 1961 and 2001 (Figure 13 below) (Campana et al. 2003). Baum et al. (2003; 2005) have shown a large, rapid decline in many other coastal and oceanic shark populations in the northwest Atlantic since the late 1980s, many of which have not been assessed by COSEWIC.

Figure 13. Estimated total biomass of porbeagle shark in the Northwest Atlantic, 1961, 1991, and 2001



Source: Campana et al. (2003).

It should be noted that only a small portion of all marine species have been assessed in terms of their stock levels. As more marine species are assessed, it is likely that more will be designated as being at risk, simply because we are learning about the state of more marine species, some of which are discovered to be in poor condition. Thus, if we use the number of designated species at risk as an indicator to track over time, it will be important to differentiate between an increase in the indicator that reflects a deterioration in the condition of certain species and of the marine environment versus an increase that simply reflects a better understanding of the condition of more marine species. One way to make this differentiation is to monitor changes in the status of already assessed species as well as numbers of at risk species. In this case, the combination of an increasing number of at risk species *and* a downward trend in an established set of species, would point to worsening conditions.

6. Shellfish closures: a measure of marine environmental quality

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

While contamination can occur from natural causes, land-based agricultural or municipal run-off often causes the closures by adding excess nutrients to the water. With these additional nutrients, algae thrive, causing algal blooms. 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. Additionally, some algae produce toxins as a natural defence against grazing predators; when the algae increases, they, in turn, can further reduce the population of grazers, thereby creating more opportunity for the algae to thrive. 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.

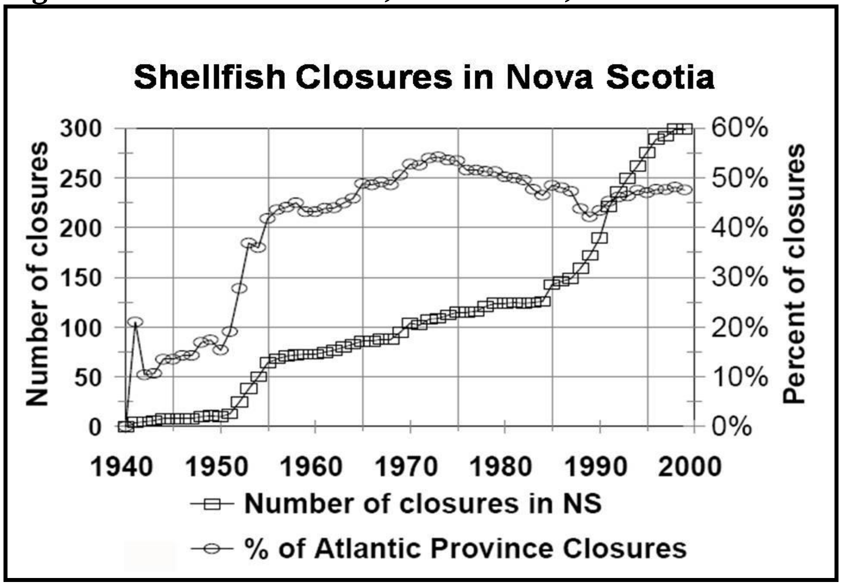
Closures due to toxins and bacterial contamination are good indicators of marine environmental quality, and often further point to the extent of land-based contamination. Closures also directly affect the health of the shellfishery sector. The loss of market, recreational opportunities, and subsistence harvests creates serious negative impacts and costs to coastal communities, and local economies, while the closures may also signal environmental problems in the marine ecosystem as a whole.

Figure 14 below shows the number of shellfish closures in Nova Scotia for each year between 1940 and 2000. The number of closures remained stable until around 1950, at which point closures began to increase steadily. Since 1985, there has been a rapid increase in the number of provincial shellfish closures, with the number of closures more than doubling between 1985 and 2000, to around 300. Indeed, additional data from Environment Canada (2004)—not shown in Figure 14—indicates that this increasing trend in shellfish closures has continued over the period 2001 to 2004.

While the results for this indicator are negative from a marine environmental health perspective, care is needed in interpreting the results. The increases over time are certainly due in large part to deterioration of marine environmental quality, but this increase could also reflect higher health standards and an expansion or increased efficiency of monitoring programs, so that there will be some contaminated sites detected in recent years that had previously been overlooked.

Figure 14 below also shows the number of closures in Nova Scotia as a percentage of all closures in Atlantic Canada. The province has the largest number of closures in the region, at about 50% of all closures, and that this proportion has remained fairly steady since around 1960.

Figure 14. Shellfish closures, Nova Scotia, 1940–2000



Sources: *Figure*: Adapted from Wilson (2000); *Data*: Environment Canada (1999, 2004).

It is possible that different levels of monitoring in Nova Scotia compared to other provinces in Atlantic Canada, rather than a different quality of the marine environment, could lead to Nova Scotia's relatively high proportion of shellfish closures. Thus, the other provinces might possibly have more contaminated sites, but fewer closures, if they also have inadequate monitoring programs. However, since shellfish monitoring is conducted by federal agencies—Environment Canada and Department of Fisheries and Oceans (DFO)—operating at a regional rather than provincial level, there are unlikely to be significant differences in the monitoring programs among the provinces in the region.

7. Employment: a measure of socioeconomic wellbeing of fishers and fishing communities

Fishery employment is valuable in helping to facilitate economic and social development, and in enhancing social stability and socioeconomic wellbeing among fishers and in coastal fishing communities (Charles 2001). This is particularly so in those rural fishing communities where fishing is the primary source of livelihood, and where there are limited alternative employment opportunities outside the fishery. In such cases, the viability of these coastal communities may hinge on employment in the fishery. If employment levels fall below a critical threshold, the wellbeing and sustainability of the community may be threatened (Jentoft 2000).

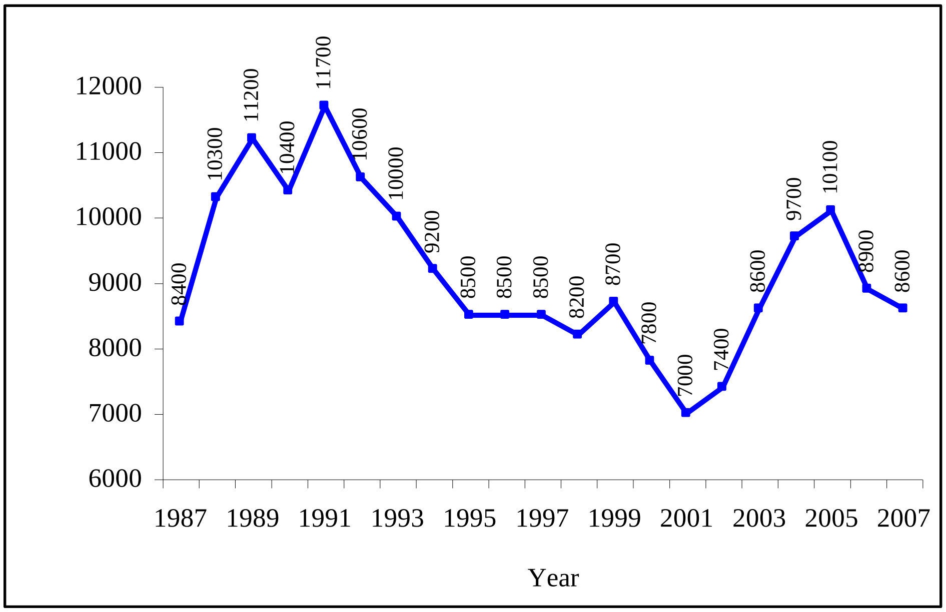
At the same time, employment has its limits in any fishery, corresponding to productive limits of the fish stocks and the need for economic viability among fishers. Therefore, we can envision the idea of "sustainable employment" in a fishery, a level that can be maintained indefinitely over time. Such a goal would imply that management approaches be used to provide employment in the fishery to the extent possible, compatible with sustainable catch levels from the fish stocks (DFO 2005). As a fishery policy goal, this fits within the broader aim of "sustainable prosperity" within Nova Scotia government policy. It means avoiding policies that seek to maximize employment, but also avoiding those policies that reduce employment unnecessarily.

A desirable indicator for this would be to measure how close society comes to achieving this balancing goal. However, the research has not been carried out to properly measure such an indicator. Instead, in this report we simply provide fishery employment levels, recognizing the need for careful interpretation of this measure.

The number of fishers employed in Nova Scotia fisheries is shown in Figure 15 below. Fishery employment increased rapidly through the late 1980s, as fishers sought to enter the booming groundfish fishery, and Canadian fisheries policy viewed employment in the commercial fishery as a key goal (Office of the Auditor General of Canada 1997). Prior to the collapse of the groundfish fishery in the early 1990s, fishery employment represented approximately 6% of Nova Scotia's total employment (Office of the Auditor General of Canada 1997). In 1991, just prior to the collapse of the groundfish fishery, employment in Nova Scotia fisheries peaked.

As catches fell dramatically with the collapse of the groundfish fishery in the early 1990s, so did employment. Between the mid- to late 1990s, the number of fishers remained relatively stable, at levels about 28% lower than the 1991 peak, but then decreased further between 1999 and 2001 to a level about 40% below the 1991 peak. From 2001 to 2005, the number of fishers in Nova Scotia increased—possibly in response to the expansion of the shellfish industry and the increase in lobster landings indicated above—to the highest levels in over a decade (reaching about 86% of the 1991 peak in 2005). However, fishery employment has again decreased in recent years.

Figure 15. Employment trend in Nova Scotia fisheries, 1987–2007



Source: Statistics Canada (2008).

Overall, Figure 15 indicates a long-term decline in fishery employment over a 20-year period, despite significant fluctuations in employment over time, as fishers enter or exit the fishery (in response to such factors as the emergence of new fisheries, changes in fish stock abundance, or trends in the value of the Canadian dollar). This decline certainly has negative implications, especially in those communities where few alternative sources of employment are available.

Two key reasons for the decline would seem to be 1) the unsustainable pre-collapse employment levels, and 2) governmental actions (e.g., failing to enforce federal owner–operator rules) that have led to unnecessarily great losses in employment. In other words, while we cannot expect employment to be maintained at pre-collapse levels, it is also the case that sustainable levels may be higher than at present, given more supportive government policies and actions. In particular, a focus on "sustainable employment" would shift fishery policy to encourage employment "per fish caught." This might involve supporting more sustainable and labour-intensive fishing methods and community-based management approaches. As noted above, the development of an indicator to monitor "sustainable employment" would be a useful priority for the future.

8. Fishery GDP: a conventional economic measure

Official and media reports on the state of Nova Scotia's fishery traditionally focus on the quantity of fish caught, the total fishery revenue, the level of fish exports—and fishery's contribution to the GDP, the conventional measuring stick of economic progress and prosperity.

Here we include this conventional indicator—even though GDP values are highly incomplete—in order to contrast results with those emerging from a GPI analysis. In particular, the GDP omits the value of many vital non-market services that Nova Scotia's marine environment provides, even though the economic health of the fisheries sector depends on these non-market services. Specifically, aspects of ecosystem health remain invisible in the GDP statistics and conventional accounting mechanisms. For example, the essential value of nutrient cycling is not captured in the GDP, despite being essential for fish growth. Similarly, habitat structure and quality are crucial to the value of Nova Scotia's fisheries, but cannot be discerned in GDP-based measures.

In particular, because the GDP only measures what we extract from the oceans and send to market, it does not account for what we leave in the sea—either the quantity and health of our fish stocks or the quality of our marine environment. Unlike the biomass, age, trophic level, environmental quality, and other GPI indicators presented above, the GDP is, therefore, incapable of sending policy makers early warning signs that could trigger timely remedial action and that might effectively avert the kinds of collapse such as the groundfish fishery in 1992, which could have been curtailed if adequate conservation measures had be put in place in time.

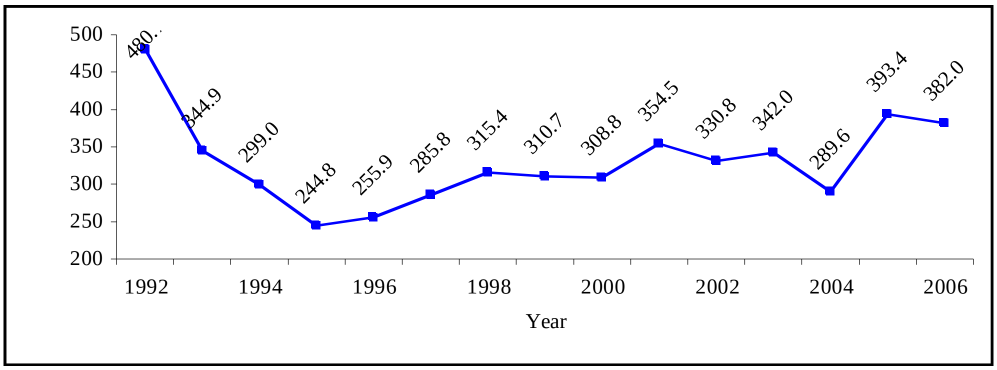
As noted in Section 1 above, Nova Scotia's fishery GDP was strong and stable in the years just prior to the groundfish collapse, suggesting a healthy economic sector. While we were catching, selling, and exporting large volumes of fish—and thus stimulating fishery GDP growth—we were simultaneously depleting the natural capital on which the fishery sector depended.

This resource depreciation—not captured in the conventional economic accounts—is analogous to what happens if the capital stock of a business (factories, equipment, etc.) is depleted or wears out over time and is not replaced. In contrast to a piece of machinery, however, fish stocks can potentially be self-sustaining and can naturally appreciate (grow) in economic value over time when harvested sustainably. If fish stocks are subjected to over-exploitation or other pressures, however, they will lose economic value. In sum, the problem with reliance on GDP-based measures of progress is not only that they *omit* key ingredients required for a healthy fishery, but also that they perversely count the depletion of natural wealth as economic gain.

Therefore, the fishery GDP is presented here, not because it is a recommended GPI indicator, but rather to demonstrate the contrast between this measure and the more nuanced assessments of fishery and marine environment health presented above.

As indicated in Figure 16 below, Nova Scotia's fishery GDP dropped following the collapse of the groundfish fishery, from $481 million in 1992 to $245 million in 1995 (in 2007 dollars), just over half the 1992 value. Nova Scotia's fishery GDP has resumed its upward trend since that time, largely in response to substantial growth in the shellfish sector (i.e., actually benefiting from the "fishing down the food chain" effect described in the trophic level indicator in Section 4 above). Thus, the province's fishery GDP increased from $245 million in 1995 to $382 million, in 2006 (in 2007 dollars), representing an increase of 56% in that time period, up to almost 80% of its 1992 level. Again, it should be noted that these GDP figures are affected by the overall landings in the fishery, the species mix in that catch, and the prices involved.

Figure 16. Fishery GDP ($2007), Nova Scotia, 1992–2006



Source: Nova Scotia Department of Finance (2008).

Notes: In Figure 16, all monetary amounts are in $2007, while Figure 1 uses $1997 as the constant dollar year. Figure 16 shows an increase in fishery GDP between 1995 and 1998, while Figure 1 shows a relatively stable trend over the same time period. Although the exact reason for this discrepancy is not clear, it is common for the Nova Scotia Department of Finance to revise earlier data sets in later years based upon updated information. Since Figure 16 uses the most recent annual estimates over the time period, its depiction of the trend between 1995 and 1998 should be more accurate than Figure 1.

9. Age structure of fishers: a measure of fishery and community resilience

The "age structure" of a fish population tells us how many fish there are of each age in the population. It is well accepted in ecological science that age structure can be an important factor in the health and resilience of fish stocks, as it is in forests and in wildlife populations.[4] In most cases, a healthy fish stock (again like a healthy forest) will ideally have a broad age spectrum that includes all age groups with a relatively even distribution among them, including an abundance of both young fish and old fish.

Resilience in human communities in general—and in coastal fishing communities in particular—might be considered similarly. Thus, an age structure that covers all age groups 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 (for example, to ensure effective transfer of skills and knowledge and 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 at all times.

Figure 17 below shows that, in Nova Scotia, the proportion of middle-aged fishers (25–44 years) has remained relatively stable over the past 75 years at around 45% of all fishers, although the proportion rose to higher levels in the 1980s and 1990s—peaking at 55% in 2001—before dropping back to 46% in 2006.

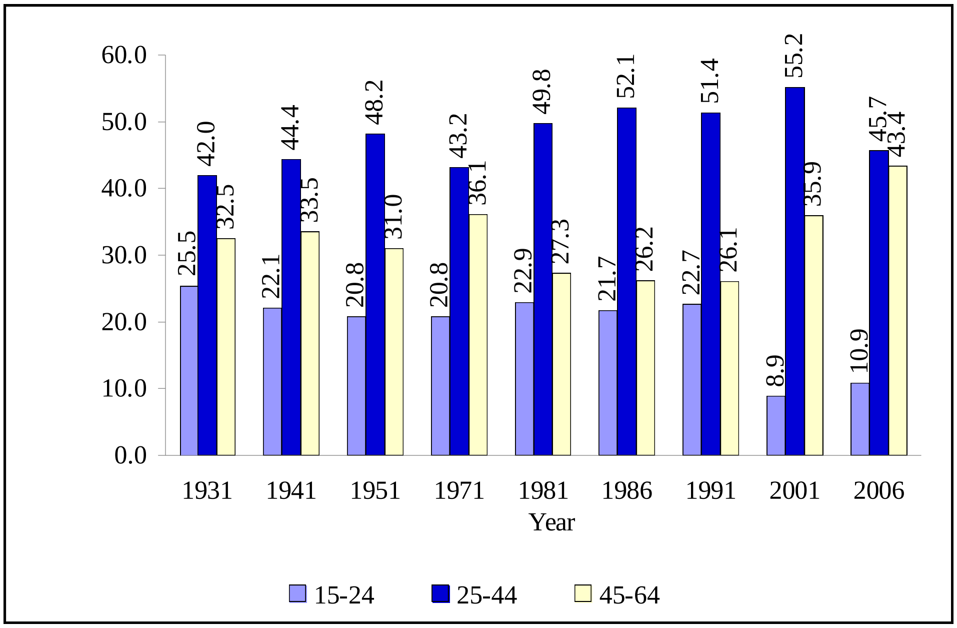
The larger changes have been at either end of the age spectrum. The proportion of young fishers (15–24 years), fairly stable for more than half a century—at 20–25% of all fishers from 1931 to 1991—has dropped by more than half since the groundfish collapse and today constitutes only about 10% of all fishers. By contrast, the proportion of older fishers (45–64 years) has risen dramatically since the groundfish stock collapse—from 26% in 1986 and 1991 to 43% of all fishers today. Thus, the overall age distribution among fishers in Nova Scotia has shifted markedly in the last 15 years to a considerably higher overall average age of fishers.

This recent and very dramatic change in age distribution in the fishing community has negative implications for the resilience both of the fishery and of coastal communities, both of which face an aging fishing population with fewer young recruits. This result also sends a message concerning problems with Nova Scotian fish stocks and with the federal government's fisheries policies. First, this indicator—showing an aging fishing population—indirectly reinforces the results of indicators presented earlier in this report pointing to diminishing fish in the sea. We can expect that, when fish are abundant, there will be more interest among young people in

[4] For example, age structure is also a key indicator of forest health and resilience in the *GPI Forest Accounts* (2001) and the *GPI Forest Headline Indicators Update* (2008). GPI Atlantic. Halifax. Available respectively at http://www.gpiatlantic.org/pdf/forest/forest1.pdf and http://www.gpiatlantic.org/pdf/forest/forestupdate.pdf. Accessed October 9, 2008.

entering the fishery and more opportunities to do so. Conversely, when such opportunities are limited, the existing employment base will likely age over time, as the data here demonstrate.

Figure 17. Age distribution of fishers (%), Nova Scotia, 1931–2006



Source: Statistics Canada, census (multiple years).

Note: For 1991, 2001, and 2006 data, the upper age group represents ages 45+.

Second, this indicator suggests that federal fishery policy is not presently ensuring a strong age structure of fishers in Nova Scotia, or encouraging young fishers to enter the fishery, but rather may be leading in the opposite direction. This suggests an urgent need to shift policy directions to diversify the fishery age structure, thereby boosting the resilience of the fishery while supporting coastal communities. For example, rather than allowing large fishing companies to gain control over fishing licenses, as at present, a more effective policy might enforce existing owner–operator rules so that young crew members have a better chance of taking over from retiring fishers.

Resilience and Diversity Indicators

Resilience reflects the ability of a fishery or a marine ecosystem to bounce back from shocks and to maintain its integrity. It is, thus, a highly desirable attribute. Resilience is an attribute both of ecological systems (in which genuine progress is assessed by the capacity of the ecosystem to maintain its "health" over time) and of human systems (in which resilient socioeconomic structures and communities are able to bounce back from dramatic changes in the natural resource base, the economy, and social conditions).

Multiple attributes are required to make a fishery resilient. A diverse age structure among fishers (Section 9 above) is just one factor. Indeed, *diversity* in the larger sense has been identified by observers as key to resilience in human communities, just as biodiversity is a key indicator of ecosystem resilience. Additional diversity indicators that may contribute to socioeconomic and community resilience include: diversification of total fishery landings across multiple species; access of individual fishers to multiple fisheries, rather than specialization in just one fishery; and economic (livelihood) diversification among fishers—all of which can be considered positive indicators from a resilience perspective.

Each of these additional diversity and resilience indicators is referenced very briefly here in order to encourage further developmental work in these areas with a view to expanding and deepening these GPI fisheries and marine environment accounts.

Diversified landings

From the human perspective in the fishery, reduced reliance on single fisheries and single fish stocks means not only a more diverse set of fisher livelihood options, thus greater resilience within fisher communities, but also potential insurance against a downturn in fish landings of a particular species. As noted from the evidence presented so far, such a downturn can occur either when fish stock abundance or health are compromised, as in the recent 30% drop in lobster landings seen in Figure 7 above or the 40% decline in pollock size shown in Figure 9 above, or as a result of particular commodity price changes. For example, a diversified fishery can clearly respond more flexibly to the kinds of price fluctuations illustrated in Appendix Figures 1 through 3, and can embrace a conservation requirement in a particular species without compromising the fishery or fishing income as a whole.

This capability to respond more effectively to both ecological and economic signals implies that a diversity of landings in a fishery system would be highly beneficial in terms of socioeconomic and community resilience, and also as a mechanism to reduce fishing pressure on declining fish stocks. Such diversification must, nevertheless, be handled with care, given the complex interactions between species in an ecosystem. In particular, diversifying by developing new fisheries (notably, on previously unexploited species) can potentially have negative ecological repercussions, perhaps on species traditionally targeted in fisheries (see Section 4 above).

Resilience and Diversity Indicators (continued)

Multi-fishery access

Diversification of landings applies not only to the fishery overall, but to individuals as well. For the reasons outlined above, individual fishers have greater flexibility and resilience if they hold licenses to fish more than one species because this enables them to switch between fisheries in response to changing abundances, ecological signals, and profitability. In particular, if the abundance of one fish species declines (or even collapses as with cod), fishers can shift to other fisheries, thereby maintaining their livelihood from fishing. From both an individual fisher and a community perspective, therefore, such multi-fishery access enhances the resilience of the overall fishery situation.

Multi-fishery access can also be positive for biological sustainability, since fishers can move to other fisheries in response to early signals of stock declines, rather than maintaining excessive effort in fishing the declining stock (but with care required to ensure that large-scale redirection of fishing is not such as to deplete a whole series of fish stocks). Thus, the extent to which fishers hold multiple licenses to harvest a range of species can also be seen as an indicator of socioeconomic and community resilience.

Diversified employment

A resilient fishing community is one that can continue to function and to guarantee its members a reasonable level of livelihood security, even during difficult times, and to bounce back from the inevitable disruptions that occur in any economy. Among the many components of a community that contribute to its resilience, including the economic and age structure aspects discussed above, a crucial one is the degree of diversification of the local economy as a whole.

Thus, abundant evidence indicates that communities with diversified economies and diverse employment opportunities are less vulnerable to variability and market fluctuations within a single industry (such as the fishery) because other industries within the community contribute to overall economic stability. Conversely, communities reliant primarily on a single industry have been much more economically vulnerable and will more likely be affected by the variable success and difficulties within that industry (Lamson 1986). This has been the unfortunate experience of some Nova Scotian communities, such as those in Cape Breton that were over-reliant on fishing, coal, or steel, and which suffered major economic setbacks and severe hardship as each of those industries collapsed. In short, employment diversity can also be a useful indicator of socioeconomic and community resilience among coastal fishing communities.

10. Institutional expenditures: resources to effectively manage fisheries and the marine environment

Institutional sustainability is an essential but often overlooked ingredient of sustainable development. In fisheries, measures to ensure sustainability are unlikely to succeed unless sufficient attention is paid to maintaining or building long-term financial, administrative, and organizational capabilities—the essence of institutional sustainability.

To assess this, we need indicators to assess the effectiveness of the management rules by which the fishery is governed, as well as the organizations that implement those rules in managing the fishery, whether formally (e.g., the legal system or governmental agencies) or informally (e.g., fisher associations or nongovernmental organizations). In general, institutional indicators need to examine 1) the manageability and enforceability of regulations, and 2) whether there is a match between i) the level of resources that society wishes to allocate to management, ii) what is needed to accomplish that management effectively, and iii) the actual level of resources available for management. Together, these considerations relate to the effectiveness of the institutions and regulations that manage and govern the fisheries, and to the inherent sustainability of those institutions.

Considerations of effectiveness and adequacy of institutional resources should include a wide range of ecological, social, economic, and cultural factors, including the ability to finance management needs, to conserve species, to foster equity, and to balance and manage the sometimes competing demands of different fisher groups. As past experience in Atlantic Canada has vividly demonstrated, these ecological, social, economic, and cultural factors in fisheries management and governance are intimately linked. Clearly, no assessment of sustainability in the fisheries is complete without careful consideration of this vital institutional dimension and without some attempt to measure management and institutional success.

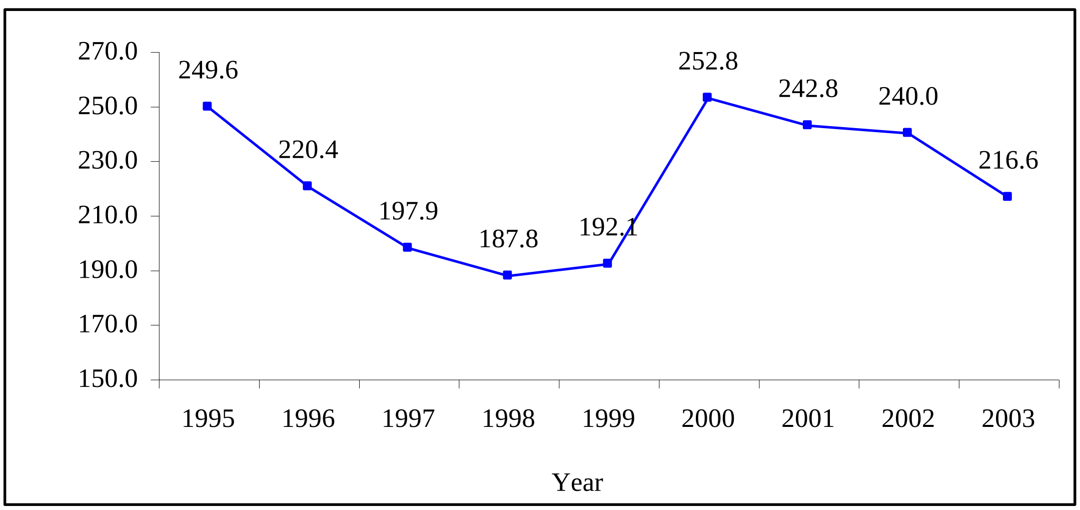
Unfortunately, it is very difficult to compile indicators that cover these various themes and dimensions, and indeed, institutional sustainability is too rarely monitored altogether as a measure of genuine progress. The discussion in this section is accordingly very preliminary in nature, reflecting the fact that new research and data collection are needed to fully develop indicators along the desired lines. Indeed, collection and analysis of quantitative data to operationalize such indicators in this field is highly recommended for future work.

In the meantime, the very limited availability of data on institutional matters means that this analysis deals with trends in only one (albeit fundamental) aspect of institutional sustainability—available levels of financial resources for the various aspects of fisheries management. Ideally, the available financial resources would be compared with those actually required to accomplish the designated and desired goals of fisheries management, but it remains unclear how levels of funding required for successful and sustainable fishery management can be determined and assessed accurately.

In short, it must be acknowledged that this indicator is still at a primitive level of development, but it is included here to highlight the importance of considering the institutional dimension of sustainability and in the hope that its inclusion here will lead to further conceptual, developmental data collection and analytical work in this area. With those caveats, we turn to a simple measure of institutional resources for which some data are available—annual expenditures by government departments. (Even here, however, considerable further analysis is required to assess the portion of these expenditures directly devoted to management of the fisheries in Nova Scotia waters.)

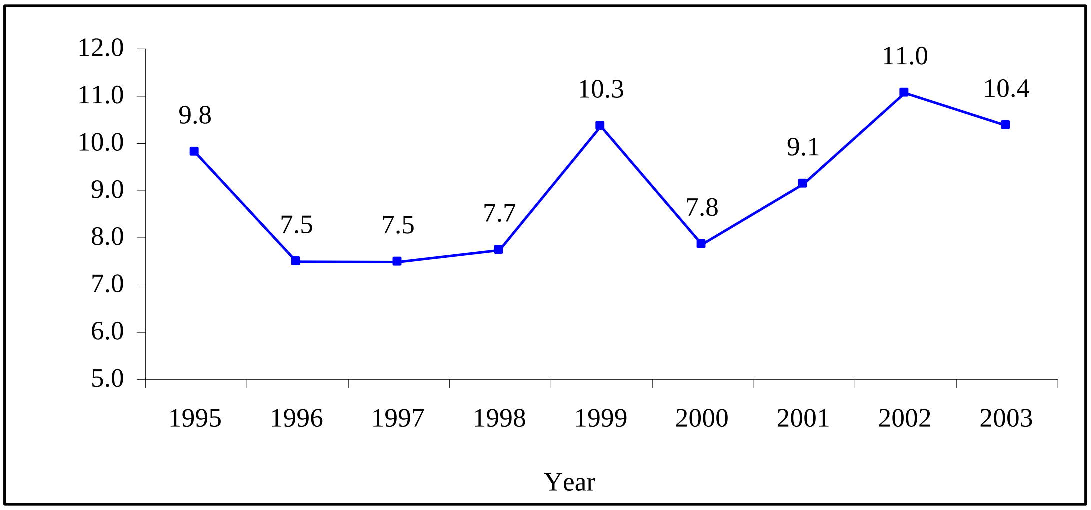
Figures 18 and 19 below depict the total expenditures of two key governmental management institutions relevant to fisheries in Nova Scotia—the federal Department of Fisheries and Oceans (DFO) and the provincial Department of Fisheries and Aquaculture (NSDFA). Figure 18, based on a 2005 study by Gardner Pinfold on the *Economic Value of the Nova Scotia Ocean Sector*, shows that DFO expenditures in Nova Scotia decreased steadily through the mid- to late 1990s before jumping sharply in 2000 by $60 million, and then decreasing from 2000 to 2003. Based on the same study, Figure 19 indicates that NSDFA expenditures have fluctuated up and down, but showed an overall increasing trend between 1996 and 2003.

Figure 18. DFO total expenditures ($2003 millions), Nova Scotia, 1995–2003



Source: Gardner Pinfold (2005).

Figure 19. NSDFA total expenditures ($2003 millions), Nova Scotia, 1995–2003



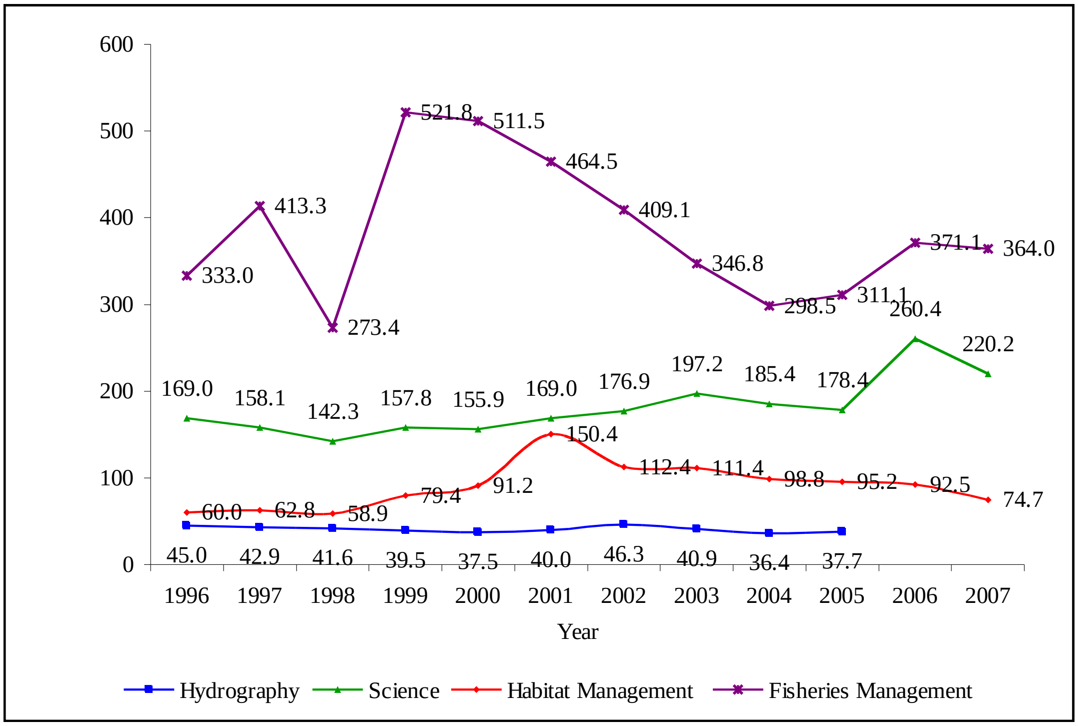
Source: Gardner Pinfold (2005).

Figure 20 below depicts DFO's national expenditures (in constant dollars) for specific scientific and management activities, in order to provide an indication of DFO's spending priorities. (A similar breakdown of DFO's expenditures specifically for the waters off Nova Scotia would be desirable for the purposes of this provincial-level GPI, but such a provincial breakdown was not available to the authors.)

Most notably, expenditures on fisheries management rose in the second half of the 1990s—to more than half a billion dollars nationwide ($2007)—and then declined steadily and considerably (by more than 40%) from 1999 to 2004. Between 2004 and 2007, DFO fisheries management expenditures rose somewhat but have remained well below levels of earlier in the decade.

Expenditures on science show a generally increasing trend over the period since the late 1990s, rising from $142 million in 1998 to more than $200 million in 2007, while spending on habitat management and hydrology remained relatively stable between 1996 and 2007 (Figure 20).

Figure 20. DFO expenditures by category ($2007 millions), Canada, 1996–2007

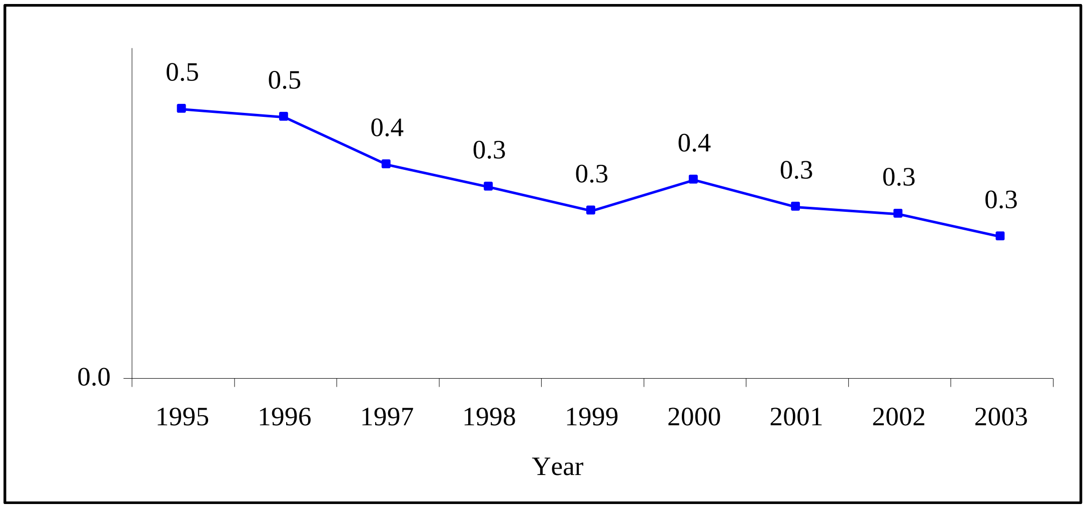


Source: Treasury Board of Canada Secretariat (2008).

While the above indicators show overall dollar expenditures by the federal and provincial departments responsible for fisheries management, it is also helpful to relate that spending to concrete fishery and environmental benefits. Thus, Figures 21 and 22 below compare governmental spending on fisheries and oceans with the total landed value of fish in Nova Scotia, showing the ratio of the two measures.

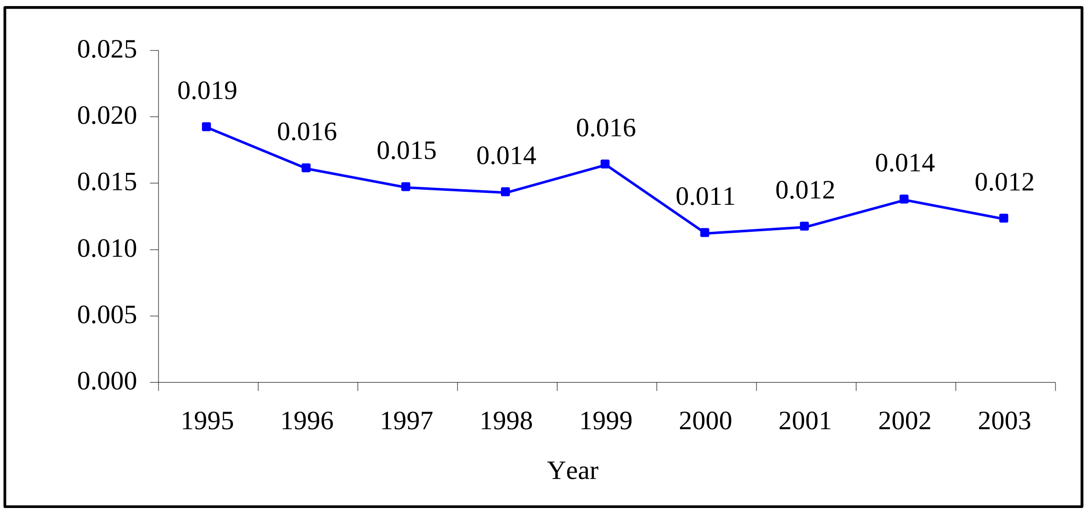
Figure 21 illustrates, for example, that total DFO expenditures in Nova Scotia amounted to about 50% of the total landed value of the province's fishery in 1995 before declining steadily to 25% in 2003. Figure 22 shows that the ratio of NSDFA expenditures to the province's total fishery landed value also declined between 1995 and 2003—from 2% to about 1.25%.

Figure 21. DFO expenditures as a proportion of the province's fishery landed value, Nova Scotia, 1995–2003



Sources: DFO (2008a); Gardner Pinfold (2005).

Figure 22. NSDFA expenditures as a proportion of the province's fishery landed value, Nova Scotia, 1995–2003



Sources: DFO (2008a); Gardner Pinfold (2005).

While these ratio indicators provide a preliminary sense of the more complete indicators that might eventually be developed for monitoring institutional sustainability, it must be highlighted that there are a number of difficulties with these measures. First, from a technical point of view, (1) available expenditure data do not fully match spending on management and scientific activities, (2) the landed value measure does not fully reflect the wide range of benefits obtained from the fishery or the marine environment, and (3) changes in the ratios have at least as much to do with changing fish prices as with changes in the operation of fishery management. For these reasons, considerable caution must be exercised in any effort to use either the expenditure data or the ratios as potential proxies for institutional management capacity.

Second, an even more fundamental problem in interpreting these indicators is that it is not clear whether a downward or an upward direction in the indicators is more desirable. On the one hand, the lower the indicator value (for both actual expenditures and as a proportion of fishery landed value), the more “efficient” each dollar spent by government might be considered to be in producing economic benefits to the fishery. If economic benefits can be produced with minimal government spending, this might be taken as meaning that the indicator trends of recent years are desirable.

On the other hand, a higher indicator value, particularly for total government expenditures on fisheries and oceans, might imply the assignment of higher priority to good management and monitoring. From that perspective—and relative to the economics of a single sector (the fishery)—higher governmental expenditures might provide better opportunities to improve our understanding of the ocean environment and to improve ocean management.

These difficulties in applying expenditure data to assessments of institutional sustainability indicate that monetary measurements alone cannot adequately account for society’s intrinsic interest in learning about and protecting the ocean. Nor can they indicate the value of ocean and fisheries management by comparison with the value of governmental management, data collection, and research in other sectors besides the fishery. In other words, there is an opportunity cost to fisheries expenditures, and this cost cannot be properly assessed when fisheries expenditures are examined as a proportion of economic benefits solely within that single sector.

Overall, therefore, a more inclusive measure of institutional capacity and sustainability in the fishery is required. Such a measure might assess management and conservation efforts against the benefits these efforts produce through a comprehensive benefit–cost analysis that incorporates social and environmental benefits and costs.

11. Conclusion

Fisheries and marine environments are extraordinarily complex and uncertain. As a result, progress toward achieving their sustainable use requires a multi-dimensional, systematic approach that considers ecological, socioeconomic, and institutional perspectives (Charles 2001, 2005). Events such as the collapse of the groundfish fishery in Nova Scotia demonstrate that an over-reliance on conventional measures (such as the fishery GDP) can send misleading signals to managers and policy makers. Such signals can lead to a belief that marine resources are being used sustainably, when indeed, there are severe problems that threaten the ecological, social, and economic wellbeing of the fishery, and therefore, of the province itself.

The select indicators from the *GPI Fisheries and Marine Environment Accounts* included in this report measure key factors of our fisheries and the marine environment, from ecological, socioeconomic, and institutional perspectives. While a number of conventional measures are included, the report has also considered cutting-edge indicators that examine previously neglected social and ecological aspects of fisheries and the marine environment.

The results obtained for each indicator in this report is summarized in Table 2. The ecological indicators assess the state of both target and non-target marine species, the relationship between fisheries and marine ecosystems and food webs, and the quality of the marine environment as a whole. Socioeconomic indicators include conventional measures such as GDP and employment, but also important measures of community resilience such as the age distribution of fishers. Finally, and with major caveats, government departmental expenditures provide a simple, preliminary institutional indicator relating to management of the fisheries and the marine environment.

Indicator	Summary
Biomass of groundfish stocks in Eastern Scotian Shelf, 1970-2006	
• Cod	• Large decline between 1985 and 2002.
• Haddock	• Large decline since mid-1980s, slight increase into early 2000s.
• Pollock	• A long and fairly steady decline until 1999, after which the stock experienced a modest increase.
Value of groundfish in Eastern Scotian Shelf	
• Cod (1972-2002)	• Steady decline in value from $200 million ($2007) in 1987 to $9 million in 2002.
• Haddock (1972-2001)	• Despite continuing price increases for haddock over 1989-1999, the value of the stock did not recover to the high levels of the mid-1980s, and in 2001 (the most recently available data), it remained at half the level (about $60 million) of the 1987 peak year.

• Pollock (1982-2006)	• Stock value plummeted from peak value of $44 million in 1987 to a 2000 low point of $11 million, before partially recovering to $25 million in 2006.
Lobster landings, Nova Scotia, 1972-2007	• Long-term increase in catches since early 1980s; 30% drop in catch levels between 2006 and 2007.
Individual fish size trends, cod stocks, 1960-2006	• Mixed trends among different populations.
Fish size trends for groundfish species, 1965-2006	
• 4VsW Cod (age 3)	• No overall trend, fluctuations up and down.
• 4X5Yb5Zc Pollock (age 5)	• Considerable decrease between the early 1980s and the mid-2000s—with a weight decline at age 5 of about 40% during this 20-year period.
• 4WX Herring (age 4)	• No overall trend, fluctuations up and down.
Mean trophic level in Nova Scotia fisheries, 1972-2007	• After peaking in 1984, the mean TL began a period of steady decline; since 2000, the mean TL has remained relatively stable at historic lows.
Marine Species at Risk	
• Estimated population trend in North Atlantic Right Whale, 1980-2005	• Recent increases in mortality rate and birth rate; the population continues to decline.
• Biomass of porbeagle shark in the Northwest Atlantic, 1960, 1991, 2001	• The estimated biomass of porbeagle declined by 89% between 1961 and 2001.
Shellfish closures, Nova Scotia, 1940-2000	• The number of shellfish closures in Nova Scotia has increased steadily since 1940, and has more than doubled since 1985.
Employment trend in Nova Scotia fisheries, 1987-2007	• The number of fishers decreased greatly from the highs of the late 1980s and early 1990s to levels later in the 1990s following collapse of the ground-fish fishery. After 2001, numbers rose somewhat, then fell again – not back to the pre-collapse levels.
Nova Scotia fishery GDP, 1992-2006	• Fishery GDP was steady and high for several years up to the groundfish collapse. Between 1992 and 1995, that fishery GDP decreased by almost half. After 1995, the fishery GDP increased again and by 2006 it had grown to nearly 80% of the 1992 level.
Age distribution of fishers, 1931-2006	• The proportion of older fishers has increased since 1931, while the proportion of younger fishers has decreased. The proportion of middle-aged fishers has remained relatively stable.
Institutional expenditures	
• Federal Department of Fisheries and Oceans total expenditures, Nova Scotia, 1995-2003	• Expenditures declined in second half of the 1990s, jumped substantially in 2000, and then decreased steadily over the period 2000–2003.
• NSDFA total expenditures, Nova Scotia, 1995-2003	• Provincial Department of Fisheries and Aquaculture expenditures show increasing trend since 1996.
• DFO and NSDFA expenditures as a proportion of the province's fishery landed value, Nova Scotia, 1995-2003	• Both federal and provincial government expenditures as a proportion of the landed value of Nova Scotia fisheries have decreased over time.

This analysis strives for a rough balance between ecological and social indicators. While there are somewhat more indicators here dealing with fish stocks and marine ecosystems, and while ecological sustainability is undoubtedly a critical dimension of sustainable development, at the same time socioeconomic and institutional indicators are recognized as essential to a genuinely sustainable fishery. However, there continues to be a challenge in obtaining socioeconomic and institutional data to develop appropriate indicators. The lack of available and appropriate data points to an obvious need for more research (cf. Boyd and Charles 2006) – which should be an important component of future work in Nova Scotia and more broadly (including initiatives to advance the *GPI Fisheries and Marine Environment Accounts*).

Note as well that in seeking to keep the number of these key indicators to the essential minimum, it is certainly the case that what is presented here reflects only a sample of possible indicators measuring health, sustainability and resilience of fisheries and the marine environment. For additional indicators, see the previous (Charles et al. 2002) report on the *GPI Fisheries and Marine Environment Accounts*.

What, then, is the "bottom line" message about the current state of Nova Scotia's fisheries and marine environment arising out of the key indicators described in this report? Before drawing some conclusions, we note that each indicator tells a story, and there is a need to assess and understand the particular nuances of that story; it makes no sense to merely "sum up" results across all of the indicators. Furthermore, we cannot expect that all the indicators will point in the same direction—for example, what is true of one fish stock does not necessarily hold for all. Some indicators point to low or no levels of sustainability, others illustrate a strong trend in the right direction, and many others show no clear trend over time. Thus, the overall picture is a complex one, and we must be cautious in interpreting the results.

Having said this, there are some crucial features in the results that raise significant concerns. First, consider the ecological perspective. The fish stock indicators show clear examples of unsustainability in biomass, natural capital, and fish condition. Furthermore, (1) ecological resilience is threatened as Nova Scotia "fishes down the food chain" with the catch focusing on decreasing trophic levels, (2) several marine species at risk remain in danger of extirpation or extinction, and (3) deterioration in marine environmental quality is illustrated through increasing shellfish closures. This is not a positive situation in terms of ecological trends.

Second, there are negative socioeconomic signals concerning the resilience of Nova Scotia's fishery, with a major shift in the age structure of the fishing population (fewer young, more older fishers). There are also concerns about equity in the fishery, as indicated by a comparison of two indicators: a decrease in employment and a rising fishery GDP. This means fewer Nova Scotians are sharing the growing monetary output from the fishery.

Clearly, these concerns must be addressed in fishery management and ocean conservation work. Moreover, with this report demonstrating the effectiveness of a broad-based indicator framework in helping to identify fisheries and marine concerns, there is a clear need to institutionalize such a system and to regularly monitor a wide variety of indicators. This is imperative if we are to move toward genuinely sustainable fisheries and healthy marine environments in Nova Scotia.

References

Baum, J.K., Myers, R.A., Kehler, D.G., Worm, B., Harley, S.J. and P.A. Doherty. 2003. Collapse and conservation of shark populations in the northwest Atlantic. *Science* 299: 389-392.

Baum, J.K., Kehler, D.G. and R.A. Myers. 2005. Robust estimates of decline for pelagic shark populations in the northwest Atlantic and Gulf of Mexico. *Fisheries* 30(10): 27-29.

Botsford, L.W., Castilla, J.C., Peterson, C.H. 1997. The management of fisheries and marine ecosystems. *Science* 25: 509-515.

Boyd, H. and A.T. Charles. 2006. Creating Community-Based Indicators to Monitor Sustainability of Local Fisheries. *Ocean and Coastal Management* 49:237-258.

Brown, M., Kraus, S., Gaskin, D. and B. White. 1994. Sexual composition and analysis of reproductive females in the North Atlantic Right Whale, *Eubalaena glacialis*, population. *Marine Mammal Science* 10(3): 253-265.

Campana, S., Joyce, W. and L. Marks. 2003. *Status of the Porbeagle Shark (Lamna nasus) in the Northwest Atlantic in the Context of Species at Risk.* Canadian Science Advisory Secretariat Research Document 2003/007.

Charles, A.T. 2005. Toward Sustainable and Resilient Fisheries: A Fishery-System Approach to Overcoming the Factors of Unsustainability. p.221-233 in *Overcoming Factors of Unsustainability and Over-exploitation in Fisheries: Selected Papers on Issues & Approaches.* (J. Swan & D. Greboval, eds). FAO Fisheries Report 782. UN Food & Agriculture Organization, Rome.

Charles, A.T. 2001. *Sustainable Fishery Systems*. Blackwell Science Ltd., Oxford UK, 384p.

Charles, A., Boyd, H., Lavers, A. and C. Benjamin. 2002. *A Preliminary Set of Ecological, Socioeconomic and Institutional Indicators for Nova Scotia's Fisheries and Marine Environment.* GPI Atlantic. Halifax, January, 2002. (http://www.gpiatlantic.org/pdf/fisheries/fisheries.pdf) September 30, 2008.

Clark, D.S. and P. Perley. 2006. *Assessment of Cod in Division 4X in 2006.* Canadian Science Advisory Secretariat Research Document 2006/087.

COSEWIC. 2005. *Canadian Species at Risk*. Committee on the Status of Endangered Wildlife in Canada.

COSEWIC. 2004. Brief History. Committee on the Status of Endangered Wildlife in Canada. (http://www.cosewic.gc.ca/eng/sct6/index_e.cfm) September 29, 2008.

deYoung, B., R.M. Peterman, A.R. Dobell, E. Pinkerton, Y. Breton, A.T. Charles, M.J. Fogarty, G.R. Munro, and C.T. Taggart. 1999. Canadian Marine Fisheries in a Changing and Uncertain World. Can. Spec. Publ. Fish. Aquat. Sci.129.199pp.

DFO. 2008a. Canada Provincial Quantities, Commercial Landings, Seafisheries. DFO Statistical Services, Department of Fisheries and Oceans. (http://www.dfo-mpo.gc.ca/communic/statistics/commercial/landings/seafisheries/index_e.htm) September 16, 2008.

DFO. 2008b. Canada Provincial Values, Commercial Landings, Seafisheries. DFO Statistical Services, Department of Fisheries and Oceans. (http://www.dfo-mpo.gc.ca/communic/statistics/commercial/landings/seafisheries/index_e.htm) September 16, 2008.

DFO. 2008c. Aquatic Species at Risk, Maritimes. (http://www.dfo-mpo.gc.ca/species-especes/home_e.asp) September 24, 2008.

DFO. 2007a. Framework and Assessment for Lobster (Homarus americanus) in the Southern Gulf of St. Lawrence Lobster Fishing Areas 23, 24, 25, 26A and 26B. Canadian Science Advisory Secretariat Science Advisory Report 2007/035.

DFO. 2007b. Framework and Assessment Indicators for Lobster (Homarus americanus) in the Bay of Fundy, Lobster Fishing Areas (LFAs) 35, 36, and 38. Canadian Science Advisory Secretariat Science Advisory Report 2007/037.

DFO. 2005. 2005-2010 Strategic Plan: Our Waters, Our Future. (http://www.dfo-mpo.gc.ca/dfo-mpo/plan-eng.htm#min) September 30, 2008.

Environment Canada. 2004. *Canadian Shellfish Sanitation Program (CSSP).* (http://www.atl.ec.gc.ca/epb/sfish/cssp.html) October 3, 2008.

Environment Canada. 1999. Environmental Protection Branch, *Shellfish Monitoring Program*, Environment Canada Atlantic Region Office, Amar Menon.

Fanning, L.P., Mohn, R.K. and W.J. MacEachern. 2003. *Assessment of 4VsW cod to 2002.* Canadian Science Advisory Secretariat Research Document 2003/027.

Fisheries Resource Conservation Council (FRCC). 2007. *Sustainability Framework for Atlantic Lobster 2007.* (http://www.frcc-ccrh.ca) October 7, 2008.

Froese, R. and D. Pauly. Editors. 2008. FishBase. World Wide Web electronic publication. (www.fishbase.org) September 19, 2008.

Garcia, S.M. and A.T. Charles. 2008. Fishery Systems and Linkages: Implications for Science and Governance. Ocean and Coastal Management 51:505-527.

Gardner Pinfold. 2005. *Economic Value of the Nova Scotia Ocean Sector*. (http://www.mar.dfo-mpo.gc.ca/pande/ecn/ns/e/ns-e.pdf) September 17, 2008.

Gavaris, S., O'Brien, L., Clark, K. and B. Hatt. 2007. *Assessment of Eastern Georges Bank Atlantic Cod for 2007.* Transboundary Resource Assessment Committee Research Document 2007/04.

Hutchings, J.A. 2000. Collapse and recovery of marine fishes. Nature 406:882-885.

Jentoft, S. 2000. The community: A missing link of fisheries management. Marine Policy 24: 53-59.

Koeller, P., M. Covey, and M. King. 1999. The Scotian Shelf shrimp (Pandalus borealis) fishery in 1999. Canadian Stock Assessment Secretariat Research Doc. 99/172.

Kraus, S.D., Hamilton, P.K., Kenney, R.D., Knowlton, A. and C.K. Slay. 2000. Status and trends in reproduction of the North Atlantic right whale. *J. Cetacean Res. Management.*

Kraus, S.D., Brown, M.W., Caswell, H., Clark, C.W., Fujiwara, M., Hamilton, P.K., Kenney, R.D., Knowlton, A.R., Landry, S., Mayo, C.A., McLellan, W.A., Moore, M.J., Nowacek, D.P., Pabst, D.A., Read, A.J. and R.M. Rolland. 2005. North Atlantic Right Whales in Crisis. *Science* 309: 561-562.

Lamson, C. 1986. Planning for resilient coastal communities: lessons from ecological systems theory. *Coastal Zone Management Journal* 13: 265-280.

Lassen, H. and R. Halliday. 1997. Biological advice on fishery management in the North Atlantic. pp.273-282 in: Hancock, D.A., D.C. Smith, A. Grant and J.P. Beumer (eds). Developing and Sustaining World Fisheries Resources: the State of Science and Management. 2nd World Fisheries Congress proceedings. Brisbane, 1996. CSIRO Publishing: Collingwood.

Mohn, R., Lambert, T.C., Wilson, S., and G.A.P. Black. 1998. *Assessment of Status of 4Vn Cod (May-Oct.):1997*. Canadian Stock Assessment Secretariat Research Document 98/09.

Mohn, R.K. and J.E. Simon. 2002. *Biological information relevant to the management of 4TVW haddock.* Canadian Science Advisory Secretariat Research Document 2002/102.

Nova Scotia Department of Finance. 2008. Nova Scotia Statistical Review. Economics & Statistics Division. (http://www.gov.ns.ca/finance/statistics/agency/publications/publications.asp?id=Pub21) October 12, 2008.

Nova Scotia Department of Finance. 2001. Information from Nova Scotia Department of Finance, Fiscal and Economic Policy, Statistics. Halifax. February 8, 2001.

Office of Protected Resources. 2000. Northern Right Whale (*Eubalaena glacialis*): Western North Atlantic Stock. National Marine Fisheries Service, Silver Spring, Maryland USA. (www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/individual_sars.html) September 28, 2008.

Office of the Auditor General of Canada.1997. Fisheries and Oceans Canada - Sustainable Fisheries Framework: Atlantic Groundfish. In *1997 October Report of the Auditor General of Canada.* (http://www.oag-bvg.gc.ca/internet/English/parl_oag_199710_14_e_8095.html). Accessed September 28, 2008.

Pauly, D. and M.L. Palomares. 2005. Fishing down marine food web: It is far more pervasive than we thought. *Bulletin of Marine Science* 76(2): 197-211.

Pauly, D., Palomares, M.L., Froese, R., Sa-a, P., Vakily, M., Preikshot, D. and S. Wallace. 2001. Fishing down Canadian aquatic food webs. *Can. J. Fish. Aquat. Sci.* 58: 51-62.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and F. Torres, Jr. 1998. Fishing down marine food webs. *Science* 279: 860-863.

Pauly, D. and V. Christensen. 1997. Trophic levels of fishes. Box 16, p. 127 In R. Froese and D. Pauly (eds) FishBase 97: concepts, design and data sources. ICLARM, Manila.

Power, M.J., Clark, K.J., Fife, F.J., Knox, D., Melvin, G.D., Stephenson, R.L. and L.M. Annis. 2006. *2006 Evaluation of 4VWX Herring.* Canadian Science Advisory Secretariat Research Document 2006/49.

Preikshot, D. and D. Pauly. 2005. Global Fisheries and Marine Conservation: Is Coexistence Possible? In *Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity.* Norse, E.A. and L.B. Crowder (eds). Washington, D.C.: Island Press.

Reeves, R.R., J.M. Breiwick, and E. Mitchell. 1992. Pre-exploitation abundance of right whales off the eastern United States. Pp.5-7 In: *The right whales in the western North Atlantic: A science and management workshop*. NEFSC Reference Document No.92-05. NOAA/ NMFS, Northeast Fisheries Science Center, Woods Hole Mass. USA. 88pp.

Riget, F. and J. Engelstoft. 1998. Size-at-age of cod (Gadus morhua) off West Greenland, 1952-92. NAFO Sci. Coun. Studies 31: 1-12.

Statistics Canada, Census. 1931. *Labour Force Survey for Canada, Provinces and Territories*. 1931 Census. Statistics Canada.

Statistics Canada, Census. 1941. *Labour Force Survey for Canada, Provinces and Territories*. 1941 Census. Statistics Canada.

Statistics Canada, Census. 1951. *Labour Force Survey for Canada, Provinces and Territories*. 1981 Census. Statistics Canada.

Statistics Canada, Census. 1961. *Labour Force Survey for Canada, Provinces and Territories*. 1961 Census. Statistics Canada.

Statistics Canada, Census. 1971. Labour Force 15 years and over by Detailed Industry, Age and Sex, for Canada, Provinces and Territories. 1971 Census. Statistics Canada. 94-747: 13-25.

Statistics Canada, Census. 1981. Labour Force 15 years and over by Detailed Industry and Sex, Showing (a) Age Groups and (b)Class of Worker for Canada, Provinces and Territories. 1981 Census. Statistics Canada. 92-921: 3-21.

Statistics Canada, Census. 1991. *Labour Force 15 years and over by Detailed Industry and Sex, Showing (a) Age Groups and (b) Class of Worker for Canada, Provinces and Territories*. 1991 Census. Statistics Canada. 93-113: 1-37.

Statistics Canada, Census. 2001. *Industry - North American Industry Classification System, Age Groups and Sex for the Labour Force 15 Years and Over of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations*. 2001 Census. (http://www.statcan.ca/menu-en.htm) October 1, 2008.

Statistics Canada, Census. 2006. *Industry - North American Industry Classification System, Age Groups and Sex for the Labour Force 15 Years and Over of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations*. 2006 Census. (http://www.statcan.ca/menu-en.htm) October 1, 2008.

Statistics Canada. 2008. *Labour force survey estimates (LFS), by North American Industry Classification System (NAICS), sex and age group, annual (persons x 1,000).* (http://cansim2.statcan.ca/) September 24, 2008.

Stone, H., Perley, P. and D. Clark. 2006. *2006 Assessment of Pollock in 4VWX and 5Zc.* Canadian Science Advisory Secretariat Research Document 2006/088.

Swain, D.P., Currie, L.G., Chouinard, G.A., Poirier, G.A., Savoie, L., Hurlbut, T. and D. Daigle. 2007. *Assessment of the southern Gulf of St. Lawrence cod stock, March 2007.* Canadian Science Advisory Secretariat Research Document 2007/033.

Thorne, S. 2000. Cod recovery unlikely, scientists predict. Chronicle Herald, Canadian Press. 2000 September 14: B5.

Treasury Board of Canada Secretariat. 2008. Departmental Performance Reports. (http://www.tbs-sct.gc.ca/rma/dpr/dpr-rmr_e.asp) September 24, 2008.

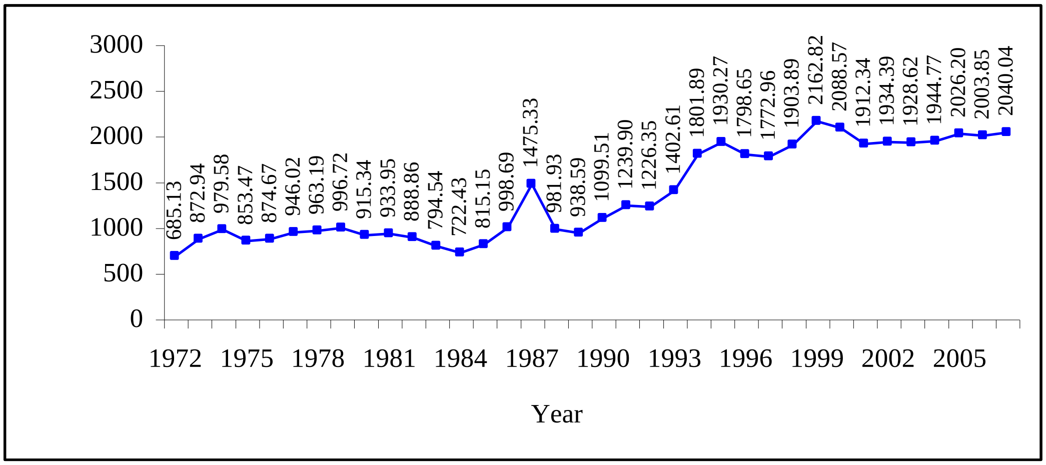
Trippel, E.A. 1995. Age at maturity as a stress indicator in fisheries. Bioscience 45(11): 759-771.

Trippel, E.A., M.J. Morgan, A. Fréchet, C. Rollet, A. Sinclair, C. Annand, D. Beanlands, and L. Brown. 1997. Changes in age and length at sexual maturity of Northwest Atlantic Cod, Haddock and Pollock Stocks, 1972–1995. Can. J. Fish. Aquat. Sci. Tech. Rep.

Wilson, S. 2000. *The GPI Water Quality Accounts,* GPI Atlantic, Halifax, section 7.1, pages 101-103.

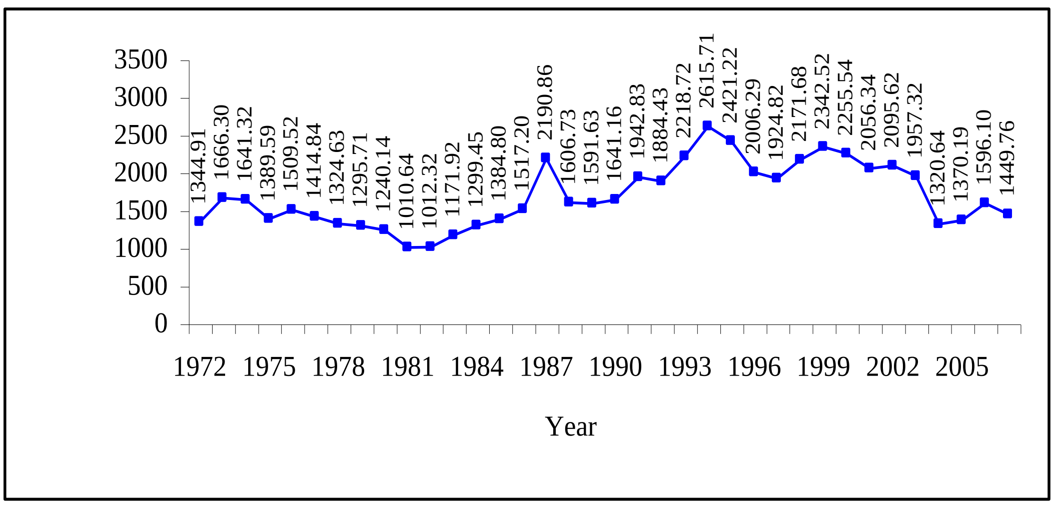
Appendix: figures and tables

Appendix Figure 1. Cod prices per metric tonne ($2007), Nova Scotia, 1972–2007



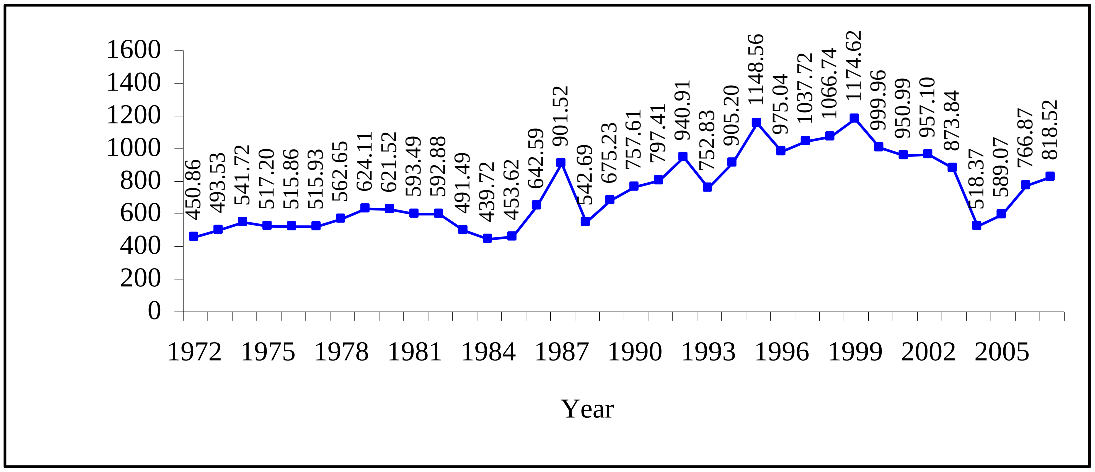
Sources: DFO (2008a); DFO (2008b).

Appendix Figure 2. Haddock prices per metric tonne ($2007), Nova Scotia, 1972–2007



Sources: DFO (2008a); DFO (2008b).

Appendix Figure 3. Pollock prices per metric tonne ($2007), Nova Scotia, 1972–2007



Sources: DFO (2008a); DFO (2008b).

Appendix Table 1. Biomass (age 3+) of cod, haddock, and pollock (000s of metric tonnes), Eastern Scotian Shelf, 1970–2006

Year	4VW Cod	4TVW Haddock	4VWX5Zc Pollock (Western)	Year	4VW Cod	4TVW Haddock	4VWX5Zc Pollock (Western)
1970	30.390	32.663	n/a	1989	79.235	35.315	42.674
1971	52.075	22.441	n/a	1990	83.553	25.318	40.229
1972	45.206	11.538	n/a	1991	66.120	19.066	37.157
1973	84.362	9.388	n/a	1992	40.594	16.552	36.307
1974	17.275	7.045	n/a	1993	58.200	11.785	28.618
1975	16.415	8.440	n/a	1994	26.085	10.190	19.813
1976	26.499	8.601	n/a	1995	33.199	12.098	16.887
1977	47.048	15.022	n/a	1996	23.842	16.333	17.730
1978	56.149	25.207	n/a	1997	22.666	17.997	21.533
1979	80.751	34.494	n/a	1998	19.219	21.389	15.337
1980	86.318	49.553	n/a	1999	16.622	23.270	9.750
1981	146.029	46.904	n/a	2000	6.702	22.782	10.930
1982	160.423	42.293	54.759	2001	10.222	28.919	14.022
1983	207.704	47.687	66.103	2002	4.722	n/a	19.744
1984	239.111	65.228	72.634	2003	n/a	n/a	24.307
1985	180.143	83.536	65.693	2004	n/a	n/a	29.719
1986	113.776	75.727	57.463	2005	n/a	n/a	31.041
1987	133.257	55.101	48.555	2006	n/a	n/a	32.828
1988	98.445	43.551	42.894				

Appendix Table 2. Size trends across cod populations (kilograms), waters around Nova Scotia, 1960–2006

Year	5Zjm	4X - Fundy	4X - Scotia	4VsW	Gulf	Year	5Zjm	4X - Fundy	4X - Scotia	4VsW	Gulf
1960	n/a	n/a	n/a	n/a	0.35	1984	2.45	1.62	1.30	0.740	0.27
1961	n/a	n/a	n/a	n/a	0.31	1985	2.09	1.48	1.07	0.710	0.32
1962	n/a	n/a	n/a	n/a	0.36	1986	2.45	1.41	1.13	0.680	0.27
1963	n/a	n/a	n/a	n/a	0.38	1987	2.50	1.57	1.40	0.480	0.25
1964	n/a	n/a	n/a	n/a	0.40	1988	2.36	1.46	1.30	0.630	0.30
1965	n/a	n/a	n/a	n/a	0.40	1989	2.27	1.52	1.57	0.770	0.28
1966	n/a	n/a	n/a	n/a	0.39	1990	2.46	1.69	1.29	0.760	0.33
1967	n/a	n/a	n/a	n/a	0.45	1991	2.55	1.88	1.13	0.770	0.27
1968	n/a	n/a	n/a	n/a	0.41	1992	2.46	1.73	1.14	0.630	0.30
1969	n/a	n/a	n/a	n/a	0.44	1993	2.31	1.73	1.21	0.570	0.30
1970	n/a	n/a	n/a	n/a	0.42	1994	2.41	1.74	1.09	0.690	0.31
1971	n/a	n/a	n/a	0.488	0.41	1995	2.51	1.77	1.23	0.690	0.25
1972	n/a	n/a	n/a	0.803	0.39	1996	2.36	1.63	1.17	0.662	0.34
1973	n/a	n/a	n/a	0.740	0.34	1997	2.23	1.65	1.30	0.512	0.22
1974	n/a	n/a	n/a	0.684	0.46	1998	2.37	1.84	1.02	1.032	0.30
1975	n/a	n/a	n/a	0.585	0.30	1999	2.29	1.94	1.72	0.759	0.28
1976	n/a	n/a	n/a	0.549	0.26	2000	2.13	2.07	1.20	0.958	0.32
1977	n/a	n/a	n/a	0.730	0.34	2001	2.33	2.00	1.52	0.897	0.32
1978	2.46	n/a	n/a	0.932	0.33	2002	2.27	1.92	1.26	n/a	0.27
1979	2.15	n/a	n/a	0.681	0.26	2003	2.15	2.30	1.37	n/a	0.26
1980	2.47	n/a	n/a	0.795	0.35	2004	2.03	1.77	1.25	n/a	0.21
1981	2.36	n/a	n/a	0.789	0.30	2005	1.72	1.74	1.47	n/a	0.30
1982	2.66	n/a	n/a	0.773	0.28	2006	1.76	n/a	n/a	n/a	0.24
1983	2.38	1.48	1.22	0.772	0.26						

Appendix Table 3. Fish size trends for cod, pollock, and herring (kilograms), waters around Nova Scotia, 1965–2006

Year	4VsW Cod (age 3)	4X5Yb5Zc Pollock (age 5)	4WX Herring (age 4)	Year	4VsW Cod (age 3)	4X5Yb5Zc Pollock (age 5)	4WX Herring (age 4)
1965	n/a	n/a	0.172	1986	0.680	3.095	0.182
1966	n/a	n/a	0.172	1987	0.480	3.046	0.153
1967	n/a	n/a	0.172	1988	0.630	3.096	0.154
1968	n/a	n/a	0.148	1989	0.770	3.068	0.162
1969	n/a	n/a	0.162	1990	0.760	2.894	0.161
1970	n/a	n/a	0.169	1991	0.770	2.866	0.147
1971	0.488	n/a	0.199	1992	0.630	2.615	0.148
1972	0.803	n/a	0.192	1993	0.570	2.312	0.153
1973	0.740	n/a	0.143	1994	0.690	2.163	0.131
1974	0.684	n/a	0.175	1995	0.690	2.296	0.136
1975	0.585	n/a	0.179	1996	0.662	2.353	0.137
1976	0.549	n/a	0.159	1997	0.512	2.446	0.161
1977	0.730	n/a	0.174	1998	1.032	2.361	0.131
1978	0.932	n/a	0.181	1999	0.759	2.419	0.120
1979	0.681	n/a	0.172	2000	0.958	2.478	0.138
1980	0.795	n/a	0.172	2001	0.897	2.929	0.150
1981	0.789	n/a	0.172	2002	n/a	2.528	0.148
1982	0.773	3.462	0.172	2003	n/a	2.376	0.149
1983	0.772	3.373	0.172	2004	n/a	2.210	0.139
1984	0.740	3.005	0.191	2005	n/a	2.126	0.141
1985	0.710	3.169	0.204	2006	n/a	2.081	n/a