Handbook of National Accounting

Integrated Environmental and Economic Accounting for Fisheries

Final draft circulated for information prior to official editing

United Nations
Food and Agriculture Organization
of the United Nations

Studies in Methods
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PREFACE

The handbook of national accounting *Integrated Environmental and Economic Accounting for Fisheries* (commonly referred to as SEEAF), presented in this volume has been undertaken by the United Nations and the Food and Agriculture Organization of the United Nations.

The handbook is the first of a series of handbooks, which support the implementation of the handbook of national accounting *Integrated Environmental and Economic Accounting 2003* (commonly referred to as SEEA-2003) by providing methodological and practical guidelines on selected components of the SEEA-2003. The handbook provides a common framework for organizing economic and environmental information related to fisheries, permitting the monitoring of the economic importance of fisheries, the improvement of fisheries management and the estimation of the full costs and benefits of fisheries.

It is intended for data producers from national statistical offices, fisheries ministries or research institutes. It is also intended to meet the needs of fisheries managers and policy-makers in other agencies, including managers at the macro-economic level. Physical and economic information on fish stocks and catch can be used by fishery managers to better manage the resources. Moreover, the integration of economic and environmental information in the SEEAF framework provides a useful tool for Integrated Coastal Area Management, adopted in Agenda 21, as it allows the evaluation of costs and benefits of different fisheries and non-fisheries policies and development strategies. One chapter of the handbook is devoted to the illustration of possible policy uses and applications of the accounts and another presents five case studies from countries that have implemented environmental-economic accounts for fisheries.

The first draft of the handbook was prepared by Mr. Asgeir Danielsson (National Economic Institute, Iceland) and Mr. Gerry Gravel (Statistics Canada) and discussed at the UNSD/FAO Workshop on Integrated Environmental and Economic Accounting for Fisheries (United Nations, New York 14-16 June 1999). A successive draft was prepared by Ms. Glenn Marie Lange (Columbia University, United States). The handbook has been presented in several international workshops in the Economic and Social Commission for Asia and the Pacific and in Southern Africa and has benefited from the advice received at these various workshops. The case studies were provided by Ms. Julie Haas and Mr. Knut Sorenson (Norway), Ms. Glenn Marie Lange (Namibia), Mr. Asgeir Danielsson (Iceland) and Mr. Robert Repetto (United States). The Institute of Advanced Studies of the United Nations University supported the initial phase of the development of this handbook, especially the organization of an electronic discussion group on fisheries accounting. All these contributions are gratefully acknowledged.

The handbook was prepared under the coordination of Ms. Alessandra Alfieri (United Nations Statistics Division) and Mr. Rolf Willmann (Fisheries Department, Food and Agriculture Organization). Ms. Ilaria DiMatteo (United Nations Statistics Division) contributed to and assisted in the preparation of the handbook.

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ACRONYMS

BEA	Bureau of Economic Analysis
BOD	biological oxygen demand
CBS	Central Bureau of Statistics
CEPA	Classification of Environmental Protection Activities and Expenditure
COFI	Committee on Fisheries
COFOG	Classification of the Functions of Government
COPP	Classification of Outlays of Producers according to Purpose
CPUE	catch per unit effort
ESA	European System of Accounts
EEZ	Exclusive Economic Zone
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross Domestic Product
ICAM	Integrated Coastal Area Management
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICSEAF	International Commission for South East Atlantics Fisheries
IPOA	International Plan of Action for the Management of Fishing Capacity
ISSCAAP	FAO International Standard Statistical Classification of Aquatic Animals and Plants
ITQ	Individually Transferable Quotas
ITSQ	Individual Transferable Share Quotas
ISIC	International Standard Industrial Classification of All Economic Activities
MAGP	Multi-Annual Guidance Program
MEY	Maximum Economic Yield
MFA	Material Flow Accounts
MFMR	Ministry of Fisheries and Marine Resources
MRI	Marine Research Institute in Iceland
MSY	Maximum Sustainable Yield
NACE	Classification of Economic Activities in the European Community
NAFO	Northwest Atlantic Fisheries Organisation
NEI	National Economic Institute in Iceland
NMFS	National Marine Fisheries Service
NOREEA	*NOR*wegian *E*conomic and *E*nvironmental *A*ccounts
NPV	Net Present Value
NRA	Natural Resource Accounting
NSCB	National Statistical Coordination Board
OECD	Organization for Economic Cooperation and Development
RME	Resource Management Expenditure
SAM	Social Accounting Matrix
SEAFO	South East Atlantic Fisheries Organisation
SEEA	System of Integrated Environmental and Economic Accounts
SEEAF	System of Integrated Environmental and Economic Accounts for Fisheries
SNA	System of National Accounts
SUT	Supply and Use Table
TAC	Total Allowable Catch

UN	United Nations
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
VPA	Virtual Population Analysis

CHAPTER I: INTRODUCTION

A. Background

1. All economies are heavily dependent on the environment as a source of materials and energy, as a sink for waste products, and as the physical habitat for human communities. This capacity of the environment constitutes our 'natural' capital. Over the past few decades, most countries have come to embrace the notion of sustainable development, expressed in popular form by the Brundtland Commission Report, Our Common Future, as

> …development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (WCED 1987)

2. There has since been a search for concepts to operationalise this notion: a clear definition of sustainable development and tools to help achieve it. One approach to operationalise sustainable development has been in the area of national accounting: incorporating the role of the environment in the economy more fully into the system of national accounts (SNA) through satellite accounts for the environment.

3. The SNA is particularly important because it constitutes the primary source of information about the economy and is widely used for analysis and decision making in all countries. However, the SNA focuses on the measurement of economic performance and only marginally deals with the treatment of the environment. With regard to fisheries, for example, until recently, the SNA recorded only the income from capture fishing, but not changes in fish stocks. This can be quite misleading when a fish stock is being over-exploited: income from over-exploitation would be recorded, but not the corresponding depletion of the fish stocks. By contrast, the SNA treats livestock quite differently, recording both production and changes in the stock so that the consequences of stock depletion, for example, during a drought year, are fully accounted for. This is due to the fact that fish stocks in the wilderness are natural assets, not subject to direct management, whereas livestock is considered as a produced asset, since the growth of the animals is enhanced and controlled by human activities.

4. The 1993 revision of the SNA partly addresses some of these problems, notably by expanding the asset boundary to include a broader range of natural assets such as capture fisheries. Even with the expanded coverage of the environment by the 1993 SNA, significant gaps remain. Satellite accounts for the environment, namely the

System of Environmental and Economic Accounts (SEEA) (UN 1993, UN and UNEP 2000 and UN et al. 2003), were developed to address these gaps.

5. As a satellite accounts of the SNA, the SEEA has a similar structure to the SNA, recording stocks and flows of environmental goods and services. It provides a set of aggregate indicators to monitor environmental-economic performance both at the sectoral and macroeconomic level, as well as a detailed set of statistics to guide resource managers toward policy decisions that, hopefully, will improve environmental-economic performance in the future.

6. There are two features that distinguish the SEEA from other databases about the environment. First, the SEEA directly links environmental data to the economic accounts through a shared structure, set of definitions and classifications. The advantage of this database is that it provides a tool to integrate environmental-economic analysis and to overcome the tendency to divide issues along disciplinary lines, in which analyses of economic issues and of environmental issues are carried out independently of one another.

7. Second, the SEEA covers all the important environmental-economic interactions, a feature that makes it ideal for addressing cross-sectoral issues, such as fisheries management. It is not possible to promote sustainable fisheries purely from the narrow perspective of managing fish stocks; rather, an ecosystem-wide approach is needed that can address threats to the health of fish habitat. These threats can come from changes in land use, pollution, forest cover, water flow, and other environmental components. As satellite accounts to the SNA, the SEEA is linked to the full range of economic activities; with a fairly comprehensive classification for environmental resources, the SEEA includes information about all critical environmental stocks and flows that may affect fisheries.

B. Policy uses of fisheries accounts

8. Fish stocks and other living aquatic resources are exposed to many of the detrimental consequences of economic activities. Many of the world's wild fish stocks are subject to high, frequently excessive, exploitation levels by commercial fishing activities. Wild fish stocks are also occasionally over-harvested by recreational fishers and by subsistence fishers. The abundance and health of wild fish stocks in inland and marine waters are also increasingly affected by water pollution and by the degradation of fish habitats through landfills, damming and diversion of rivers, clearance of mangroves, sedimentation, coral mining, deforestation in the hinterland, etc. The dual impacts of excessive exploitation levels and habitat degradation result in the loss, or reduction, of the economic value of the goods and services provided by the aquatic ecosystems and a loss of biodiversity and genetic resources.

9. The main reason for the failure to protect fisheries from these negative impacts is that, until the late 1970s, most marine fishing grounds were treated as common property,

open access resources, accessible to all. In 1982 the United Nations Convention on the Law of the Sea recognised the right of coastal states to a 200-miles Exclusive Economic Zone (EEZ). The 1982 Convention was further strengthened with respect to fisheries on the high seas through the 1995 Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. This Agreement obliges states to co-operate and to "adopt measures to ensure long-term sustainability of straddling fish stocks and highly migratory fish stocks and promote the objective of their optimum utilisation" and to "ensure that such measures are based on the best scientific evidence available and are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, …"

10. A contributing factor to the over-exploitation of many fish stocks has been insufficient knowledge about the biology of the stocks and about the levels of exploitation actually taking place. The FAO has played an important role in systematising the collection of data on landings and international trade in fisheries products, supporting research on the state of fish stocks and fisheries, and in promoting effective fisheries management. In its work programme, FAO is guided by the Code of Conduct for Responsible Fisheries which stresses the importance of acquiring more and better information on fish stocks and on the fishing industry in order to improve the management of the fisheries and to solve the pressing structural problems that the industry faces. Improving national accounting for the fisheries sector and the natural resources it exploits will contribute towards this end.

11. For all resources, policy analysis and decision-making take place on three relatively distinct levels: the local or company level, the sectoral/industry level, and the macroeconomic (national) or regional level. The contribution of SEEA to policy analysis has been primarily at the sectoral and macroeconomic levels, especially as a tool for coordinating policies in different ministries when there are cross-sectoral impacts. Policy-makers at this level have the responsibility for multi-sectoral strategic planning that requires setting national priorities and policies of all sectors and based on weighing alternatives and tradeoffs among sectors.

12. For fisheries and related accounts, there are two distinct users: fisheries managers and policy-makers in other agencies including managers at the macro-economic level. While the usefulness to fisheries managers of physical and economic information about fish stocks, catch, etc. is fairly obvious, the usefulness to other policy-makers may be less so. For non-fisheries policy-makers, sustainability of fish may appear to be a fairly clear-cut issue: preserve the fish stock at a level determined by fisheries managers using a range of tools that target fishing. But, as discussed above, achieving even this simple notion of sustainability requires an ecosystem management approach that aims at maintaining the health of the fish habitat.

13. Fish habitat can be seriously affected by human activities in coastal areas and further inland or upstream. Policy-makers must consider, for example, the impact of changes in land use, agriculture or forestry policy, urban expansion in a coastal area, or the development of large-scale tourism facilities. How does a policy-maker weigh these

trade-offs among competing users? Continued growth of economic activities and populations in coastal areas will only intensify these pressures in the future.

14. These non-fisheries activities are all beyond the control of fisheries managers. Sustainability of fish stocks requires cooperation between fisheries managers, with expertise relevant to managing stocks, and macro-economic managers, who coordinate policies in other sectors that impact on fisheries. Fisheries sector accounts provide information that can be used for monitoring and policy analysis by both fisheries managers and non-fisheries policy-makers. Agenda 21 (UN 1992) called for Integrated Coastal Area Management (ICAM) approach to development in these areas. The SEEAF could provide a useful framework for ICAM for integrating environmental and economic information necessary for weighing up the costs and benefits of different policies and development strategies.

15. The applications of the SEEA will be discussed in greater detail in Chapter V; some of the issues that can be addressed with information from the fisheries accounts can be grouped into three main categories - monitoring the economic importance of fisheries, improving fisheries management, estimating the full costs and benefits of fisheries. A summary of these issues is provided below.

Monitoring the economic importance of fisheries

- contribution to national income, employment and foreign exchange earnings of fisheries and its subsectors;
- distribution of benefits from fisheries among different groups in society, e.g., commercial, recreational, and subsistence fishers;
- economic linkages between the fisheries sector and other sectors of the economy;
- value of natural assets, in particular commercial fish stocks, and the cost of depletion;
- value of fisheries resources shared with other countries;
- monitoring implementation of international instruments (e.g., UN Law of the Sea, UN Fish Stocks Agreement, Code of Conduct for Responsible Fisheries).

Improving fisheries management

- assess the economic efficiency of fishing in the subsectors, and the potential value of fish under alternative management and policies. Fisheries management can then be compared to management of other resources in the economy;
- assess government policies, such as fisheries taxes and subsidies, on incentives for sustainable utilization of fishery resources, on the distribution of access to fisheries and benefits from fisheries. Again, fisheries policies and management can be compared to other resources in the economy;
- assess the impact of macro-economic policies on the fisheries sector, such as economy-wide changes in taxes or interest rates. Are fisheries especially vulnerable to specific policies?
- monitoring the inter-relationship between fisheries, the natural resource base and ecosystem health;

- management of resources shared with other countries, including on the high seas.

Estimating the full costs and benefits of fisheries

- assess the extent of resource rent recovered by the government, accrued to the private sector, or dissipated on overcapacity and overfishing;
- assess the extent of government fisheries management costs and habitat protection costs;
- assess environmental externalities caused by fisheries, or generated elsewhere in the economy and borne by fisheries (measured in both physical and monetary terms).

16. The policy issues listed above are related to sustainable development policies. Fishery resources accounting, in addition to providing a framework to derive a consistent set of indicators for fisheries to monitor progress towards sustainable development, it also provides an analytical framework for integrated policy analysis, allowing for scenario modelling and projections. The relationship between the SEEAF and sustainable development indicators for fisheries is discussed at greater length in Chapters III and IV.

C. Overview of environmental accounts and concepts of sustainability

1. Environmental accounting in the United Nations

17. In response to the request of Agenda 21 (UN 1992), which recommended countries to implement environmental-economic accounts at the earliest date, the United Nations Statistics Division (UNSD) published the handbook of national accounting, *Integrated Environmental and Economic Accounting* (UN 1993), commonly referred to as SEEA. The SEEA was issued as an "interim" version of work in progress since discussion of concepts and methods had not come to a final conclusion.

18. As a result of the publication of the SEEA handbook, several developing and developed countries started experimenting on the compilation of the SEEA. The London Group on Environmental Accounting was created in 1994 to provide a forum for practitioners to share their experiences on developing and implementing environmental accounts. Increased discussion on concepts and methods of environmental accounting, accompanied with country experience led to a convergence of compilation methodologies for selected modules of the SEEA.

19. The handbook *Integrated Environmental and Economic Accounting - An Operational Manual* prepared by the Nairobi Group (a group of experts from national and international agencies and non-governmental organizations established in 1995) and published by UNSD and the United Nations Environment Programme (UNEP) in 2000 reflected the on-going discussion since the publication of the SEEA in 1993. Based on the experiences in developed and developing countries, the handbook provides step-by-

step guidance on how to implement the more practical modules of the SEEA. It also elaborates the uses of integrated environmental and economic accounting in policy-making.

20. In parallel with the work of the Nairobi Group, the international agencies in cooperation with the London Group worked on the revision of the SEEA. The revision was carried out through a series of expert meetings and was built upon a wide public discussion process. The revised SEEA, SEEA-2003, is an important step forward towards the standardization and harmonization of concepts, definitions and methods in integrated environmental and economic accounting.

21. The SEEA-2003 comprises four categories of accounts:

- asset accounts, which record stocks and changes in stocks of natural resources like fish stocks, as well as resources which may be related to fish health, such as land use, forestry, and ecosystems;
- flow accounts for pollution, energy and materials, which provide information at the industry level about the use of energy and materials as inputs to production and final demand, and the generation of pollutants and solid waste. These accounts are linked to the Supply and Use Tables of the SNA, which are used to construct input-output (IO) tables;
- environmental protection and resource management expenditure accounts, which identify expenditures in the conventional SNA incurred by industry, government and households to protect the environment or to manage resources. Also included in this part of the accounts are items such as taxes and property income received from the sale of, for example, fishing licenses or purchase of the right to fish;
- environmentally-adjusted macroeconomic aggregates, which consider how the economic aggregates may be adjusted for the impact of the economy on the environment. Two sorts of adjustments are considered: those related to depletion and those related to degradation.

Each component of the SEEA and its relationship to the SNA are discussed in greater detail in Chapters II and III.

22. The SEEA framework allows the compilation of both physical and monetary asset accounts and flow accounts for pollution, energy and materials. The issue of valuation is a central problem in environmental accounting. Controversy about valuation stems from two major sources: disagreement over concepts of sustainability and concern about the reliability of economic valuation of some environmental benefits, especially non-market benefits such as ecosystem services and biodiversity conservation. Both these issues are discussed below, and valuation methods will be described in greater detail in Chapters II and III.

2. Concepts of sustainability

23. While this report cannot review all the literature about sustainability, a brief discussion of the topic is necessary in order to understand some of the issues underlying the different approaches to environmental accounting. (For a comprehensive review, see Pezzey 1989, Pezzey and Toman 2002.) Because environmental accounting is a view of the environment primarily from an economic perspective, this discussion will focus on economic concepts of sustainability. John Hicks is generally recognised as having provided the first clear statement about economic sustainability when he defined income in the following manner:

> …income is the maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning (Hicks 1946).

24. Hicks' statement has generally been interpreted as the amount of income that can be spent without depleting the wealth that generates the income. Hence, sustainability requires non-decreasing levels of capital stock over time, or, at the level of the individual, non-decreasing per capita capital stock. For Hicks, sustainable income was a question of management of a portfolio of assets. Indicators of sustainability could be based on either the value of total assets every period, or by the change in wealth. A proper measure of sustainability requires that all assets be included: produced capital, natural capital, human capital and social capital. In the past, only produced capital was recorded in the SNA, but the recognition of the importance of natural capital has led to the expansion of the asset boundary to include these assets. (Human and social capital have not yet been included because there is no agreement about how to measure them; they are not discussed further.)

25. Sustainability can be defined as strong or weak, reflecting in large part different assumptions about the degree to which one form of capital can substitute for another (Pearce *et al*. 1989). Weak sustainability requires non-declining wellbeing over time. Weak sustainability is grounded in standard assumptions of neoclassical economics about production and welfare, in particular, virtually unlimited substitutability between produced capital and natural capital as inputs to production. This assumption appears reasonable enough for many small tradeoffs between manufactured and natural capital, but is it implausible at the extreme, when severe natural resource constraints are reached? The relative prices of manufactured capital and different kinds of natural capital reflect their relative scarcity and the possibilities for substitution, given current technology. As a resource becomes scarce, its price will rise - eventually becoming infinite when a constraint is reached, which, in effect, eliminates the possibility of further substitution. As long as market prices reflect true scarcity, the prices for scarce resources will signal these constraints.

26. Under these assumptions, weak sustainability only requires that the combined *value* of all assets remains constant. It is possible, indeed it may be desirable, to substitute one form of capital for another, i.e., natural capital can be depleted or the environment degraded as long as there are compensating investments in other types of capital: produced capital, human capital, or another type of natural capital. For example,

minerals may be extracted to fund public infrastructure development or education. One of the major advantages of weak sustainability is that it provides a way to aggregate very different physical phenomena into a single indicator of sustainability, based on the numeraire of their economic value. Consequently, measurement of weak sustainability requires accurate estimation of the monetary value of environmental stocks and functions.

27. The major challenge of weak sustainability is to accurately measure, in monetary terms, all the benefits lost and gained in the transformation of one form of capital into another. The problem is that some resources and environmental functions, such as global climate, biodiversity or ecosystems, may not have market prices; other resources may have market prices that do not reflect their true scarcity. Proponents of weak sustainability recognise that it is extremely difficult to estimate values for many natural assets when:

- resources or environmental functions do not have market prices such as global climate or biodiversity;
- resources or environmental functions have current market prices, but there are no futures or insurance markets to determine their market prices over the time horizon relevant for sustainability, e.g., for the next few generations, 100 years or more;
- there is great uncertainty about the future of ecosystem functioning, including the possibility of threshold effects and irreversibilities.

28. Strong sustainability is based on the concept that the substitutability between produced capital and natural capital is limited, and that in some instances, the limits are being rapidly approached. It emphasizes maintaining the environmental functions of natural capital, especially given uncertainty about the effect of ecosystem degradation on viability and resilience in the future. Philosophically, many proponents of strong sustainability derive this approach from a strong sense of environmental stewardship based on rights-based ethics, and concepts of community rather than the individualistic concepts underlying the utilitarian analysis of neoclassical economics. Intra- as well as inter-generational equity is important. This approach has led to a set of general guidelines for strong sustainability associated with the precautionary principle:

- renewable resources, such as fish or forests, should be exploited only at the natural rate of net growth;
- the use of non-renewable resources should be minimized and, ideally, used only at the rate for which renewable substitutes are available (e.g., fossil fuel should be replaced by renewable energy over time);
- emissions of wastes should not exceed the assimilative capacity of the environment and environmental functions critical to life support should be maintained.

29. These rather restrictive guidelines imply that little or no change to natural systems should occur, and that substitution between natural and manufactured capital should be quite limited. An example of a policy that implements strong sustainability is

the Endangered Species Act of the United States. The act requires that endangered species must be protected, regardless of the costs and benefits of doing so. Such policies may not be overly burdensome when applied to a select set of resources. However, the application of these principles to all natural resources has not been found practicable by any society at this time.

30. In further work addressing the substitution possibilities, it was recognised that some natural assets constitute 'critical capital' - natural capital that is both essential for human survival and irreplaceable - that should be maintained according to the principles listed above. Other natural capital, such as some minerals, may not be essential and irreplaceable, and could be transformed either into other forms of natural capital (e.g., forestland converted into agricultural land) or other forms of capital without affecting the sustainability of the economy.

31. The corresponding measures of strong sustainability, incorporating the concept of critical capital, would be partly monetary (for those assets, produced and natural, which are not critical and for which substitution is possible) and partly physical, for each major category of critical natural capital, e.g., carbon stocks in the atmosphere, etc. It can be very difficult for policy-makers to weigh the different physical measures and perhaps the major drawback of strong sustainability is the lack of a single-valued indicator of sustainability. Some attempts have been made to construct an aggregate indicator based on physical accounts (e.g., 'ecological footprint,' Material Intensity of Production), or partially aggregated indicators (NAMEA theme indicators), but aggregate or composite physical indicators have often serious limitations. Furthermore, they neglect the economic dimension of capital.

32. One need not take a hard line on sustainability, and one of the advantages of the SEEA is that it offers a framework to support both approaches. For weak sustainability, the value of total capital may be used, supplemented by physical measures of critical natural capital. Proponents of strong sustainability can also benefit from the SEEA monetary accounts. They may find it useful for policy to know the best estimate of the economic value of a resource, such as fish stocks, even if they are not satisfied with an indicator of sustainability based on the sum of the economic value of natural capital and environmental functions.

3. Fisheries management and concepts of sustainability

33. The fundamental objective of fisheries managers is to maximize the welfare derived from fishery resources by present and future generations. This requires the conservation of these resources and limiting harvesting rates to a sustainable level. The principles of fisheries management are therefore consistent with strong sustainability.

34. Fisheries resources can be exploited at different sustainable harvesting rates by limiting annual harvest to the net annual increment of the resource. The maximum sustainable harvesting rate, more often referred to as the Maximum Sustainable Yield

(MSY) is enshrined as a target or limit reference point in all modern international agreements on fisheries. The use of MSY as a target reference point is subject to critique by both fisheries economists and biologists. From an economic point of view, at the stock size producing MSY, a fishery may already show serious signs of economic over-fishing (i.e., fishing at a level where a significant part of the potential resource rent is wasted). On the other hand, fishing at the MSY level may not only increase the instability of the ecosystem but also neglect species interactions (Garcia *et al.* 1986; 1996). In addition, given the inherent uncertainties in estimating stock abundance, a precautionary approach to resource conservation may require targeting stock sizes higher than those producing MSY. The idea of precaution was incorporated into the 1995 UN Fish Stocks Agreement (UN 1995).

35. In practice, fisheries have not always been conserved. Many fisheries are presently over-exploited, affecting their capacity to reproduce and cope with environmental change, and leading to poor economic performance. In addition, some fisheries are suffering due to other changes in the ecosystem, such as coastal development and associated pollution.

36. In an ecosystem-based framework, fisheries are viewed as exploiting natural capital consisting of the target, associated and dependent species, and their environment plus some more intangible elements such as genetic information. An ecosystem-based perspective also requires that the impacts of other economic activities on the ecosystem are considered. Extending the strong sustainability approach that guides fisheries management requires that neither fishing activities nor other economic activities lead to changes in biological and economic productivity, biological diversity, or ecosystem structure or function from one generation to the next (Garcia 2001; National Research Council 1998).

37. In practice, ecosystem function in many coastal areas has not been maintained any better than fisheries. More importantly, with high and increasing concentrations of population and economic activity in coastal areas, coastal development policy is usually not guided by the principle of strong sustainability. Most often, policy-makers attempt to weigh the trade-offs among competing users of resources and ecosystems, based on a range of criteria including ecological sustainability, employment and income creation, and political expediency. This has created a potential conflict between the objectives of fisheries managers and of regional or macro-economic managers.

D. Objectives of the handbook

38. Institutionalisation of fisheries resource accounts requires cooperation among fisheries experts, statisticians familiar with national accounting concepts, and policy analysts. The fishery resource accounts can be implemented alone or as part of a more comprehensive environmental accounting programme. The purpose of this handbook is to expand on the SEEA to develop the System for Integrated Environmental and

Economic Accounting for the Fisheries (SEEAF). The SEEAF has several major objectives:

- *Clarify the SNA and SEEA concepts and expand them for fisheries and related resources.* Such resources include ocean areas, inland lakes and rivers, and coastal areas surrounding these water systems, as well as the environmental services of the biological stocks living in these aquatic systems.

  The main focus of this handbook will be on accounting for commercial fisheries and aquaculture and the natural resources they exploit. But coastal areas and the biological systems in oceans, lakes and rivers clearly have other economic benefits. Coastal areas are popular recreational areas and the basis for flourishing tourist industries. Oceans and other water systems are important dumping places for residuals from firms and households, and the oceans are extremely important for the earth's weather systems. In some cases the different uses of these natural assets complement each other while in other cases they inflict cost on each other. The handbook will touch upon these, often quite complicated, issues, but it will not discuss them in detail mainly because of data limitations.

- *Harmonise accounting practices for fisheries so that accounts are comparable across all countries.* Harmonised accounts will support international comparison and analysis. SEEAF will provide internationally applicable principles and methods for accounting for the fisheries sector and its contribution to the national income and improve compatibility of accounting practices, based on the principles and definitions laid out in the SNA and the SEEA.

  There are some limitations to the ability to achieve harmonization. The SEEAF is bound to be a compromise between economic theory and available data, and will vary among countries due to their differing needs and data compilation capacities. Furthermore, the SEEA and SEEAF handbooks should be regarded as a work-in-progress. Where no consensus about methodology has been reached, all different approaches are presented, their merits and shortcomings discussed. Statisticians and economists will continue to explore the different methods, and hope to resolve areas of disagreement through further experience with the SEEA.

- *Promote accounting for the fisheries sector.* Fisheries accounts are useful for policy makers both within the fisheries sector as well as at the macroeconomic level. The SEEAF handbook includes a chapter on policy applications of the fisheries accounts, as well as case studies from several countries, which indicate what policy-makers might gain from fisheries accounts.

- *Provide a guide and a training tool.* The SEEAF is intended for fisheries statisticians, economists, biologists, sociologists and staff of agencies responsible for fisheries management and coastal management as well as for national accountants entrusted with the preparation of fisheries accounts. The handbook provides step-by-step guidance for the implementation of SEEAF using case studies.

39. The handbook is organised as follows: Chapter II discusses the conceptual framework of the SEEAF and its relationship to the SNA. Chapter III discusses the empirical implementation of the SEEAF, including issues such as how the economic

value of fish stock is estimated. Chapter IV reviews the uses of the SEEAF for constructing indicators and conducting policy analysis. It includes examples from fisheries accounts already compiled by some countries, as well as indications of additional analysis that could be carried out with the SEEAF. This chapter also discusses the links between the SEEAF and sustainable development indicators for fisheries. Chapter V provides case studies from four countries for which fisheries accounts have been constructed on a pilot basis: Norway, Namibia, Iceland and the United States of America.

CHAPTER II: THE FRAMEWORK FOR FISHERIES RESOURCES ACCOUNTING

A. Introduction

40. Economic information on the fisheries (e.g. production of the fishing industry, manufacturing of fish products, consumption of fish products by households, etc.) has been compiled in the SNA mostly in monetary terms. Physical information about the fish stocks, catches, and physical flows of fish and fish products is often compiled by fisheries ministries according to concepts, definitions and classifications which respond to specific regulatory or administrative purposes and often are not consistent with the economic statistics. The objective of this handbook is to provide guidelines on how to integrate the fishery data with the economic data in an accounting framework in order to obtain a consistent data set, which can be used for the derivation of a coherent set of indicators and for performing more in-depth analysis of the impact of fishery policies on the economy and environment and economic policies on the fisheries sector.

41. An accounting approach is designed to bring a more systematic discipline to the organisation of environmental statistics. It does this by:

- encouraging the adoption of standard classifications in environmental statistics;
- encouraging the development of comprehensive and consistent data sets over time; and
- facilitating international comparisons.

42. The need for an internationally agreed accounting system for monetary flows in the economy has long been accepted and the SNA has been widely used in most countries of the world for many years. The SNA serves purposes of economic analysis, decision-taking and policy-making. Its figures, such as gross domestic product (GDP) and national income, are comparable across countries and credible in virtue of the fact that they are derived from an internationally recognized standard.

43. A country's system of national accounts includes two main categories: *flows* of goods and services and *stocks* of assets used in the production of goods and services. Another name for the stocks is *capital*. Both stocks and flows are measured in monetary terms. The objective of the national accounts is thus to measure not only the flows of

goods and services resulting from production (GDP or net domestic product (NDP)) but also the capital stock itself, the country's economic wealth.

44. The 1993 SNA explicitly included natural resources in its balance sheets and accumulation accounts, and introduced environmental accounting in a satellite accounting framework (1993 SNA, chaps. XII and XXI). Naturally occurring assets such as land, subsoil assets and non-cultivated fisheries and forests are included in the balance sheets provided that institutional units (households, government units, corporations and non-profit organizations) exercise effective ownership over these assets and draw economic benefits from them. The two criteria of enforced ownership and actual and potential benefits make them "economic assets" (1993 SNA, para. 10.2), qualifying these assets for inclusion in the balance sheets and asset accounts.

45. The 1993 SNA also describes the links between the SNA and environmental accounting in a separate chapter on satellite accounting. The introduction of satellite accounts enhances the analytical capacity of the system without overburdening or disrupting it (1993 SNA para 21.4). Satellite accounts, and in particular, fisheries resources accounts, allow for:

- the provision of additional information on specific concerns (e.g. production of boats and fishing gears, aquaculture facilities, etc.);
- the use of complementary concepts, definitions and classifications of fishery resources (e.g. classification of protection of fish habitats and fishery management expenditures; etc.);
- coverage of costs and benefits of human activities (e.g. depletion of fish stocks, degradation of the marine ecosystems);
- further analysis of data by means of relevant indicator and aggregates (e.g. a wide range of sustainability indicators for fisheries can be derived from the accounts, as well as environmentally-adjusted macro-aggregates);
- linkage of physical data with monetary accounts (e.g. physical accounts for stocks and flows, emission accounts linked to the production accounts, etc.).

46. The SEEAF, presented here, is an attempt at integrating information related to the fisheries sector with the conventional accounts. A detailed discussion on the framework is presented below.

B. Some concepts of the 1993 SNA relevant to fisheries resources accounting

47. Integrated environmental and economic accounting is a satellite system of the SNA. It has a similar structure to the SNA and uses concepts, definitions and classifications consistent with the conventional accounts. Here we describe those concepts of the SNA that are used in the SEEA and in particular in the SEEAF.

1. Main economic agents

48. The economy is composed by five sectors: the non-financial corporation sector, the financial corporation sector, the general government sector, the non-profit institutions serving households sectors, and the households sector. These sectors are themselves composed by resident institutional units which are economic entities that are capable, in their own right, of owing assets, incurring liabilities and engaging in economic activities and in transactions with other entities (1993 SNA paragraph 4.2).

49. When looking at the institutional units in their capacity as producers, they are referred to as enterprises. They can be involved in a range of various productive activities which may be very different from each other with respect to the type of production processes carried out and also the goods and services produced. Therefore to study production, it is more useful to work with groups of producers who are engaged in essentially the same kind of production. These are called establishments and are institutional units disaggregated into smaller and more homogeneous units. The SNA defines industries as groups of establishments. The production accounts and generation of income accounts are compiled for industries as well as sectors.

50. The categories of the classification of industrial economic activities the International Standard Industrial Classification of All Economic Activities (ISIC, Rev.3). and the functional classifications, namely the classification of total outlays of government by functions, the classification of outlays of producers by purpose and the classifications of environmental protection activities, relevant to the fisheries sector are described in more detail below.

2. Concept of residency

51. It is important to clarify the concept of residency as it applies to the fisheries as the residency status of producers which determines the limits of domestic production and affects the measurement of GDP and many important flows in the 1993 SNA. Residence is not based on nationality or legal criteria but on the center of economic interest of an institutional unit in the economic territory of a country. In order to understand the concept, the center of economic interest and the economic territory of a country have to be defined.

> An institutional unit is said to have *a centre of economic interest* within a country when there exists some location within the economic territory on, or from, which it engages, and intends to continue to engage, in economic activities and transactions on a significant scale either indefinitely or over a finite but long period of time. In most cases, a long period of time may be interpreted as one year or more (1993 SNA, para 4.15).
>
> The *economic territory* of a country consists of the geographic territory administered by a government within which persons, goods, and capital circulate freely. The economic territory of a country includes, among other things the

airspace, territorial waters, and continental shelf lying in international waters over which the country enjoys exclusive rights or over which it has, or claims to have, jurisdiction in respect of the right to fish or to exploit fuels or minerals below the sea bed (1993 SNA, para 14.9).

52. The 1993 SNA further refines the concept of economic interest for units using mobile equipment, such as ships that operate outside the economic territory in which the units are resident - either in (a) international waters or airspace, or (b) in other economies. In the first case (a), these activities should be attributed to the economy of residence of the operator (the same applies if the activity takes place in more than one economy during the course of, but for less than a year). In the second case (b), the unit is a resident of the economy in which the activity (production) occurs, if accounted for separately by the operator and is so recognized by the tax and licensing authorities there. Otherwise, the activity may be attributed to the country of residence of the original operator (1993 SNA para.14.25).

53. In the particular case of ships flying flags of convenience, it is often difficult to determine the residence of the operating unit, because of complex arrangements involving the ownership, mode of operation and chartering of such ships, and the fact that the country of registry in most instances is different than the country of residence of the operator (or owner). Nonetheless, in principle, the shipping activity is to be attributed to the country of residence of the operating unit (1993 SNA para 14.26).

54. Earlier international manuals (UN 1968 and IMF 1993) recommended that fish production be allocated to the country of registration of the vessel. With the increasing practice of registering ships under flags of convenience, this practice became unrealistic and, as a result, the 1993 SNA and the corresponding balance of payments manual recommend the attribution of production to the country of residence of the operator. However, fisheries statistics do not use the same concept when collecting data (see Chapter III, section B.1). Moreover, the determination of residence of the operator of the fishing vessel has no reference to where the fish is caught or landed. These issues are further discussed below.

3. Principal identities of the SNA accounting framework

55. The conventional accounts consist of an integrated sequence of accounts which describe the behaviour of the economy from the production of goods and services – generation of income – to how this income is made available to various units in the economy and how it is used by these units. The SNA has identities among each account and between accounts that ensure the consistency and the integration of the system.

56. A particularly useful identity for the SEEA involves the total supply and total use of products. In a given economy, a product can be the result of domestic production or production in another territory – Imports. Hence

Total Supply = Domestic Production + Imports.

57. On the other side, the good and services produced can be used in various ways. They can be used by: a) industries to produce other goods and services (intermediate consumption); b) households and government to satisfy their needs or wants (final consumption); c) they can be acquired by industries for future use in the production of other goods and services (capital formation); and finally they can be used by the economy of another territory (exports). Therefore

Total Use = Intermediate Consumption + Households/Government Final Consumption +

+ Capital Formation + Exports.

Total supply and total use as defined above have to be equal. In the SNA this identity is expressed only in monetary terms, but in the SEEA it has to hold also when the accounts are compiled in physical terms.

58. Another identity of the SNA involves the generation of value added. Gross value added is the value of output less the value of the goods and services, excluding fixed assets, consumed as inputs by a process of production, (intermediate consumption); and is a measure of the contribution to GDP made by an individual producer, industry or sector. When we take into account also the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage (consumption of fixed capital), we then obtain net value added:

Gross Value Added = Output – Intermediate Consumption

Net Value Added = Gross Value Added – Consumption of Fixed Capital.

59. Once the value added is generated, it is decomposed in compensation of employees, to pay or receive taxes and subsidies on production and operating surplus:

Value added = Operating Surplus + Compensations of Employees + Taxes – Subsidies.

60. Another identity of the SNA particularly useful in the SEEA involves assets. This identity describes how the stock of some assets at the end of an accounting period is the result of the initial stock level of the asset (opening stock); the value of a producer's acquisitions, less disposals, of fixed assets during the accounting period, changes in inventories and acquisition less disposal of valuables (gross capital formation); the consumption of fixed capital; changes in value of assets due to changes in their prices (holding gains/losses on assets); and other changes due neither to transactions between institutional units, as recorded in the capital and financial accounts, nor to holding gains and losses (other changes in the volume of assets)

closing stocks = opening stocks + gross capital formation – consumption of fixed capital

+ holding gains/losses on assets + other changes in volume of asset.

C. The framework

61. gives a simplified representation of the SEEA accounting framework for fishery resources, SEEAF. The figure shows how the horizontal supply and use accounts overlap with the vertical asset accounts, where supply and use constitute part of the changes in stocks of the assets.

62. The unshaded boxes represent monetary accounts that are already part of the SNA. The boxes with double border represent the internal satellite accounts and are compiled in monetary terms. The term "internal satellite accounts" is used to indicate a rearrangement of the existing SNA transactions: no new flows are added but those which are there may be presented and aggregated differently and in some case separated out from existing records by a process of "deconsolidation". In the SEEAF they indicate expenditures for protection of fish habitats and fisheries management accounts. The grey boxes represent accounts that are introduced in the SEEA and are not covered in the SNA. They are measured in physical units. The grey boxes with double border represent accounts which are compiled both in physical and monetary terms.

63. The SEEAF asset accounts cover:

- produced assets
  - capital used for fishing and manufacturing of fish products (e.g. boats, fishing gears, etc.);
  - cultivated fisheries (e.g. aquaculture)
- non-produced assets, which include wild fish stocks, a portion of which is exploited.

The SEEAF includes also asset accounts for water ecosystems, which provide habitat for fishery resource. They are not presented in for ease of presentation. Ecosystem accounts can be represented by opening and closing stocks which consist of qualitative characteristics of the water ecosystems (e.g. size, health, quality of the water, etc.).

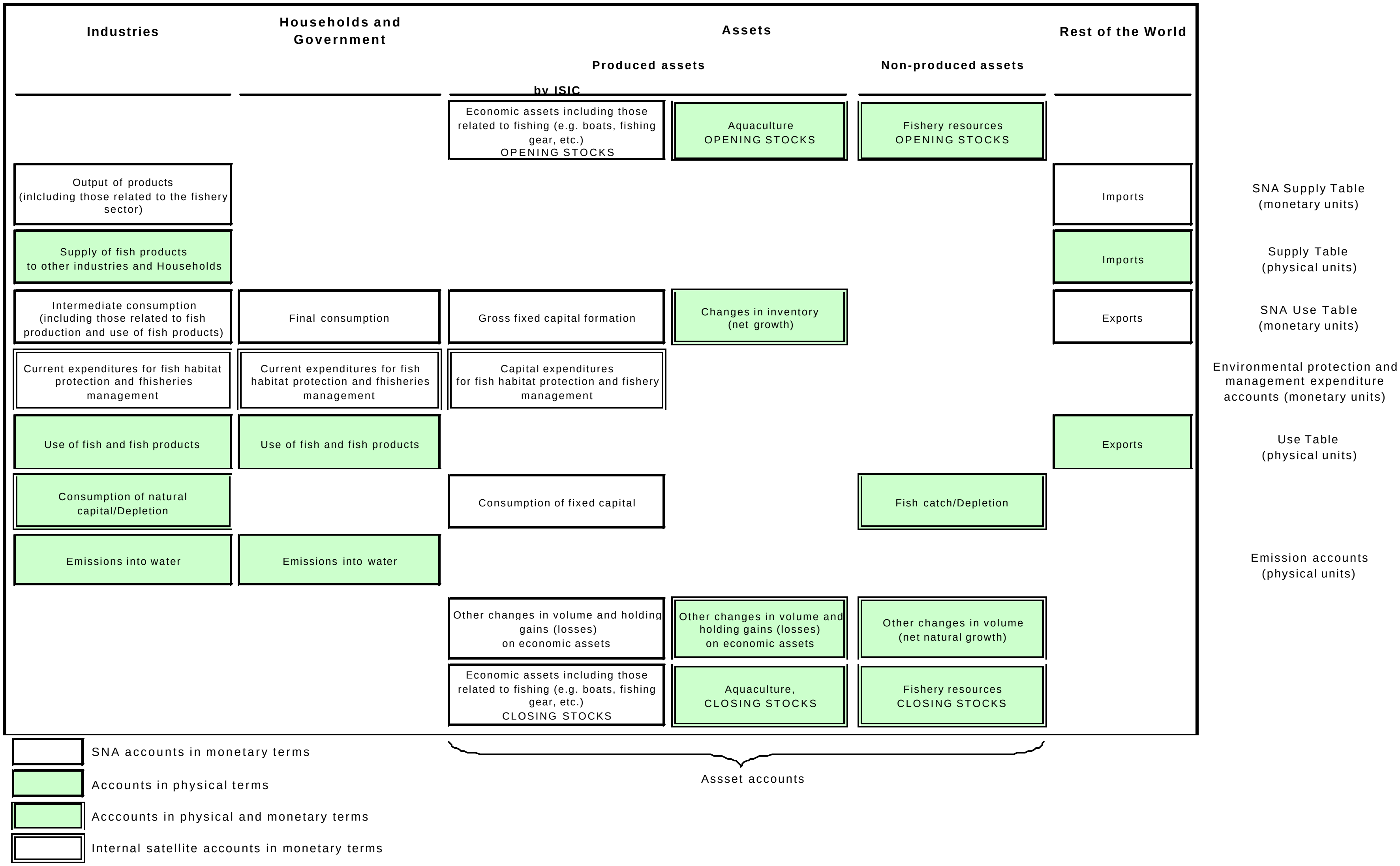
64. The asset accounts for produced and non-produced assets present the stocks of assets related to fisheries at the beginning and end of the accounting period and changes therein. The changes in stocks are disaggregated according to whether they are due to human activities (e.g. capital formation in boats, net growth of fish in aquaculture, fish catch, etc.), or to natural causes (e.g. natural growth and mortality in capture fisheries).

65. The SEEA allows for the inclusion of costs for the depletion and degradation of natural assets in the production accounts. This constitutes a major deviation from the conventional accounts where the depletion and degradation of (economic, non-produced) natural assets are recorded as "other changes in volume" in the asset accounts. In consistency with the conventional accounts, changes in environmental assets that cannot be attributed to production and consumption, such as impacts of natural disasters and natural growth, are recorded as "other changes in volume of assets".

66. As illustrated in , the SEEA flow accounts incorporate environmental concerns partly by rearranging items already in the SNA and partly by adding new items:

- *Expenditures for protection of fish habitats and resource management accounts.* They are already included in the SNA, but the SEEA reorganizes these expenditures in order to make them more explicit, and thus, more useful for policy analysis. In this sense, these accounts are similar to other satellite accounts, such as transportation or tourism accounts, which do not necessarily add new information, but reorganize existing information. This set of accounts has three quite distinct components:
  - expenditures for protection of fish habitat and resource management, by industries and households;
  - activities of industries that provide environmental protection services;
  - environmental and resource taxes and subsidies.
- Resources produced and used by industries and households. They are usually measured in physical and monetary units. To the extent that the extraction, processing and use of resources take place through markets, the monetary values of these transactions are included in the core SNA.
- Emission accounts, usually measured in physical units, produced by industries and households. Emissions into water may have an impact on the fish habitat and for this reason they are included in the SEEAF framework. Degradation caused by the emissions into water can be valued. For a detailed discussion on valuation techniques for degradation, see Chapter 9 of the SEEA-2003.

Figure II.1 Framework for Integrated Environmental Economic Accounts for Fisheries (SEEAF)



D. Special characteristics of the fisheries accounts

67. The fishing industry has several unique characteristics that are relevant to the construction of SEEA fisheries accounts:

a) Wild stocks may migrate between different countries' EEZ's and between EEZ's and the open seas, which are international waters. These straddling and migratory stocks pose special challenges for management and accounting since they do not occur exclusively in one country's economic territory
b) The treatment of catch differs according to whether the stock is cultivated or non-cultivated.
c) The abundance and health of wild fish stocks are increasingly affected by water pollution and by the degradation of fish habitats so that fisheries management requires some accounting for these related resources.

These characteristics are discussed in relation to the construction of fisheries accounts in the next sections.

E. Environmental assets and fishery resources in the 1993 SNA and SEEA-2003

68. SEEAF discusses at great length the compilation of asset accounts for fisheries. It is important at this stage to introduce a discussion on what is considered an environmental asset in the SNA and in the SEEA-2003 with particular reference to the fisheries.

69. In economic accounting the definition of an asset is associated with the conferring of economic benefits on the owner of the asset. Thus the 1993 SNA defines assets as:

> entities over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time (1993 SNA, paragraph 10.2).

70. In particular, environmental assets are defined as:

> …naturally occurring assets over which ownership rights have been established and are effectively enforced, qualify as economic assets and [are to] be recorded in balance sheets. [Such assets] do not necessarily have to be owned by individual units, and may be owned collectively by groups of units or by governments on behalf of entire communities. In order to comply with the general definition of an economic asset, environmental assets must not only be owned but be capable of bringing economic benefits to their owners, given the technology, scientific knowledge, economic infrastructure, available resources and set of relative prices prevailing on the dates to which the balance sheet relates or expected in the near future (1993 SNA, paragraphs 10.10 and 10.11).

71. Environmental assets that do not meet the above criteria fall outside the asset boundary of the 1993 SNA. In particular, fishery resources over which effective ownership rights cannot be established are excluded. With the increased management of the fishery resources, a greater number of fisheries resources fall within the SNA asset boundary.

72. A distinction is made between those fishery resources, which come into being as a result of economic production and those which occur in nature but which are drawn into the economy. These assets are described as produced and non-produced respectively. The words cultivated and non-cultivated are used as synonyms for produced and non-produced. For cultivated fishery resources, a further distinction is made between fish which yield the same product repeatedly over a period of time, and fish which yield a product only once.

73. In the SNA, an asset, even an environmental asset, is defined in terms of the "benefit" limited to the provision of income or a stock of wealth which can be converted to monetary terms. For the SEEA-2003, the concept of an environmental asset is linked to the provision of environmental "functions". The environment is defined as the naturally produced physical surroundings on which humanity is entirely dependent in all its activities. The various uses to which these surroundings are put for economic ends are called environmental functions. When the use of one function is at the expense of the same or another function now, or is expected to be so in the future, there is competition of functions. Thus the function of the oceans as a sink of pollutants is in competition with the oceans' function as habitat for marine life including fish stocks.

74. Three types of competition among environmental functions can be distinguished: spatial, quantitative and qualitative. Spatial competition occurs when the amount of space available is inadequate to satisfy existing or expected future wants. Quantitative competition covers fish which may become quantitatively insufficient in the future. Qualitative competition covers the case where changes in the type of species or substances cause changes to other possible uses such as physiological functioning and habitat for other species.

75. Tracing the forces leading to competition of functions shows that the current use of the environment for production and consumption inhibits current and future availability of environmental functions, including those needed for future production and consumption. It is the need to maintain these functions in future and to investigate how present economic activity threatens them which explains the need to integrate environmental and economic accounting in both physical and monetary terms.

76. The functions provided by the environment can be grouped into: resource functions, sink functions and service functions. The economy benefits from the use made of these functions. For this reason the SEEA extends the SNA asset boundary to include not only use benefits but also non-use benefits as they provide a variety of services (often difficult to quantify) to humans. The SEEA asset boundary thus includes all land, ecosystems and natural resources. In the case of fisheries, all fish stocks and

aquatic ecosystems are included in the SEEA-2003. The complete SEEA asset classification is included in Annex I.

F. Physical asset accounts for fisheries resources

1. SEEA asset classification for aquatic resources

77. The SEEA asset classification for aquatic resources covers fish, shellfish and other aquatic resources such as sponges and seaweeds as well as aquatic mammals such as whales as follows:

EA.143 Aquatic resources
- EA. 1431 Cultivated
  - EA.14311 For harvest
  - EA.14312 For breeding
- EA.1432 Non-cultivated

Resources, such as marine ecosystems, that are related to fisheries are discussed at the end of this section. This handbook focuses mostly on accounting for fisheries resources and only briefly touches upon ecosystem accounts.

78. Aquatic resources distinguish cultivated assets from non-cultivated assets. Following the FAO definition of aquaculture, the SEEA considers all farmed aquatic organisms to be cultivated assets, and all types of wild, enhanced and ranched fish stocks as non-cultivated assets, also known as 'capture fisheries.' Capture production is much greater than the production of aquaculture both globally and in marine waters but not in inland waters. However, aquaculture is increasingly becoming an important activity.

79. A cultivated asset is a result of a production process, which in the SNA sense does not consist of just legislative control. Examples of production are: (i) control of regeneration (for example, controlling the fertility of the fish); and (ii) regular and frequent supervision of the fish, attend to illnesses, or restrict the area over which fish may roam to be within a supervised or otherwise designated area. It should normally be the case that the process of production has to be one that was classified to the fishing industry. It is not sufficient that it only be part of government administration. Further, the level of this production activity has to be significant relative to the value of the resource and directly connected with the fish stock in question.

80. Like the SNA, the SEEA separates cultivated resources into those used exclusively for breeding and those raised for harvest, although it is not very common to keep fish purely for breeding purposes. Fish-for-harvest that mature over more than one year are treated as inventories, a work-in-progress.

2. Structure of physical asset accounts

81. The physical asset accounts show the fish stocks at the beginning and end of the accounting period and changes therein. The components of stock accounts for each category of fishery resources are shown in Figure II.2.

Figure II.2 Physical asset accounts for aquatic resources in the SEEAF

(measured in tons or other physical units)

EA.1431 Cultivated aquatic resources		EA.1432 Non-cultivated aquatic resources
EA.14311 For harvest	EA.14312 For breeding	
Opening stocks	Opening stocks	Opening stocks
Change in inventory/growth	Net growth of breeding stock	Catch
Other changes in volume of assets (catastrophic losses)	Other changes in volume of assets (catastrophic losses)	Other changes in volume of assets (net natural growth + catastrophic losses)
Closing stocks	Closing stocks	Closing stocks

82. The accounting period is typically one year, corresponding to the accounting period for the national accounts. *Opening stocks* record the volume in tons at the beginning of the accounting period, and *Closing stocks* record the volume at the end of the accounting period. Changes in stocks during the year are divided into:

- changes that result from economic activity (c*hanges in inventory*, *net growth of stock*, or *catch*);
- changes due to other factors (*other changes in volume*).

The role of economic activity is different for cultivated and non-cultivated fisheries, so the treatment of common items such as catch and natural growth differs for the two categories of fish.

83. For cultivated assets, stock raised for harvest over a period more than one year is treated as a work-in-progress, so the changes in stocks are recorded as *Changes in inventories*. For cultivated assets kept as breeding stocks, annual changes are measured as the *Net growth of the breeding stock*, which is equivalent to gross fixed capital formation minus consumption of fixed capital (losses of breeding stock). *Other changes in the volume of assets* includes catastrophic losses due to, for example, environmental events or disease, uncompensated seizure, and other factors that are not directly related to economic activity.

84. For non-cultivated assets, the source of change resulting from economic activity is the annual *Catch*. *Other changes in the volume of assets* include catastrophic losses but also the net natural growth of the stock (births or recruitment minus natural mortality). The reason for including net natural growth as part of *other changes in*

volume is that this growth is not under the control or management of economic activities, in contrast to cultivated fish stocks.

3. Accounting for straddling and highly migratory stocks

85. Fish stocks that straddle or migrate between EEZ's and the high seas, or which live permanently in the high seas might not qualify in the SNA as economic assets. The reason is that bilateral, multilateral or international agreements on the managements of such stocks might not confer the kind of ownership rights over such resources that would qualify them as economic assets in the 1993 SNA.

86. The term "shared fish stocks" is understood by the FAO (see, in particular, the FAO Code of Conduct for Responsible Fisheries, Article 7) to include the following:

(a) fish resources crossing the EEZ boundary of one coastal State into the EEZ(s) of one, or more, other coastal States – transboundary stocks;

(b) highly migratory species, as set forth in Annex 1 of the 1982 UN Convention on the Law of the Sea (UN 1982), consisting, primarily, of the major tuna species. Being highly migratory in nature, the resources are to be found, both within the coastal State EEZ, and the adjacent high seas;

(c) all other fish stocks (with the exception of anadromous/catadromous stocks) that are to be found, both within the coastal State EEZ and the adjacent high seas – straddling stocks;

(d) fish stocks to be found exclusively in the high seas – discrete high seas fish stocks. Clearly, these categories are not mutually exclusive. One can find many examples of fish stocks that fall into Category (b), or Category (c), which also fall into Category (a).

87. It might be argued that where an international agreement has established the total allowable catch (TAC) and how it is shared among the participating fishing nations that a sufficient degree of control has been exercised to consider the stock as an asset and to attribute portions of the asset to member countries. For straddling, highly migratory and high seas fish stocks, it is suggested that physical accounts be compiled identifying, whenever possible, fish catch by country and aggregate stock size. Valuation may be difficult, as fleets of different countries would depict different cost structures resulting in non-comparability.

4. Measuring changes in stock for cultivated and non-cultivated fisheries

88. The production boundary of the SNA includes all activities carried out under the responsibility, control and management of a resident institutional unit. In the case of cultivated fisheries raised for harvest, the growth of fish in fish farms is treated as a

process of production whether the fish are harvested or not. The output should be recorded as being produced continuously (that is, as a work-in-progress) by distributing the value of the slaughtered fish over time in proportion to the costs incurred in each period. If data are unavailable, or the future selling price is expected to fluctuate, additions to work in progress could be valued as the costs incurred during the period plus some mark-up to account for operating surplus or mixed income.

89. All capture fishing (the catch of non-cultivated fish) by residents should be recorded as production, including, data permitting, that part of the catch which fishermen use for feeding their families and the landings of catches from recreational fishing even if not sold in the market. The catches used for own consumption should be valued at the prices for which they could be sold in the market excluding any taxes payable at the time of sale. The catch from illegal fishing should also be estimated wherever possible.

5. Capture fishing by residents and non-residents

90. It is common for a country to allow non-resident vessels to fish in its waters. The 1993 SNA generally considers the extraction of natural resources part of the production of the country where the extraction occurs, regardless of whether the extracting company is a resident or non-resident. Marine fisheries, however, are an exception to this rule. As discussed in Section B.2, for mobile equipment, such as ships, catch should be attributed to the economic production of the country where the operator of the vessel is resident, not the country where the fish is caught.

91. In the past, the nationality of these non-resident vessels was attributed to the vessels' country of registration (that is, the flag under which the ship sails). The 1993 SNA changed this definition: the residence of the operator of the vessel now determines residence. If a vessel is owned by or chartered to a resident of country A, whether it is chartered with crew and equipment or without, it is operated from country A and, in the SNA as well as the FAO's fisheries statistics, the vessel's catch is the production of country A. Even if the person chartering the vessel is not a personal resident of country A, as long as the business is operated from country A, the catch is considered part of country A's production.

92. In principle, all catch within a country's EEZ should be part of that country's production (for capture fisheries). However, the SEEA-2003 and SEEAF follow the 1993 SNA recommendation, on the ground that usually the operator establishes residency in the country where the boat fishes. Therefore most of the catch is attributed to the production of the country where it is caught. Nonetheless, there could be difference between the fish landed and the residence of the operator of the vessel.

93. The difference in the approach, that attributes the catch to the country where the operator resides and the approach which attributes the catch to the country where the fish is caught, is illustrated in Table II.1. For a given country, part of the catch is by

resident operators (100 tons) and part is by non-resident operators (25 tons). Resident operators also operate outside national waters, obtaining a harvest of 10 tons. Total harvest from national waters is the sum of all vessels' catch regardless of the operator residency, 125 tons (100 + 25) which is the total catch reported in the asset account. However, the total national production includes only the catch by resident operators, regardless of where it occurs, 110 tons (100 + 10) which constitutes production in the supply and use tables.

Table II.1 National fish catch by residence of operator and location caught

	Fish in national waters	Fish outside national waters	Total
Resident operators	100	10	Total economic production = 110
Non-residents operators	25		
Total	Total extraction from national waters = 125		

6. Disaggregation of the asset accounts by species and other characteristics

94. Accounts should be constructed for individual species and may be disaggregated by geographic region and, for long-lived species, by age class if sufficient information is available. Practical problems dealing with methods to measure fish catch and stock size are discussed in Chapter III. Illegal catch should be estimated and added to the legal catch to make up the total catch. Legal catch may be further disaggregated according to the nature of the fishing operation, e.g. large-scale commercial, small-scale commercial and artisanal, and recreational catch. These issues are described further in Chapter III.

7. Accounts for fish habitat and assets related to fisheries

95. Fisheries are dependent on ecosystem health, so it is useful to construct accounts for those components of ecosystems that provide fish habitat. Stock accounts can be constructed for habitats such as mangroves, sea grass beds, coral reefs, lagoons, and others including water itself as well as for terrestrial ecosystem resources that affect fish habitat, such as forests. Ecosystems are within the SEEAF asset boundary. As monetary valuation of these habitats is often difficult or impossible, these assets should be included in the physical accounts and, where appropriate, supplemented by suitable indicators of abundance and sustainability.

96. Physical accounts can be expressed in a combination of area (e.g., hectares) and qualitative classifications such as excellent, good, fair, bad, etc. Degradation of aquatic ecosystems and habitats can be measured in quantitative (e.g., loss of area due to conversion or other factors) and qualitative terms or a combination thereof. Species

diversity and changes over time can be expressed in numbers and proportions of the observed species. At this time no country has yet constructed such accounts or explored integrating these accounts with the accounts for commercial fish species.

G. Monetary asset accounts

1. Structure of monetary accounts

97. The monetary asset accounts have the same structure as the physical asset accounts with one additional component, *Revaluation* that records the economic value of holding gains or losses (see Figure II.3).

Figure II.3 Monetary assets for aquatic resources in the SEEA

(measured in monetary terms)

Opening stocks
Net changes due to economic activity and natural growth
Cultivated resources, breeding stock: net growth
Cultivated resources, harvest: change in inventories
Non-cultivated resources: catch
Other changes in volume of assets
Revaluation
Closing stocks

98. The value of any asset is the sum of the discounted stream of net income, or resource rent, that it is expected to generate during its lifetime. For assets that are freely traded in competitive markets, the market price of the asset should reflect its value. Some fisheries are managed under a system of freely tradable individual fishing rights, Individual Transferable Quotas (ITQs). Under the right circumstances, the trading prices for ITQs can reflect the asset value of a fishery. However, only few fisheries are managed through ITQs, and thus such quota markets do not exist. Even when ITQs are used, the market may be 'thin' or subject to other constraints that distort the quota price.

99. In such cases an alternative method is used to estimate the value of a fishery. The first step in this approach is to estimate the resource rent generated by a fishery in a given year. The second step is to estimate the likely future stream of resource rent, since it is the net present value of lifetime earnings that constitutes asset value.

2. Measuring resource rent

100. Rent, *R*, is the value of production (quantity *x* price, or *Qp*) minus the marginal exploitation costs, *MC*:

$$R_t = Q_t p_t - MC_t$$

Marginal costs include intermediate consumption, compensation of employees/mixed income, and the cost of fixed capital; some of these items are discussed further below. In actual implementation, average cost is used rather than marginal cost because data about marginal costs are not generally available. This practice may introduce an upward bias into the measure of rent because average cost is usually lower than marginal cost.

Cost of fixed capital

101. The cost of fixed capital has two components: the consumption of fixed capital and a normal profit on fixed capital invested in the business. There is no general agreement about what a normal rate of return to fixed capital should be. There are at least three views about how to determine a rate of return. The first is that it is determined by the net operating surplus generated from the capital stock of the particular industry in question. Secondly, the return to produced capital could be seen as covering the cost of financing the acquisition of the produced capital stock. Alternatively, it can be interpreted as the opportunity cost of the investment in the produced capital assets. This opportunity cost could be estimated as the average real rate of return on investment elsewhere in the economy.

102. In the first approach, the concept of a "normal" rate of return is often used to apply to the value of fixed capital stock. This "normal" rate is sometimes determined by reference to the ratio between net operating surplus (rate of return) and capital stock in an industry assumed to have similar performance characteristics but without the presence of a natural resource.

103. The second approach assumes the interest rate on bonds issued by resource companies or the return on shares in resource industries is appropriate for use as the rate of return. The financing cost approach has the advantage that the returns are directly related to the risks associated with the operation of the capital (in the case of the bond price). However, returns on shares reflect both returns on capital and the resource, as well as being influenced by external factors in the market. Therefore, while the use of the interest rate on bonds seems appropriate as a proxy for estimating returns on capital, the use of return on shares does not.

104. The third approach relies solely on the opportunity cost of capital elsewhere in the economy. An interest rate based on long-term government bond rates is taken as the value of the rate of return for use in estimating the return to produced capital in the accounts. The disadvantage with the use of the long-term government bond rate as an appropriate "return to capital" is that it is a "riskless" rate. The rate does not include a premium to cover the risk and uncertainty involved in extractive industry operations.

105. The first and second approaches attempt to approximate the internal rate of return, whereas the third is clearly an external rate which it is supposed should hold more generally. The rate of return on corporate bonds could be used to derive returns on capital in the particular industry under consideration. Where there are few corporate bonds issued in the country compiling asset values, then either of the other approaches may be adopted, provided an allowance is made to counter the deficiencies in the approaches.

Compensation for the labour of the self-employed

106. Total labour costs in fishing include:

- fishing crew share on fishing revenues, wages and salaries paid to workers, which are recorded as compensation of employees in the national accounts, and
- the cost of labour provided by the self-employed, which is included as part of mixed income along with profit earned by the self-employed.

107. The latter is not included in compensation of employees because, as the owners of business, the self-employed, do not pay themselves an explicit wage. As a result, the true cost of labour is often underestimated and the operating surplus is overestimated, which will result in an overestimation of rent. In many industrialized and developing countries, fishing by the self-employed is common, so the underestimation of labour costs can be a serious problem. Various methods are used to estimate the labour component of the earnings of the self-employed. These methods are discussed in Chapter V.

3. Measuring asset value: projecting future rent

108. The Net Present Value (NPV) method discounts the sum of future net income stream or rent. At the beginning of period τ, the value, V_t , is:

$$V_t = \sum_{t=t}^{T_t} \frac{p_t Q_t}{(1+r)^t}$$

$$p_t = \frac{R_t}{Q_t}$$

$$T_t = \frac{S_t}{Q_t}$$

where:

V_t value of the asset at period t

p unit rent price of the resource

Q_t quantity of resource harvested during period t

r the social discount rate

R total resource rent

T the remaining lifespan of the resource

S the stock volume at the close of the accounting period.

In the case of a renewable resource like fisheries, which is being harvested at a constant, sustainable rate, the lifetime is infinite and the formula reduces to:

$$V_t = \frac{p_t Q_t}{r}$$

109. The NPV calculations require projections of future prices, technology, costs of production, fish stock levels, and resource exploitation paths. Future stock levels depend partly on fisheries policies and partly on environmental conditions and their impact on fish stocks, which are difficult to forecast. The economics of fishing also depends on fisheries policy: a more efficient fishery generates higher rent and is of greater economic value. In the absence of alternative information, common practice has been to assume that the current year's prices, technology, and production costs remain constant in the future. The calculation then relies on the remaining variables, levels of stock and exploitation.

110. In some relatively well-understood fisheries, it has been argued that a bioeconomic model should be used to assess the likely future stocks, costs of fishing, and rent under different management regimes (see case studies for Iceland and United States study in Chapter V). However, one must make a clear distinction between the potential value of a fishery under an alternative management regime, and the value of a fishery under current conditions. The SNA and the SEEA record actual values and not optimal ones.

111. The way these formulas are implemented depends on the information that is available and the assumptions that have to be made to deal with missing data. These issues are discussed in Chapter III.

Discount rate

112. All expected future rents must be discounted in order to express their value at the present time, reflecting the fact that income received in the future is not as valuable as income received today. Discounting is reflected in the way people behave: consumers must be paid to save, reflecting a preference for consumption today rather than in the future (positive rate of time preference); producers invest only where the productivity of capital is positive (opportunity cost of capital).

113. In valuing public assets[1], the 'social' discount rate is typically used, rather than a 'private' discount rate. Generally, the private discount rate is higher than the social discount rate, implying that the private sector requires a faster return on assets than governments do, and, in some interpretations, bears less of a responsibility to future generations than government does. The social discount rate may be lower that the private discount rate for several reasons (see Hanley and Spash 1993 for a concise summary):

- The social opportunity cost of capital is lower than the private opportunity cost of capital, largely due to taxation, and, in some instances, differences in risk;
- Market failure: there may be positive externalities which private savings decisions made on the basis of a higher discount rate, do not take into account;
- Individuals act in two very different roles: as consumers concerned with private benefits and as citizens concerned with the well-being of society. The discount rates expressed by individuals' behaviour for costs and benefits incurred as consumers is typically higher than the discount rate expressed as citizens. Government should act as a disinterested party promoting the well-being of society and use the lower discount rate;
- Finally, some economists have argued that it is not ethical to discount the well-being of future generations, because they have no say in the decisions made today that will affect them. This argument is particularly strong for environmental issues, such as preventing climate change, for which near-term costs are relatively high, but benefits accrue far in the future; the costs are lightly discounted while the benefits are heavily discounted.

114. There is considerable controversy over these arguments and a number of alternative approaches to calculating an appropriate social discount rate have emerged. Which one prevails depends on whether asset value is calculated in the context of a private economic perspective or a broad social perspective. In most countries, governments provide guidelines for discounting that have been used for the asset value calculations. Not surprisingly, these discount rates have varied significantly among countries, and tend to be higher for developing countries than for industrialised countries.

Asset value and the divergence between private and social net benefits

115. Regardless of the method, there are several qualifications to this approach to valuation that must be noted. This estimate of rent is based on the *private costs* of extraction. The *social costs* of extraction, and hence the social value of rent may diverge from the private value of rent for several reasons.

[1] In fisheries economics literature, the term *resource rent* usually only refers to the social value of rent, i.e. it is calculated on the basis of opportunity costing of labour and capital inputs and net of taxes and subsidies. In more recent publications, the importance of accounting too for fisheries management costs has been highlighted (Schrank, Arnason and Hannesson, 2003).

116. Another source of divergence between the private and social costs occurs when there is substantial environmental damage from resource extraction, such as air and water pollution, or the disruption of natural habitat. All resource exploitation has the potential to damage ecosystems resulting in loss of environmental function. Including such costs would reduce the value of rent and of the asset.

117. Finally, most asset valuation has focused on the dominant commercial use of a resource. Some assets may have multiple uses, providing environmental services both of a commercial nature and public goods nature. For example, fish, in addition to their direct commercial use, may be essential to the health of an entire aquatic ecosystem, providing indirect benefits to other users. In principle, all these values should also be included in the value of the fish stocks.

4. Monetary depletion and degradation

118. Integrating environmental issues within standard economic accounting through the estimation of depletion and degradation costs was one of the main objectives of integrated environmental and economic accounting. Recently, the approach has changed and the SEEA-2003 has been developed as an information system which gives the countries the option of calculating depletion and degradation costs for the derivation of environmentally-adjusted aggregates.

119. Parallel to the consumption of produced capital, depletion could be considered as consumption of natural capital. Monetary depletion is defined as the decline in the value of the stock as a result of human harvesting activities. It is a measure of the reduced ability of the fish stock to generate resource rent in the future.

120. There are a number of difficulties in estimating depletion cost. First, as discussed more in detail in Chapter III, while fish catch may be known with a fair degree of reliability, assessing the size of a fish stock is intrinsically difficult because of seasonal and inter-annual climatic and oceanographic changes which affect recruitment, natural mortality and individual growth.

121. Even more complex is the estimation of the depletion cost because the fish stock is part of an ecosystem and interacts with other commercially exploited fish stocks in predator-prey relationships. For some stocks these interactions are known to some extent which allow for multi-species bio-economic modelling and analysis. For many others, these are not known and, therefore, depletion cost estimates need to be based on partial analysis.

H. Flow accounts

122. Flow accounts related to fishing include the following:

Fishing and related economic activities in the national accounts: both the supply and use tables (SUT) and the social accounting matrix (SAM), monetary and physical measures;

Environmental impacts from fishing and fishing related industries, and on fishing;

Resource management and environmental protection expenditures incurred by government and the private sector for managing fisheries resources;

Taxes, subsidies, license fees and other levies in relation to resource management expenditures and resource rent.

Each component is discussed below.

1. Fishing and related activities in the supply and use tables

Economic analysis

123. The central framework of the SNA contains detailed supply and use tables (SUT) in the form of matrices that record how supplies of different kinds of goods and services originate from domestic industries and imports, and how those supplies are allocated between various intermediate or final uses, including exports. These tables involve the compilation of a set of integrated production and generation of income accounts for industries - that is, groups of establishments as distinct from institutional units - that are able to draw upon detailed data from industrial censuses or surveys. The supply table gives information about the sources of goods and services. The use table gives information on the uses of goods and services, and also on cost structures of the industries.

124. The fully developed SNA extends the SUT to include detailed information about transactions among institutions: different categories of households, enterprises, government and other institutions. This expanded framework is called a Social Accounting Matrix (SAM). Households are usually disaggregated according to characteristics important to the society, such as income, and rural-urban residence. Enterprises can be similarly disaggregated into, for example, household enterprises, unincorporated businesses and large corporations. The SAM allows one to trace ownership of resources and income distribution. SAMs are widely used in economic modelling to analyse, for example, policy impacts on equity and income distribution.

125. Fishing and fish products are represented in the SUT/SAM in the following way. The supply table shows supply of fish from imports, the commercial fishing industry and own-account/household production, which includes recreational and subsistence

fishers. The Use table shows deliveries of fish products to major users and consumers, including exports and fish processing, but also hotel and restaurant industries, etc.

126. Fishing is often a relatively small industry in most countries, even in those countries that are major world suppliers of fish. However, fishing has a range of forward linkages (processing, marketing and distribution) and backward linkages (production of inputs, especially vessels and gear), that support economic activities and employment in other, related industries. Table II.2 and Table II.3 show the most important industries related to fisheries in terms of forward and backward linkages.

Table II.2 Industries in the ISIC Rev.3.1 related to fisheries

Forward linkages

ISIC Class	FORWARD LINKAGES
1512	**Processing and preserving of fish and fish products** This class includes: - preparation and preservation of fish, crustaceans and molluscs: freezing, deep-freezing, drying,smoking salting, immersing in brine, canning, etc.; - manufacture of fish, crustacean and molluscs products: cooked fish, fish fillets, roes, caviar, caviar substitutes, etc.; - manufacture of prepared fish dishes; - manufacture of fishmeal for human consumption or animal feed; - manufacture of meals and solubles from fish and other aquatic animals unfit for human consumption
1514	**Manufacture of vegetable and animal oils and fats** This class also includes: -extraction of fish and marine mammals oil
1549	**Manufacture of other food products n.e.c.** This class also includes: - manufacture of foods for particular nutritional uses, e.g. other foods containing homogenized ingredients (including meat, fish, fruit etc.) - manufacture of extracts and juices of meat, fish, crustaceans or mollusks
2925	**Manufacture of machinery for food, beverage and tobacco processing** This class also includes - manufacture of machines and equipment to process diverse foods (including machinery to prepare fish, shellfish or other seafood)
5122	**Wholesale of food beverages and tobacco** This class also includes wholesale of fishery products
5220	**Retail sale of food, beverages and tobacco in specialized stores** This class also includes stores specialized in the sale of fish, other seafood and products thereof
5239	**Other retail sale in specialized stores** This class also includes retail sale of sports goods, fishing gear, camping goods, boats and bicycles
9241	**Sporting activities** This class also includes operation of sport fishing preserves and support activities for sport or recreational hunting and fishing

Table II.3 Industries in the ISIC Rev.3.1 related to fisheries

Backward linkaeges

ISIC Class	BACKWARD LINKAGES
1723	**Manufacture of cordage, rope, twine and netting** This class also includes: manufacture of products of rope or netting: fishing nets, ships' fenders, unloading cushions,loading slings, rope or cable fitted with metal rings etc.
3511	**Building and repairing of ships** This class includes the building and repairing of ships, except vessels for sports or recreation,and construction and repair of floating structures. This class includes: - building of commercial vessels: passenger vessels, ferry-boats, cargo ships, tankers, tugs etc. - building of warships - building of fishing boats and fish-processing factory vessels This class also includes: - construction of hovercraft (except recreation-type hovercraft) - construction of drilling platforms, floating or submersible - construction of floating structures: • floating docks, pontoons, coffer-dams, floating landing stages, buoys, floating tanks, barges, lighters, floating cranes, non-recreational inflatable rafts etc. - manufacture of sections for ships and floating structures
3512	**Building and repairing of pleasure and sporting boats** This class includes: - manufacture of inflatable boats and rafts - building of sailboats with or without auxiliary motor - building of motor boats - building of recreation-type hovercraft - building of other pleasure and sporting boats: • canoes, kayaks, rowing boats, skiffs - maintenance, repair or alteration of pleasure boats

Source: UN 2002.

Environmental impacts

127. The major problem caused by capture fishing is stock depletion. However, fishing can also cause environmental damage if methods are used that damage fish habitat or harm other aquatic species. Fishing vessels can emit a range of air and water pollutants. Aquaculture can result in water quality degradation and harm to wild fish populations. Aquaculture in coastal areas can also result in major changes in land use and net degradation of land.

128. Industries related to fishing through forward and backward linkages may also cause environmental damage through pollution, land degradation and use of scarce resources.

2. Fisheries management and environmental protection expenditures

129. In addition to the direct costs of fishing, which are incurred by the fishing industry, governments incur substantial costs for management of a fishery, and for protecting and restoring fisheries ecosystems. It is important to determine the cost of these services and the extent to which these costs may be recovered from the private sector or households through various forms of taxes and levies. In some countries, the fishing industry contributes nothing to these costs and, in fact, is heavily subsidized relative to other industries.

130. The reason to establish accounts for environmental protection and resource management is thus to identify and measure society's response to environmental concerns through the supply and demand for environment goods and services, through the adoption of production and consumption behaviour aimed at preventing environmental degradation of ecosystems and by managing fishery resources in a sustainable way.

131. Another way of using environmental protection and resource management accounts is to model the effects of possible changes in environmental measures, in order to estimate the way such changes will affect (directly and indirectly) environmental pressure, economic activity, growth and employment in the future. A particular use of such models may be to estimate the effect on value added, employment and trade of a given level of environmental protection measures in fishery-related industries. A further, immediate, use of environmental protection and fisheries management accounts is the production of indicators which illustrate how actions to remedy the environmental impact of the economy are changing over time.

132. This component of the SEEA differs from the others in that it doesn't add any new information to the national accounts but reorganizes expenditures in the conventional SNA that are closely related to environmental protection and resource management. The purpose is to make these expenditures more explicit, and thus, more useful for policy analysis. In this sense, they are similar to other satellite accounts, such as transportation or tourism accounts, which do not necessarily add new information, but reorganize existing information. This set of accounts has several quite distinct components:

- Expenditures for environmental protection by public and private sectors;
- Natural resource management and exploitation activities;
- Environmental and resource taxes, fees and other charges, as well as subsidies;
- Environmentally-beneficial activities;
- Minimization of natural hazards.

133. This section focuses on the first three components: expenditures for environmental protection and resource management, and taxes. The other components -

activities of industries that provide environmental protection services and minimization of natural hazards – are not directly relevant to fisheries accounting.

Expenditures for environmental protection

134. Environmental protection activities are those where the primary purpose is the protection of the environment; that is, the avoidance of the negative effects on the environment caused by economic activities. Examples include spending by companies on end-of-pipe equipment to reduce or eliminate emissions or make them less hazardous and spending on environmentally protective technology to minimize emissions and pollutant discharges during the production process. In the case of fisheries, they include expenditures by industries, including fishing industries to reduce/avoid the impact of production on water ecosystems. They also include expenditures to avoid the capture of endangered species (e.g. turtle excluding devices in trawl fisheries). By convention, this heading also includes spending on those technologies where only part of the new equipment has an environmentally beneficial component. For example, equipment may need replacing at the end of its life, which is the reason for the investment, but the primary purpose of the "clean" element is to protect the environment.

135. The classification suggested for organising environmental protection activities is the Classification of Environmental Protection Activities (CEPA). The classification also applies to expenditure and products. Within the CEPA, environmental protection activities are first classified by environmental domain (water, air, waste, nature protection, etc.) and then by type of measure (prevention, reduction, etc). The main one-digit headings of CEPA are listed in Table II.4; the detailed classification is given in Annex III.

Fishery resource management and exploitation activities

136. There is no international agreed classification for fishery resource management and exploitation activities. Management activities include research into management of fishery resources, monitoring, control and surveillance, data collection and statistics, costs of the natural resource management authorities at various levels as well as temporary costs for facilitating structural adjustments of sectors concerned. Activities and transactions specifically for environmental protection, for example management of protected marine ecosystems, are not included. (They are included under environmental protection expenditure activities where the primary purpose is the protection of the environment as mentioned above.) Similarly, qualitative protection activities of natural resources, for example activities for biodiversity or activities aimed at preserving certain functions or the quality of the ecosystems, are also included under environmental protection. Management activities may also result in associated, secondary, environmental benefits such as protection and restoration of wildlife and natural habitats.

Table II.4 Classification of environmental protection activities and expenditure (CEPA 2000)

1.	Protection of ambient air and climate
2.	Waste water management
3.	Waste management
4.	Protection and remediation of soil, groundwater and surface water
5.	Noise and vibration abatement
6.	Protection of biodiversity and landscape
7.	Protection against radiation
8.	Research and development
9.	Other environmental protection activities
9.1	General environmental administration and management
9.2	Education, training and information
9.3	Activities leading to indivisible expenditure
9.4	Activities not elsewhere specified

Source: SEEA-2003 (UN *et al.*, 2003)

137. Exploitation activities include fish catch, including exploration and development. These accounts correspond to the standard economic accounts for fisheries.

Fisheries taxes, licenses and quotas

138. In many countries, a fishing license issued by government is required in order to practice either fresh water or marine fishing. If these licensing fees (in the sense of a resource user charge) are levied for a period not exceeding one year, they are recorded in the SNA as taxes. For enterprises they are treated as taxes on production; for private individuals fishing for pleasure they are recorded as taxes on income. In some instances, a private individual or unit such as an angling club may own the fishing rights over a stretch of water and also charge a fee to would-be fishermen. This fee should be recorded as expenditure on recreational services.

139. An increasingly frequent approach to managing marine fisheries is through harvesting quotas. These are usually allocated by government (which is responsible for ensuring their enforcement as well) and may apply both to fishing within the waters of the country's EEZ and to fishing on the high seas. Quotas typically apply to a particular fish stock. They may be allocated for free based on criteria such as historical catches by fishers or fishing firms and/or allocated to communities in locations where fishing is the main source of livelihood. They may also be auctioned or allocated in other ways (e.g. by lottery). A quota may be valid for one year only but typical for a longer period, and often in perpetuity. It may be tradable to third parties or not. Even if not tradable, in certain circumstances it may still be transferable; say, from one generation to the next.

140. If a quota can be sold by the holder to a third party, then the quota is recorded as an asset quite separately from the fish to which it relates. Quotas are classified as

intangible non-produced assets in the SNA and are included as memoranda items in the SEEA asset classification. The value of the license or quota should ideally be determined by the price it would fetch on the open market. When no such price is available, the value of the license or quota should be set equal to the estimated net present value of the resource rent in proportion of the amount of fish, which can be caught under it. If the fish are to be harvested over a period of years, the value of the license should be equal to the estimated net present value of the resource rent from fishing over the period for which the license/quota is valid.

141. Whether or not a monetary valuation can be placed on fishing licenses and quotas, it is useful to have information available on their existence and the proportion of various fish stocks covered by them.

3. Buy-back or vessel decommissioning

142. A recent policy with major implications for fisheries management expenditures is the decision to reduce overcapitalization of fisheries through the purchase by governments of excess vessels. Excess fishing capacity is pervasive in many capture fisheries throughout the world and perhaps more so in many high-seas fisheries. The existence of excessive fishing capacity is largely responsible for the depletion of fishery resources, for the dissipation of food production potential and for significant economic waste.

143. The issue of managing fishing capacity has been discussed in FAO's Committee on Fisheries (COFI) in reference to the growing concern about the spreading phenomenon of excessive fishing inputs and overcapitalization in world fisheries. This has led to the adoption of the International Plan of Action for the Management of Fishing Capacity (IPOA) in 1999. The IPOA is of a voluntary nature. It calls on States to prepare and implement national plans of action for managing fishing capacity by the end of 2002 and, if required, reduce fishing capacity to balance it with the sustainable use of fisheries resources.

144. Vessel buy-back or decommissioning programmes have been undertaken in several countries including USA, Japan and countries in the European Union. This raises the question how such programmes should be treated in the 1993 SNA and SEEAF. In the fisheries economics literature, the provision of financial incentives for vessel decommissioning is sometimes referred to as "investment into "dis-investment". This terminology, however, is misleading because the funds made available by governments to buy-back (or decommission) fishing vessels are, in principle, transfer payments. The fishing industry may subsequently use these funds for investments - and the great danger of such programmes is that investments flow back into the same fishery rather than into other economic activities – but for accounting purposes, this transfer is a subsidy to the owners of the fishing vessels.

145. A special case, however, may arise when the government would buy the vessel with the intention of selling it subsequently in the domestic or export market. The

vessels could be used, for example, in other not yet fully exploited fisheries, or in another sector such as transport. In this case, the buy-out may simply amount to a transfer in ownership and change in the economic sector where the physical asset (vessel) would be recorded. It is unlikely though that the vessel buy-out price and the resale value would be the same. The reason is that in a buy-back scheme, the vessel owner would not only expect to receive the current market value of the vessel but also a compensation for giving up his privilege to participate in the fishery. The lowest compensation a fisherman would accept to voluntarily surrender his privilege is, in Hannesson's words (1988:16) "the present value of the difference between the income he expects to get from fishing and the income he expects to be able to get by doing something else." For accounting purposes, it suffices to note that the difference between the vessel purchase and re-sale value would be recorded as a subsidy to the vessel owner because whereas the owner is compensated for giving up his entitlement, it is not the government which acquires it or benefits from it but those fishing vessel owners who remain in the fishery and who will realize higher catch rates and profits in the future.

146. More typically, the vessels removed from a fishery in a buy-back programme would be scrapped. The scrapping/dismantling of the vessel is a service and would normally incur a cost. This scrapping cost could be either lower or higher than the value of the materials recovered from the vessel. For accounting purposes, the residual scrapping value net of all scrapping costs (which could be positive or negative) would have to be considered in accounting for the full cost of the buy-back programme. Thus the following accounting entries may arise:

- a financial transfer, i.e. subsidy, from the government to the fishing industry;
- a net residual scrapping value of the vessels (a cost or a revenue) accruing either to the government or the fishing vessel owners depending on who is charged with disposing off the vessels.

CHAPTER III: IMPLEMENTING THE SEEAF

A. Introduction

147. While the previous chapter described the conceptual representation of fisheries resources in the SNA and SEEA, the purpose of this chapter is to discuss the empirical implementation of the accounts for fisheries resources. This chapter describes the data sources and methods for estimating stock sizes, presents specific methodologies for valuation, and describes the practicalities of constructing useful accounts, given the data limitations. It begins with asset accounts, produced and non-produced, and then discusses the flow accounts. The flow accounts have three components: the representation of the economic aspects of fishing and related industries, the environmental impacts caused by fishing as well as environmental impacts on fishing by other industries, and expenditures for fisheries management and associated taxes and fees. Of the three components, the first, fisheries and related activities, is obtained directly from the national accounts; the second, environmental impacts, is provided by the SEEA; and the third component is part of the national accounts, but often combined with other components of the national accounts so its relationship to fisheries is not identified explicitly in the national accounts. Finally there is a discussion of the relationship of fisheries resource accounts to macroeconomic aggregates and memorandum items useful for fisheries accounts.

148. Norway, Iceland and Namibia construct accounts for fish on a regular basis; other countries (e.g., New Zealand and UK) have constructed them only in physical terms; others (e.g., Chile, Costa Rica, the Philippines, Korea and United States of America) have either compiled one-off sets of fisheries accounts or conducted academic studies of individual fisheries. Relative to other resources, fisheries accounts are not constructed by many countries. In part, that may be because fisheries do not contribute significantly to the economy in most countries even though they may be very important for specific regions and areas, and often are a major food supplier of animal protein. In addition, the compilation of fisheries accounts presents greater measurement challenges than other resources.

149. Fisheries accounts are generally constructed only for the economically important species. However, where appropriate, it could also be useful for fisheries managers to compile accounts for major predators and prey for these species; to disaggregate by

geographic region; and to distinguish between commercial, recreational and artisanal fishing.

150. In managing fisheries, it is also important to account for related resources and ecosystems. The status of a fish population may depend greatly on the health of a coastal area, river estuary, coral reef or mangrove forest that provides its spawning or feeding grounds. These supporting resources and associated ecosystems are affected in turn by land use, forest conversion, soil erosion, water use and pollution that may originate along the coast or even far inland. This web of environmental interdependence suggests that fully accounting for fisheries requires more than just fish accounts; it requires accounting for all natural resources that affect fish stocks. Accounts are well defined for some of these related resources and environmental impacts such as forests, land use and pollution. Other accounts, such as ecosystems, have been identified in the SEEA but are less well defined in practice; there are no agreed methods yet for their valuation. The purpose of this handbook is to focus on fisheries and this chapter emphasises the implementation of accounts for fish resources; a more general description is provided for related resources and environmental impacts.

B. Fisheries asset accounts

151. As described in Chapter II, fisheries can be divided into produced assets and non-produced assets, based largely on the degree of control over the production process. Produced assets include aquaculture and mariculture, while non-produced assets include capture fisheries and ranching. This distinction affects the way output is measured in each sector, but the construction of asset accounts is the same for both sectors. As described in Chapter II, fisheries resource accounts are consist of opening stocks, changes that occur during the accounting period, and closing stocks. Changes that occur during the period are divided into those that are due to economic activity (e.g., fish catch), and those that are due to natural processes (e.g., growth, recruitment, and natural mortality) or other factors. Other changes in volume can include factors such as the migration of fish stock out of the country's EEZ due to environmental events.

152. Where data are available, stock accounts may be constructed by age class, as is done for forestry, but few countries have done this so far. For longer-lived species such as cod, age-structured data are often available because the applied stock assessment method (see below) is based on the calculation of stock abundance by age class. In addition, stock accounts may be disaggregated by geographic region and may be constructed for important predator or prey species.

153. It is often difficult for capture fisheries to disaggregate the changes in stocks according to natural and human-made causes. However, this is important for separating depletion due to economic activity from other sources of a decline in stock size. The changes in stocks are thus often collapsed into two categories: Catch and Other changes in volume.

1. Physical accounts

154. Compilation of the physical accounts can present problems in terms of what to measure as well as how to measure the different components of the accounts. Resources like marine fish stocks are not observed directly and require biological models to estimate stocks and changes in stock sizes. The SNA and SEEA define all fish within a country's EEZ as assets belonging to that country, but there are many straddling and migratory species, which are not clearly owned and managed by a single country. This is further discussed below.

Measurement of fish catch and stock sizes

155. The general approach to estimate fish stocks uses population models with data about fish abundance and age distribution. Virtual Population Analysis (VPA) is the most widely used model for estimating stock size. It uses data on catches from different cohorts of the same stock, together with data on catch per unit effort. The VPA method provides consistent estimates of the size of the stock at the beginning and at the end of the accounting period, as well as all flows: catch, recruitment, increases in weight and losses due to sickness, accidents and predators. As more information becomes available about individual cohorts, it may be possible to improve estimates of stock levels made in earlier years. When using the VPA method, biologists must make assumptions about natural mortality of the stock, based on a number of factors including the size of some predator stocks. However, biologists rarely present this information in an accounting format because of uncertainty about the reliability of data, in particular the natural mortality rates. Confidence intervals are usually provided for the estimates of stock sizes, and these can be significant (see, for example, the confidence intervals estimated for hake in the Namibian case study in Table V.9 in Chapter V).

156. The VPA method can only be used to estimate the size of the stock of those species that are relatively long-lived and where data on the proportions of the different cohorts in the catches and the total catches are available. When this information is not available, biologists rely on other models. These models commonly make use of catch per unit of effort, which relates the size of the stock to the availability of fish, or other indeces of biomass. Methods that rely only on catch per unit of effort are often very imprecise, partly because it is very difficult to estimate the volume of effort in homogenous units. Better estimates of biomass may be possible in some cases. For example when fish gather into schools, it may be possible to use observations from echo integrators (instruments that use sound-waves to observe the fish in the water) to estimate the size of the total stock. Stocks of bigger aquatic animals like seals and whales can be estimated by direct enumeration of the number of animals in randomly sampled areas.

157. Better result can be obtained when the data used as input into population models are obtained from two or more independent methods for estimating biomass or relative biomass, for example, from direct surveys and an analysis of commercial fish catch.

The method for direct surveys depends on the nature of the fish species (swept-area trawl surveys, acoustic surveys, etc.). Analysis of commercial catch, catch per unit effort, and biological information such as age structure provide additional information.

158. There are a number of limitations to the data obtained from commercial fisheries. In most fisheries, data are collected at the point of landing and not on board of the fishing vessels. As a consequence, reported data often omit catches that have been discarded at sea. This is a problem in some fisheries where the amount of unwanted by-catches is high and discarding is common. In many other fisheries, especially small-scale fisheries, the entire catch is usually landed. Where discarding is common as with some industrial fisheries, however, unless observers are placed on each vessel, commercial landings rather than actual catch are reported. This may result in under-reporting of the actual catch or of by-catch, the harvesting of non-target species. The reported fish catch may also be subject to high-grading, which distorts the true age structure. High-grading is most likely to occur when a species is differentiated into more than one economic grade. Price differentials between the grades create economic incentives for the fisher to discard lower-value grades and replace them with higher-value grades. These potential distortions can be reduced by having observers on each vessel, and by carrying out independent surveys. However, many countries do not use the costly observer system and may not be able to afford independent surveys.

159. In many cases, the biologists' estimates of the fish stocks are very imprecise. Population models relating the age distribution of the fish catch to underlying populations are subject to considerable uncertainty, a weakness often compounded by poor catch data. There is also uncertainty about the relationship between spawning stocks and recruitment of juveniles. Recruitment can be affected more strongly by environmental factors than by the size of the spawning stock. Often, there is also not enough information to distinguish between the impact of harvesting on fish stock and the impact of environmental changes with any certainty.

160. In most fish accounts, because the distinction among growth, natural mortality and other changes cannot be determined with certainty, the changes in stocks include only catch and other changes in volume. An example of the fish stocks for north-arctic cod (Norway) is shown in Table III.1.

Table III.1 Stocks of North-arctic cod, 1990-1996

1000 tonnes

	1990	1991	1992	1993	1994	1995	1996
Opening stocks, 1 January	960	1510	1940	2510	2340	2100	2040
Total landings	-187	-269	-384	-532	-746	-740	-722
Other changes in volume	737	699	954	362	506	680	622
Closing stocks, 31 December	1510	1940	2510	2340	2100	2040	1940

Source: Chapter V

161. For the estimate of stock size based on catch and effort data, it is essential that all catches be recorded. This means that not only should all landings, legal and illegal, by

commercial and recreational fishermen, be recorded, but also all fish that are discarded at sea. The discarded fish should not be counted as part of production, but be recorded as other changes in volume. The more detailed structure for the asset accounts reflecting these other aspects is shown in Table III.2.

162. Many small-scale and recreational fishers target more than one species, and information about the catch by species may not be available for these fishers. Under such circumstances, it may only be possible to construct these full accounts for total fish, or for categories of fish (e.g., pelagic), rather than for individual species. Information about small-scale fishing has often been incorporated in the fisheries accounts. Information about recreational fishing has usually not been incorporated, partly because there is little information about this sector and partly because it is usually a small share of total catch relative to other sectors.

Table III.2 Detailed structure of the asset accounts for fisheries

	Physical Accounts (thousands of tons)
Opening Stocks	
Changes in Stocks	
Total catch	
Commercial, large-scale	
Small-scale, commercial and subsistence	
Recreational	
Estimated illegal catch	
Net Natural Growth (recruitment minus natural mortality)	
Other Changes in Volume	
Estimated Discards	
Other	
Closing Stocks	

163. Ideally, the physical accounts would be constructed for individual species. However, in many small-scale, tropical fisheries it may be extremely difficult to obtain such data. Catch is often recorded either by category of fish (demersal, pelagic, etc.) or category of vessel and gear (purse-seine, trawl, long-line, etc.) rather than by species. In such cases, accounts can be constructed for these broader categories.

Resident and non-resident catch

164. As mentioned in Chapter II, SEEAF considers production the fish catch by residents. This treatment does not consider the fish catch by non-resident units and may provide an incomplete picture of a fishery under a jurisdiction of a country. However, given that many operators of fishing vessels have to establish residency in the country they fish, most of the fish catch will be covered in the accounts. In this way,

consistency with the 1993 SNA and the SEEA-2003 is maintained. FAO's fish catch statistics, however, is not consistent with the SEEAF treatment of catch as it attributes catch according to the flag of the vessel (see description of FAO statistics below).

Straddling and highly migratory stocks

165. As discussed in Chapter II, the treatment of migratory and straddling stocks in the accounts is not always well defined. Where straddling stocks are jointly managed by the countries involved, setting TAC and assigning shares of the TAC to each country, then a country's share of TAC may be used to assign it a share of the associated stock (UNSD and FAO 1999). This has been the practice in Norway and Iceland, for example (see case studies in Chapter V). However, where there is no joint management it is not possible to implement this approach. For example, some of Namibia's fish are migratory within the Benguela Marine Ecosystem, which encompasses three countries, Namibia, South Africa and Angola. The circumstances under which fish migrate are not well understood and there is no agreement yet for joint management among the three counties sharing the ecosystem. A regional fisheries management body, South East Atlantic Fisheries Organisation (SEAFO) has been established but only deals with fish resources of the high seas, not with those within the EEZs of the coastal states. Consequently, Namibia and South Africa estimate their own fish stocks without a separate estimate for migration, a factor that may account for some of the otherwise unexplained large inter-annual fluctuations.

166. Fish stocks that inhabit temporarily or permanently the open ocean beyond a country's EEZ, such as oceanic squid, are not treated as assets at this time if there is no agency which exercises control over them. In the future, as regional fisheries organisations may extend effective management to these stocks, they may be incorporated in the accounts of the cooperating countries.

Fishing and fish processing

167. One other difficulty that may be encountered when compiling production accounts for fisheries is the separation of harvesting from processing activities. Although it is desirable to allocate the production to the relevant activity, this may be difficult in practice. This difficulty may occur when factory vessels are used, which combine harvesting and processing on a single vessel, or when companies, whose primary activity is land-based fish processing (a manufacturing industry), also operate some fishing vessels. If data are not available, some on board fish processing will have to be included in fishing and some fishing activities may have to be recorded under fish processing (UNSD and FAO 1999).

FAO catch statistics

168. While similar, there are some differences between catch as recorded in the SEEAF and catch as reported in the FAO statistics, notably with regard to treatment of discards, and assignment of nationality. Below, a brief description of FAO catch statistics is provided.

169. The annual period used in FAO catch statistics is the calendar year (1 January – 31 December) with the exception of a few individual countries and data on catches in the waters around Antarctica for which the split year (1 December – 30 November) is used. Split-year data are shown under the calendar year in which the split year ends.

170. Data relate to nominal catch of fish, crustaceans and molluscs, the production of other aquatic animals, residues and plants and catches of aquatic mammals, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The concept of nominal catch refers to the landings converted to a live weight basis (for details see flow chart in Figure III.1). The harvest from mariculture, aquaculture and other kinds of fish farming are reported separately. Data include all quantities caught and landed for both food and feed purposes but exclude discards. Catches of fish, crustaceans and molluscs are expressed in live weight, that is, the nominal weight of the aquatic organisms at the time of capture. The harvest of aquatic plants is given in wet weight. Data are given in metric tons, except those for whales, seals and crocodiles, which are given in numbers and those for corals, pearls and sponges which are given in kilograms.

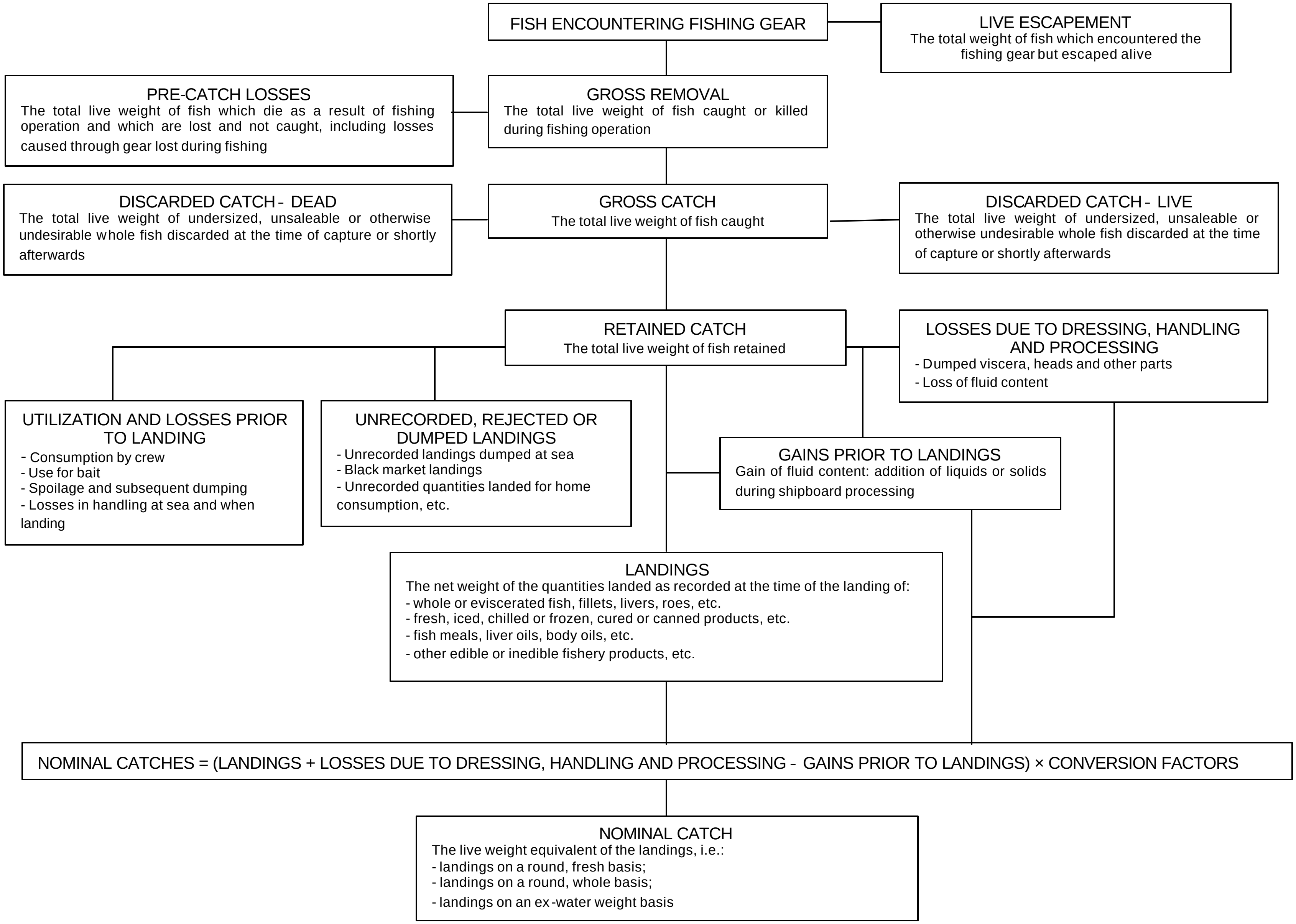
171. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise. Fish, crustaceans, molluscs and all other aquatic organisms included in the database have been classified according to approximately 1,500 commercial species items, further arranged within the 50 groups of species constituting the nine divisions of the FAO International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP). The taxonomic code descriptors are taken from FAO's Aquatic Science and Fisheries Information System.

172. According to the inland or marine area where caught, capture production is also classified into seven major inland fishing areas and 18 major marine fishing areas, internationally established for fishery statistical purposes. Several countries still report their catches by large groups of species. In these circumstances the catch data presented by individual species items are likely to be underestimated. Therefore, when the statistics are examined for a particular species, it should be noted that an unknown proportion of the catches for that species might have been reported by the national office under the generic, family or order name of the species, or even more roughly as "marine fishes unspecified". Consequently, species-item totals frequently underestimate the real catch of the individual species.

Asset accounts for fish habitats

173. There is increasing awareness of the ecological importance and economic significance of the various habitats of fish and shell fish including mangroves, sea grass beds, coral reefs, lagoons, and others including water itself. In most instances, these natural assets can be considered economic assets because they are publicly or privately

Figure III.1 Catch concepts: diagrammatic presentation



owned. As monetary valuation of these habitats is often difficult, these assets should be included in physical accounts and, where appropriate, supplemented by suitable indicators of abundance and sustainability. At this time, no country has yet constructed such accounts or explored integrating these accounts with their accounts for commercial fish species.

Sustainability, depletion and degradation

174. A major reason for constructing asset accounts has been concern to better monitor sustainability by accounting for depletion or degradation of natural assets. The simplest expression of sustainability is that fish catch is equal to net growth so that the size of the stock at the beginning of the period is maintained, under the condition that beginning stock size was within safe or precautionary limit reference points. Allowing for uncertainties concerning the rate of growth during the period, the definition of sustainable exploitation can be reformulated in terms of probabilities and expected values: fish are managed in a sustainable way if the expected size of the stock at some given future point in time is at least equal to the present, precautionary, size and the likelihood of extinction is negligible.

Depletion

175. With regard to renewable resources like fish, SEEA defines the physical dimension of depletion as that part of the harvest that exceeds the sustainable level of resource use. Depletion is defined here in terms of the impact of economic uses, mainly harvesting, on the stock. Fish stock may decline for other reasons, such as adverse environmental conditions; however, such changes in stock are not defined as depletion, but as other changes in volume. In practice, it may be difficult to always distinguish depletion from other changes in volume. Some environmental changes are not directly related to fishing activity but may be related to other economic activities. Examples include the removal or degradation of fish nursery or spawning habitat such as sea grass beds, mangroves or corals, or physical alterations and pollution caused by seabed mining, oil spills, or even more distant actions, such as pollution far upstream, or the cutting of forests which results in increased sedimentation of estuaries.

176. It may also be difficult to interpret a reduction in a fish stock because, under certain conditions, it may be economically advantageous to reduce a fish stock (these conditions are described more thoroughly in the appendix to this chapter). A fish stock can be exploited on a sustainable basis within a range of stock sizes and annual harvests, and one of the tasks of fisheries managers is to determine the optimal stock size. Thus, a reduction in the size of a fish stock from one accounting period to another, due to a harvesting level above net natural growth, does not necessarily imply an unsustainable use. Once a fish stock is reduced from its virgin size, i.e. its equilibrium size where growth and natural mortality are in balance, the stock generates surplus growth (growth greater than natural mortality), which can be harvested. Surplus growth initially increases as the stock is reduced from its virgin size and becomes zero at some minimum level when the stock collapses. The maximum surplus growth and thus

maximum sustainable yield (MSY) is reached at a stock size and harvesting level somewhere between these two extremes.

177. Depletion requires a more precise definition when applied to a wild fish stock. If over successive accounting periods, the fish harvest always exceeds net natural growth, clearly there will come a point when the stock collapses in commercial terms if not in biological terms. The sustainable harvesting potential of the stock only declines once stock size has been reduced to a level below that one generating the maximum surplus growth. In physical terms, therefore, it might be appropriate to define depletion by two criteria: (1) a level of harvesting which is greater than net natural growth during the accounting period provided that (2) the remaining stock size (closing stock) is below that one which can produce the maximum sustainable yield in future accounting periods. In other words, as long as the remaining (closing) stock does not drop below the size that can produce the MSY, no physical depletion should be accounted for in SEEAF.

178. The above second criterion could be defined alternatively as a stock below that one which can produce the maximum economic yield (MEY). The application of this definition would usually require bio-economic analysis of a fishery to determine the stock size and fishing effort which can yield the MEY, as described in the appendix.

Degradation

179. Concurrent with depletion, the quality of the stock may also degrade in that its age structure is altered and the risk of an irreversible stock deterioration is increased. In fisheries biology, an accepted indicator of the latter risk is the share of the spawning biomass in the stock, i.e. age groups which can contribute to spawning. Other indicators of degradation of a qualitative nature are not commonly reported on a fish stock. Quality indicators may be reported as memorandum items in the asset accounts.

2. Monetary Accounts

180. As described in Chapter II, the value of fish, like any other asset, is the net present value of the stream of income (rent) it is expected to generate in the future. Constructing monetary accounts has two components: 1) defining how rent has to be calculated and 2) making projections about the future rent a fishery is likely to generate. Both these components raise unique challenges for fisheries.

Measuring resource rent

181. Resource rent is defined as the excess profit owing to the scarcity of a resource; it is valued as the cost of production minus the marginal exploitation costs. For fisheries, there are two approaches to measuring rent, a market-price approach and the residual value approach[2]. When available, the market price, established by a trading

[2] The SEEA-2003 mentions a third approach to measuring rent, government appropriation, in which a resource tax, such as a quota fee or mineral royalty, is simply assumed to be equal to value of the rent. In

mechanism such as Individually Transferable Quotas (ITQ), is the preferred method of valuation because it is consistent with the definition of value used in the SNA and SEEA, and because it can be observed directly. The residual value approach is also consistent with the SNA and SEEA but cannot be observed directly and its estimation requires a number of assumptions. In practice, however, a market-determined rent is rarely observed for most of the world's fisheries.

182. A market price for the value of fish *in situ* (rent) may be established when there are well-defined property rights such as individual catch quotas or, more rarely, quotas of harvesting effort, or territorial fishing rights, and when there is a well-functioning competitive market where these rights are freely traded. Under such conditions, economic theory predicts that the total market value of the fishing rights will approximate the economic value of the fish stock, minus any transactions costs for trading of fish rights. However, there are a number of conditions, which may distort market prices for fishing entitlements.

183. In a competitive market, such as might occur under the ITQ management regime, transactions costs may be quite low and the market price for quota will be a good approximation of the true resource rent potential. However, transactions costs, which are very difficult to measure, are usually higher when the market for trading quota is not well developed, for example, when trading is not legal. Even when trading is legal and permanent entitlements to the exploitation of some stock may have many characteristics of property-rights, their legal status is often inferior to that of property rights to other assets. Market prices may also deviate from rent due to income taxes, input subsidies, rental fees and taxes, and other fiscal measures that affect the financial profitability of the fishery. Other conditions can also distort quota-trading prices, such as unequal power between buyers and sellers. It has also been frequently observed that the prices of the entitlements to fish from some stock tend to reflect marginal short run profits rather than marginal long run profits. There are cases, such as Icelandic fisheries, where this state of affairs has persisted for a long period of time. (See the Icelandic case study in Chapter V for more detailed discussion of this issue).

184. In most of the world, fishing rights, even where well-defined, may not be freely tradable, and even where markets for fishing rights have been established, they do not always function well enough to provide an accurate reflection of resource rent. Consequently, the most commonly used method for measuring rent, not only for fisheries but for most other resources as well, is the residual value approach. This method uses data about revenues and costs to estimate rent as the residual of the two. Data from a range of sources may be used including national accounts, fishing company surveys and other information, but national accounts most often provide the starting point for the calculations. In actual implementation, rent is calculated as the difference between revenue and *average* cost rather than marginal cost because data about marginal cost are generally not available. Rent is calculated for each fish stock using the following formula:

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the case of fisheries, which are often heavily subsidized the equivalence between rent and government appropriation cannot be assumed and should be empirical determined.

$$R = TR - (IC + CE + CFC + NP)$$

$$NP = i \times K$$

where

R	resource rent
TR	total revenue
IC	intermediate consumption
CE	compensation of employees
CFC	consumption of fixed capital (depreciation)
NP	normal profit
i	the rate of return on capital, considered the opportunity cost of capital
K	the value of fixed capital stock invested in the industry.

185. Most of the data required for the rent calculation can be obtained directly from the data source, whether that data source is the national accounts or a survey. The one component that cannot be directly obtained is the rate of return on fixed capital, necessary for calculating normal profit. In addition, where owner-operated vessels account for a significant share of fishing, an estimate must be made of the labour component of the earnings of the self-employed.

Return on fixed capital

186. The cost of capital, or so-called "normal profit," is usually viewed as either the cost of borrowing capital or the opportunity cost of capital. Long-term bond rates in the fishing industry would indicate the cost of capital in that sector. However, in many countries there is little public borrowing by fishing companies, so another method must be used to determine the appropriate rate. One could use an average rate of return to capital in an economy, but this average rate may not properly reflect the risks within the fishing industry. Rates of return for different industries are determined by a general return plus a risk premium. Different countries have used a wide range of rates of return to fixed capital reflecting a combination of the general return to a riskless asset like government bonds, plus a risk premium (see the case studies in Chapter V).

Compensation for the labour of the self-employed

187. As discussed in Chapter II, labour costs in fishing include wages and salaries paid to workers as well as the cost of labour provided by the self-employed. The latter is recorded as mixed income and not included in the compensation of employees. The cost of labour by self-employed has to be estimated and included in the calculation of the total cost of labour. The methods that are used are based on imputing labour cost from hours worked and a reasonable hourly wage. This issue is described in more detail in the Norwegian case study in Chapter V. The calculation of resource rent for Norway's fish accounts is shown in Table III.3.

Table III.3 Resource rent for Norwegian fisheries

Million kroner

	1990	1991	1992	1993	1994	1995
Output	5,257	6,247	6,115	6,126	7,539	8,275
Intermediate consumption	2,119	2,232	2,243	2,341	2,682	2,900
Compensation of employees (calculated from survey data)	1,931	2,313	1,709	1,783	2,829	3,170
Consumption of fixed capital	1,723	1,650	1,634	1,760	1,685	1,554
Normal return on capital	1,851	1,726	1,748	1,860	1,785	1,660
Resource rent	-2,367	-1,674	-1,219	-1,618	-1,442	-1,009

Source: Chapter V, Norwegian case study.

Fishing and fish processing

188. Many fishing operations may be highly integrated with fish processing, a manufacturing industry. Integration may result from the technology employed, as in the case of factory trawlers whose continuous-process operation make the separation of fishing from fish processing somewhat arbitrary. Integration may also result from legal and institutional arrangements, where the same company (or parent company) handles both fishing and fish processing and fish is transferred from fishing to fish processing without a monetary transaction. The price chosen to record the transfer may not represent a market price but rather a price that assists in achieving the parent company's global strategy.

189. In the case of vertical integration, a true estimate of resource rent may only be obtainable if the boundary between the fishing and fish processing industries is relaxed and the residual method is applied to both activities. The combination of a primary industry and its immediately downstream processing industry is common practice in accounting for forestry (Eurostat 2000). This approach was used, for example, for the fish accounts in Namibia, where both causes of vertical integration exist. In 1998, 40 per cent of hake was processed off-shore and 60 per cent processed on-shore (Uulenga 1999). In addition, there is a great deal of vertical integration of the companies who both fish and process fish on shore.

Measuring asset value: projecting future resource rent

190. The value of each fish stock is the net present value of the rent it will generate in the future. The present value calculation requires projections of future prices, technology, costs of production, fish stock levels, and resource exploitation paths. Future stock levels depend partly on fisheries policies and partly on environmental conditions and their impact on fish stocks, which are difficult to forecast. The economics of fishing also depends on fisheries policy: a more efficient fishery generates higher rent and is of greater economic value. The general formula for calculating the asset value of fisheries is:

$$V_0 = \sum_{t=0}^{T_0} \frac{p_t Q_t}{(1+r)^t}$$

$$p_t = \frac{R_t}{Q_t}$$

$$T_0 = \frac{S_0}{Q_0}$$

where

V_t value of the asset at time t

p_t unit rent price of fish at time t

Q_t quantity of fish catch during time t

r the discount rate

R_t total resource rent at time t

T_0 the remaining lifespan of the resource computed at time 0

S_t volume of stock at the end of the accounting period t.

191. This formula allows for future changes in stock and exploitation levels, technology and associated fishing costs, and prices. For example, in a given year, fish stock may be in a relatively depleted state and fisheries managers may reduce TAC for a period of years in order to allow stock to recover to a more desirable level. This would result in reduced catch and rent for a period, followed by a period of higher rents in the future, if the policy is successful.

192. For long-lived fish subject to regulation of the age/size of catch or whose value varies with age or size, it may be appropriate to use an age-structured asset valuation model. Such models are commonly used for forestry. An example of an age-structured fisheries asset valuation model is given in Chapter V, the case study of Atlantic sea scallops.

193. Whenever possible, expected figures should be used in the asset value calculations. However, prediction of future stock levels is much more difficult with capture fisheries than with other renewable resources, such as forests, because there is a very high element of uncertainty about the dynamics of many fish populations and of large aquatic ecosystems. In some relatively well-understood fisheries, a bio-economic model can be used to assess the likely future stocks, costs of fishing, and rent under different management regimes. If government has clear and credible management objectives, the model can be used to assess the value of the fish stock with reasonable accuracy. Such a model was used, for example, to assess the value of Iceland's fisheries based on fisheries managers’ objectives (see case study for Iceland in Chapter V).

194. Another study of the Atlantic sea scallop fishery (Chapter V) compared the value of the fishery under current management to the value that would be generated under a new fisheries management plan. The plan called for a temporary, one-year decrease in

harvest in order to increase the surviving biomass and future harvest. The resulting new stock size and its distribution by age, size and weight (the last two components affecting the price paid per scallop) were used as the basis of asset valuation. Of course, one can point to numerous instances where fisheries management plans designed with the best scientific information available failed to meet their objective, so in using such plans as a basis for valuation, it is important to monitor how they compare over time to actual performance of the fishery. If the fishery does not respond as predicted, then the plan is probably not a good basis for asset valuation. This issue is taken up again below in the section on negative rents and potential asset value.

195. In the absence of alternative information, the convention in asset accounting valuation has been to assume constant prices, technology, and production costs. The calculation of asset value then relies on the remaining variables: levels of stock and exploitation. For a renewable resource, there are several possibilities for future stock sizes that give rise to different rents and asset values for fish:

Option 1. Stocks remain constant under stable, sustainable management so that rent is constant over time;

Option 2. Stocks are increasing, recovering from depletion so that rent will increase over time;

Option 3. Stocks are declining and depletion will continue until the fish stock collapses irreversibly, so that rent declines until none is generated.

196. Whether they succeed or not, the goal of most fisheries managers is sustainable or increasing fish stocks, so option 3 will not be considered further. Governments usually change management when a fish stock faces collapse in an attempt to restore the stock to previous high levels, but whether they succeed depends on three factors: (a) that the fish decline is, in fact, reversible; (b) that fisheries manager have sufficient knowledge of the fish dynamics to design effective measures to restore the fish stock; and (c) that there is a credible commitment by managers to policy changes, which may be politically very difficult. Most fisheries have not recovered as often, or as quickly, or to the levels that managers have set as objectives. So, without clear evidence of success of achieving the objectives, option 2 may not be a reasonable basis for estimating the asset value of fish.

197. The most commonly used assumption for asset valuation is option 1, stable fish stocks, based on conservative assumptions of a sustainable, but not growing fish stock. In this case, where fish are harvested at a constant, sustainable rate in perpetuity, the formula for asset value reduces to:

$$V_t = \frac{p_t Q_t}{r}.$$

198. As with the physical fish stocks, the monetary value should be based on the rent obtainable from all fishing sectors: large-scale, artisanal, and recreational. If based only on one sector's performance, the value of the fish stock will be underestimated. Including all fishing sectors, the total value of the stock would equal:

$$V_t = \frac{p_{L,t} Q_{L,t}}{r} + \frac{p_{S,t} Q_{S,t}}{r} + \frac{p_{R,t} Q_{R,t}}{r}$$

where

$p_{L,t}$, $p_{S,t}$, $p_{R,t}$ unit rent for the large-scale, small-scale, and recreational fishing sectors respectively;

$Q_{L,t}$, $Q_{S,t}$, $Q_{R,t}$ catch for the large-scale, small-scale, and recreational fishing sectors respectively.

199. As discussed in the section on physical accounts, information may not be readily available by species for small-scale and recreational fisheries, so it may only be possible to add the value from these other sectors when calculating the total value of all fisheries. For example, in Namibia, the total value of fisheries, based on large-scale commercial fishing for three major commercial species, was N$4,489 million in 1995. There is a significant recreational fishing industry in Namibia, but no small-scale fishing to speak of (although the line between recreational and small-scale commercial fishing is not always easy to draw). Assuming that recreational fishers caught about 5% of the volume of large-scale fishers, and that the rent per unit was half that of large-scale fishers, then the added asset value from recreational fishing would be N$112 million and that total value of Namibia's fish stocks would be N$4,601.

200. Because the asset valuation method only requires catch and unit rent data, it has been suggested that this method can be applied to fisheries where there is no information about stock sizes. This is typically the case in tropical fisheries where multi-species ecosystem makes stock size measurement very difficult. However, this assumption must be used with care - without supporting evidence that the fish stocks are being managed sustainably, this method will provide the wrong signal to policy-makers by overestimating fish asset value and masking possible losses.

201. For fish stocks with strong natural fluctuations (primarily small pelagic species like anchovies or sardines that are subject to the El Niño phenomenon), the catch and unit rent in any given year may not be a good indicator of long-term asset value. For such fisheries, it may be more useful to average the catch and unit rent over a series of years. This, in fact, is the procedure adopted by a number of countries for mineral accounts. The reserves of minerals are usually well known and extraction is rarely affected by non-economic factors. However, mineral prices are subject to large year-to-year fluctuations. Consequently, Australia, for example, uses a 6-year lagged moving average of the unit rent to value its mineral assets. Other countries may use a different number of years, but the principle is the same.

Discount rate

202. All expected future rents must be discounted in order to express their value at the present time, and the choice of a discount rate is critical. One of the controversies concerns whether a private or social discount rate should be used. Table III.4 shows the discount rates used by different countries to construct monetary asset accounts for fish.

These rates vary from a low of 3% (United States) to a high of 10% (Namibia). The choice of discount rate is discussed further in the case studies of Chapter V.

Table III.4 Discount rates used to calculate fisheries asset value

Country	Discount rate
Iceland	8%
Namibia	10%
Norway	3.5%
United Kingdom	4%
United States	3%

Source: Case studies in Chapter V;
For United Kingdom: Office for National Statistics 2003.

Negative rent and the potential asset value of fish

203. It is not uncommon to find that fishing rents are zero or even negative, and in such cases the asset value of fish is treated as zero. It may be perplexing to fishers that the economic value of a fish stock could be zero when their livelihood depends on it. In simple terms, it means that the revenue from fishing does not cover all the costs of fishing. For commercial fisheries, this should not be surprising given the extensive subsidization of fishing in many countries. In open-access fisheries, which continue to characterize many marine capture fisheries, it is well established that fishing will expand until rents are eliminated.

204. The economic interpretation of negative rents is that the fishery is being managed in an economically sub-optimal way. Moreover, inputs such as capital and labour are also being used in a sub-optimal activity, implying that there would be an improvement in economic welfare if these resources were employed elsewhere in the economy and subsidies did not have to be paid. However, while economically inefficient, fisheries management may achieve other non-economic objectives that are important to society (see discussion in Chapter IV).

205. When rent is found to be negative and the value of fish stocks are zero, this does not mean that it is unimportant to construct fisheries resource accounts. The physical accounts are still useful for management, and it is important for policy-makers, both fisheries managers and those responsible for the macro economy, to know that a resource is not being managed efficiently from an economic perspective. In addition, when the value of an important resource, like a fish stock, has an economic value of zero, it is important for fisheries managers to ask what the value of the stock would be under optimal management. Analysis with a bio-economic model could show how resource rent might change with the rate of exploitation of the fish stock.

206. In estimating the potential, optimal value of fish stocks, however, the optimal value of fisheries should not be mistaken for the 'true' value of fisheries and substituted for the actual value of fisheries in the accounts. The exception would be in the case described above where fisheries managers have a credible policy and commitment to

bringing about optimal stock levels. The SNA and the SEEA are measures of economic activity not economic welfare. Consequently, the accounting practices of the SNA and the SEEA require asset valuation based on current value, not potential value. This issue is discussed further in Chapter IV and in the case studies presented in Chapter V.

Monetary depletion and degradation

207. The section on physical accounts already pointed out the difficulties in measuring depletion because it requires distinguishing the impact of economic activities from the impact of natural causes on stock size. Once depletion has been defined in physical terms, the question arises of how it should be valued. The SNA defines depletion of a natural economic asset as the reduction in the value of the asset (e.g., fish stock) as a result of harvesting or other economic uses. This cost is the difference between the present value of the future economic rent that the stock *could* have generated before depletion, and the present value of the rent that will actually be generated by the depleted stock. The depletion measure shows the present value of the foregone rent in the future. Such valuation requires a bio-economic analysis based on assumptions about future prices and costs and fisheries management policy. In practice, it could simply be measured as the difference between the previous year's estimate of discounted future rent, and the new estimate of discounted future rent. An example of calculation of depletion costs is provided for Icelandic cod in Chapter V. Two alternative calculations are given, based on different assumptions about the decline in stock size that is due to economic activity versus non-economic causes of decline.

208. The damage cost of degradation of fish stocks and of related ecosystems and habitats can be estimated as the impact of degradation on the ability of a stock to generate resource rent in the future. Where there is a clear relationship between degradation and rent generating capacity of a stock, a damage cost for degradation can be determined. For example, the influence of a reduction in the spawning biomass of a fish stock on future recruitment could be estimated in certain circumstances and for certain species.[3] However, in many instances, these relationships are poorly understood and cannot be quantified at this time. Consequently, it has not been possible to determine a damage cost for stock degradation and degradation is best measured in physical terms.

C. Flow Accounts

209. As mentioned in Chapter II, flow accounts related to fishing include: fishing and related economic activities in the national accounts; environmental impacts from fishing and other related activities; resource management and environmental protection expenditures; and taxes, subsidies and license fees. Each component is discussed below.

[3] Discernable stock-recruitment relationships can usually be estimated at low levels of spawning biomass. Such low levels normally indicate heavy overfishing and entail the risk of stock collapse.

1. Fishing and related activities in the Supply and Use Table

Economic Analysis

210. Chapter II discusses in details the SUT specifically disaggregated for the fisheries sector. To the extent that data allow, it is useful to disaggregate the fishing industry into a number of sub-sectors on the basis of:

- production process: aquaculture and capture fisheries; small-scale, industrial and recreational fishing;
- product: species or group of species;
- geographic location: inland and marine, specific geographic region.

211. Naturally, not all of these distinctions are relevant to each country, and the decision about disaggregation will depend on the characteristics of a country's fisheries and the important policy issues. The SAM provide further distinctions, for example, which categories of households and enterprises are involved in different fishing activities and which categories of households are most dependent on fish and fish products.

212. Chapter II shows the different forward linkages (processing, marketing and distribution) and backward linkages (production of inputs, especially vessels and gear) of the fishing industry presented in the SUT. Determining those linkages is important for the fisheries managers to measure the economic contribution of both fishing and industries related to fishing, such as fish processing (forward linkage) and ship building (backward linkage). Some secondary linkages may also be important, notably the use of processed fish as an input to agriculture: as fertilizer for crops, and feedstock for livestock and aquaculture. These secondary linkages may be more difficult to trace through the SUT unless there is a great deal of disaggregation.

213. Material flow accounts (MFA) for fish products can be constructed from the monetary SUT accounts by transforming the monetary data into physical accounts. Such detailed MFA have been constructed for materials as diverse as forest products, energy, water, metals, etc. They are particularly useful for commodities that are widely used in an economy, with many forward and/or backward linkages. Such accounts provide the basis for assessing the direct and indirect dependence of the economy on such materials. However, fish products have relatively few linkages - most fish products are delivered directly to exports, to households for direct consumption, or to fish processing where most of the product is sold in turn to a handful of industries and final consumers. These physical interdependencies are not as important for fish as for other commodities.

Environmental impacts

214. The impact of fishing on itself in the form of stock depletion is perhaps the most obvious form of damage, and is addressed under the asset accounts. Some methods of capture fishing can be very harmful both to fish stocks and to the aquatic ecosystem.

Such methods include use of dynamite or poison for fishing, use of very small mesh nets, loss of nets resulting in so-called ghost fishing, and inappropriate harvesting methods that harm other aquatic species, such as seabirds and mammals. These environmental impacts are difficult to quantify and no effort has been made to quantify them within the SEEA at this time.

215. Some types of aquaculture can have a significant impact on water quality and the health of wild fish populations. The emission of solid waste by shrimp and milkfish culture has been documented in the environmental accounts for the Philippines. Pond aquaculture in coastal areas can also have a major impact on land use, for example the clearing of mangrove forest area for the creation of fish ponds.

216. Fishing vessels can also emit a range of air and water pollutants, including accidental oil spills, which can be represented in the SEEA. However, the fishing industry has not been identified with major pollution impacts on the marine environment, except for local instances.

217. Industries related to fishing may also have environmental impacts. Upstream industries like commercial shipbuilding generate air and water pollution. Subsistence fishing gear, such as boats, nets and baskets, is often constructed from local materials, which may be depleted by over use. Downstream industries like fish processing may use scarce resources, like wood for smoking or freshwater, and produce pollution.

2. Fisheries management and environmental protection expenditures

218. Chapter II identified the SNA classifications for government expenditure, which are useful for identifying these costs. In that classification, fishing is included with agriculture, forestry and hunting. Obviously, further information is required to separate fishing from these other components, but most of this information is usually fairly easy to obtain from annual publications about government revenues and expenditures. The SNA also provides a classification of outlays by purpose that was described in Chapter II. Some of these categories, such as Outlays on research and Outlays on general administration, correspond well with the major purposes of expenditures for fisheries management. Other categories do not fit so well and may need to be modified. For example, a study of the Namibian fisheries management expenditures identified three major components:

- monitoring, enforcement, control and surveillance;
- research;
- general administration and other.

219. Expenditure for environmental protection represents part of society's effort to prevent or to reduce pressures on the environment. Classifications currently proposed for environmental protection activities were also discussed in Chapter II. Environmental protection expenditure is generally defined in terms of objectives pursued through

actions or programmes related, for instance, to waste disposal, preservation of water quality, protection of other natural media, etc. Waste-water management is likely to be most important for fisheries, although the other components may also affect the health of fisheries.

220. The interpretation of environmental expenditures can be ambiguous since the result of the expenditure is unknown. An increase in expenditures cannot be unambiguously associated with a positive change in, for example, water quality and ecosystem health, nor can a decrease in expenditures necessarily be associated with a negative change. Expenditures may increase, but not as quickly as pollution damage so that water quality declines even as expenditures increase. Furthermore, pollution prevention and remediation may come about through low-cost or even cost-saving technologies. In such cases, environmental improvements may be associated with lower expenditures.

221. Environmental protection expenditure may be particularly relevant to aquaculture. However, much of the effort to reduce pollution from aquaculture takes the form of process modification, rather than end-of-pipe measures aimed solely at environmental protection. For example, if an existing facility is modified by adding settling ponds to treat wastewater, this modification may be treated as an environmental protection expenditures. On the other hand, if an entirely new facility with wastewater treatment an integral part of the production process, there are no clearly identifiable costs that can be assigned to environmental protection.

3. Fisheries taxes, fees, and other charges

222. In many countries, the state is the owner of capture fisheries resources, marine or inland, and the owner of territorial waters used for aquaculture. In some instances, local communities may own these resources or have exclusive use rights. As the owner of fisheries resources, government (or a local community) has a right, like any other owner, to charge for the use of its resource. Such charges are common throughout the world for minerals and, to a lesser extent, for exploitation of forests. Currently, the extraction of resource rent by governments through fess and taxes is not widely applied. Fishing tends to be less heavily taxed and, in a number of countries, fishing is subsidised.

223. The SEEA accounts for a range of charges on fishing by government - subsidies, taxes, fees, levies - hereafter referred to simply as taxes. Some of these taxes are designed to recover resource rent and other charges or fees are intended to recover at least part of the resource management services provided by government. This account is intended to help fisheries managers address two issues: (1) the extent to which resource rent is recovered by government, and (2) the extent to which private fishers pay the full costs of fisheries exploitation including the costs of environmental impacts as well as resource management costs.

224. Some of these charges are intended to be fees for specific services, such as an Observer Fund Levy which is used to pay the costs of a government-run system of placing observers on each vessel to ensure compliance with quota and other regulations. However, these fees usually do not go into a dedicated revenue fund, so it is not easy to determine whether fees actually cover the cost of services. Comparison of the accounts for government fishing outlays by purpose with the accounts for different kind of fishing taxes allows fisheries managers to determine the extent to which fees cover the cost of services.

D. Macroeconomic indicators and memorandum items

1. Macroeconomic indicators

225. Indicators of sustainable development and environmental-economic accounts have developed independently. Several lists of environmental indicators have been proposed at the national and international level. These lists are often designed to respond to particular regulatory needs and, while they are usually internally consistent, they lack comparability across lists. The use of an accounting framework to develop indicators, such as the SEEAF, would provide credible, compatible and consistent information for policy-making, regardless of the specific needs for which the information is used.

226. In the past, environmental-economic accounting was conceived mainly to provide a more accurate measure of sustainable income by revising conventional macroeconomic indicators (usually NDP) to reflect depletion and degradation of natural capital. The approach that is most relevant for fisheries resources subtracts the depletion of natural capital from conventional NDP to obtain depletion-adjusted NDP. The adjustment of NDP for asset depletion parallels the treatment of produced assets in the national accounts, and is accepted in principle by most economists and statisticians. However, as discussed earlier, it is not easy to measure depletion for fish stocks. Depletion requires identifying a decline in fish stocks attributable to economic activity, not natural causes, which is not always easy. Even where physical depletion can be quantified, there is not yet a consensus over the correct way to value the depletion of natural capital. Consequently, no country yet includes depletion of fish stocks in their national accounts, or even in experimental accounts.

227. Recently, the SEEA-2003 (UN *et al.* 2003) was developed to provide an information system consistent with the concept, definitions and classifications of the SNA, from which a consistent and comparable set of indicators could be derived. In the case of fisheries, in recent years, there have been efforts to develop a set of indicators for sustainable fisheries, based on economic, social, ecological, and institutional statistics. FAO published a review of potential indicators for marine capture fisheries under its series of Technical Guidelines for Responsible Fisheries (FAO 1999).

228. The SEEAF provides an information system, which can be used for the derivation of sustainable development indicators for fisheries. It focuses on the interactions between the economy and the environment separately identifying transactions related to the fisheries sector and the impacts on the fisheries of other economic activity. Although at present the framework does not specifically address the social aspects, these, as well as indicators that cannot be directly derived from the accounts, could be linked to the core accounts through supplementary tables. These supplementary tables could be designed in such a way that the definitions and classifications are consistent with the core framework thus generating consistent set of information.

Examples of indicators that could be derived from SEEAF and their link to the Pressure State Response framework

229. Indicators for fisheries that can be derived from the SEEAF are grouped for convenience within the Driving Force-State-Response Framework (Willmann 2000). There are many other possible indicators that could be added to the below list derived from supplementary information to the accounting framework.

230. In the Driving Force-State-Response framework, driving forces represent pressures from human activities exerted on the environment. *Driving force indicators* are related to consumption and production patterns and often reflect resource use intensities and emissions, along with related trends and changes over a period of time. They also include population growth, demographic patterns and economic growth. *State indicators* provide an overview of the situation of the environment and its development over time. Examples of state indicators include concentration of pollutants in environmental media, degraded environmental quality and its effect on health, status of natural resource stocks and of ecosystems, etc. *Response indicators* show the extent to which a society responds to environmental concerns. They refer to individual or collective actions intended to mitigate or prevent the impact of human activities on the environment, halt or revert environmental damages already inflicted, or preserve the natural resources. Examples of response indicators include environmental expenditures, environment-related taxes and subsidies, etc. Conceptually, no unique attribution of sustainability indicators into one of these three categories appears warranted as one and the same indicator could serve as a driving-force indicator as well as a state or response indicator.

Driving force indicators

Physical accounts for stocks and material flows:

- ratio of closing stock to opening stock to assess trends;
- supply of fisheries-related natural resources (e.g., fish stocks, mangroves and other forests, coral reefs, wetlands, fresh water, etc.);
- use of fisheries-related natural resources by all sectors of the economy;

- residuals and pollutants by various economic sectors (fishing fleets, fish processing firms, distribution and transport of fish and fishery products, industries and hotels in coastal areas, etc.) released into or received by the ambient and aquatic environments during the accounting period;
- residuals and pollutants per unit of value added and per person employed by fisheries related sectors.

Monetary asset and flow accounts:

- distribution of national wealth among manufactured and natural capital;
- comparison of the value of fisheries assets to the value of other natural resources;
- amount of resource rent generated by fisheries activities compared to resource rent generated by other natural resource sectors;
- ratio of current rent to potential rent and, hence, of value of fish stocks under current management to potential value under alternative management;
- trends in per capita national wealth over time;
- ratio of value of capital stock of fishing capacity and value of stock of fishery resources;
- cost of degradation of fisheries resources;
- conventional and environmentally-adjusted gross and net value added and their components for the fisheries sector (e.g. capital depreciation; wages and salaries; interest payments; profits) and ratios between unadjusted and adjusted values;

Note that for all these indicators, trend analyses are possible based on time series data over successive accounting periods.

State indicators

Asset accounts:

- physical stocks of various natural resources (e.g. fish stocks; fish habitats);
- economic value of stocks of various natural resources; stocks of human-made capital (e.g. value of fish stocks and habitats; fishing fleets; and fish processing capacities);

Flow accounts:

- number of persons employed and person-years of employment in the fisheries sector;
- number of households dependent on fishing and related industries;

Response indicators

- fisheries resource management costs incurred by government and private sector;

- environmental protection expenditures incurred by government and private sector to remediate or prevent damage to fisheries habitat;
- ratio of management costs and environmental protection costs to income (value-added) generated by the fisheries and related industries;
- subsidies, taxes, charges/fees on production inputs and/or outputs including residuals/pollutants; and
- ratio of charges to management costs to determine whether the industry is paying the full costs;
- ratio of taxes to resource rent to determine if government is recovering rent.

2. Memorandum items

231. A number of memorandum items have been recommended for the SEEA because of their relevance for the use of the accounts. For fisheries resources, these items can include:

- indicators of quality for fish stocks, such as share of spawning stock in the biomass;
- indicators of quality for ecosystems: species diversity, extent and qualitative assessment of major ecosystem components such as mangroves, coral reefs, sea grass beds, etc.;
- employment in fishing and related industries;
- information about number and characteristics of fishing vessels, and fish processing plants;
- holdings of fishing rights and their value, if available;
- number of households dependent on fishing.

CHAPTER IV: POLICY APPLICATIONS OF FISHERIES ACCOUNTS

A. Introduction

232. The motivation for environmental accounts has been the adoption by many countries of the notion of sustainable development. The design and implementation of strategies for sustainable development relies on information about the interactions between the environment and the economy. Information is needed to monitor progress toward meeting environmental goals. Information is also needed to assess alternative development strategies, and to design environmental policy instruments to achieve sustainable development. The SEEAF is designed to provide this information for fisheries resources.

233. This chapter describes a range of applications of the SEEAF - by no means exhaustive - to help in the design and implementation of policies for a more sustainable future. Most of these examples are drawn from applications of existing accounts, or from closely related analysis, and reflects the emphasis of these accounts. They refer mostly to larger scale fisheries exploiting a small number of species for which adequate data are available. Many fisheries of developing countries, especially in the tropics, are of a small-scale nature. The small-scale sub-sector is usually characterised by large numbers of fishermen who employ labour-intensive fishing techniques and land their catch all along the coast in small landing places and harbours or directly on the beach. Whilst most of them produce for commercial sale in the market, a share of the catch is usually taken for home consumption (own final use). Moreover, some fishermen operate for subsistence on a part-time basis and derive most of their income from agriculture or other activities.

234. The data collection and accounting task for the small-scale sector is especially difficult because of the large numbers of operators, their geographical spread and because of inadequate catch records and lack of business accounts in small-scale fisheries. While catch statistics are in many, but in no way in all, instances produced from regular sample surveys, price and cost data are often not available and sample cost and earnings surveys are not undertaken, or at least not on a regular basis. The paucity of reliable data for the small-scale sector has been one important factor for systematically underestimating its contribution to national income and, more broadly, to national welfare. It is hoped that for the applications for policy analyses shown in this

chapter, as well as for reasons of completeness of both conventional SNA and SEEAF, efforts are enhanced at national levels to collect the most basic data on catches and costs and earnings of small-scale fisheries.

235. It has been noted several times in this handbook that fisheries are often affected by policies and developments not directly related to fisheries, e.g., land use policy which encourages forest conversion, urban and industrial development in coastal or riverine areas which increase pollution loadings of coastal ecosystems, etc. Indeed, an important audience for this handbook includes the policy-makers and macro-economic managers outside of fisheries, who would benefit from a better understanding of fisheries and its interactions with the rest of the economy. Although there is a clear need for integrating accounts for fish in a broader accounting and policy framework, there are no examples of such work at this time.

236. Section B discusses asset accounts for fish stocks in terms of the information they provide policy-makers about weak and strong sustainability. The uses of the resource management accounts and environmental tax accounts are discussed in connection with the asset accounts. Section C describes the uses of the physical and monetary flow accounts for resource use and emissions. The flow accounts have many uses, both as for deriving indicators for monitoring sustainability as well as for detailed analysis leading to policy recommendations about how to achieve a more sustainable economy. Sections D and E provide a general overview of accounts for degradation and management expenditures accounts. Finally, concluding remarks are provided, in Section F, that summarize the experience so far with accounts for fish and related resources, and area where further work is needed.

237. For each component of the SEEAF, the discussions begin with the kinds of applications which statistical offices can reasonably do on their own, then proceeds to applications which require more specialized expertise in techniques of economic analysis and modelling. In most countries, full use of the SEEAF will require extensive cooperation with fisheries management agencies, as well as other agencies with economic expertise.

B. Asset accounts for fish

238. Asset accounts for fish stocks contribute to more effective monitoring of both fish resources and national wealth and can be used to improve management of natural capital from fishery resources. Some of the issues that the asset accounts address include:

(a) Monitoring fish stocks and their asset values

- physical stocks of fish and changes in stocks over time
- economic value of fish stocks and their share in total wealth
- depletion of fish stocks and the economic cost of depletion

(b) Analysis of fisheries management. SEEAF helps to answer the following questions:

- is the resource rent being generated in the fishery and collected by government through economic instruments?
- is the rent recovered from the fisheries appropriate in view of the management functions fulfilled by government and in view of other considerations such as the financing of social development activities and alternative use of the rent by the private sector?
- is the maximum rent being generated by fisheries policy? If not, are there other socio-economic objectives that are being met, and what is the economic cost of meeting these other objectives?
- is the budgetary allocation adequate to effectively fulfil the required fisheries management tasks?
- is rent extracted from the fisheries used to promote sustainable and equitable development?

1. Monitoring fish stocks and national wealth generated by fishery resources

Physical accounts

239. Physical asset accounts provide information on ecological sustainability that can be used for the economic concept of strong sustainability, as well as detailed information for management. For example, the volume of fish biomass, especially when disaggregated by age class, helps to determine sustainable yields and the harvesting policies appropriate to that yield. In addition, changes in stock over time indicate the effect of fisheries policy on the stock and whether depletion is occurring. In the case of Namibia, the biological depletion of major commercial fish stocks since the 1960's has provided a very clear picture to policy-makers of the devastating impact of uncontrolled, open-access fishing (see Figure IV.1). This policy was revised since Namibian independence in 1990.

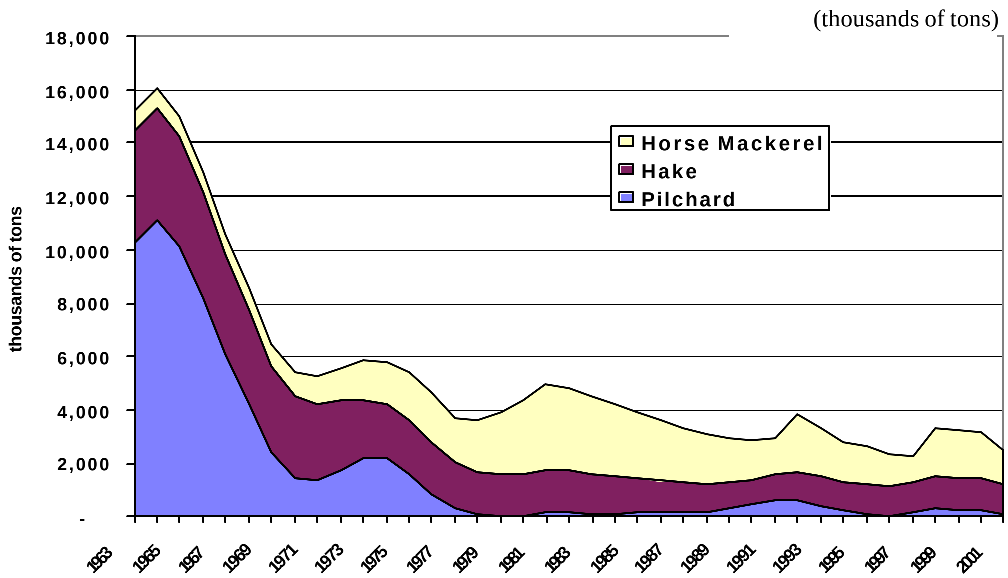
240. The physical accounts report not just stock levels, but also the factors that cause changes in stock, distinguishing changes due to human actions (catch) from other changes attributed to "natural" causes. These other changes include recruitment, natural mortality, and migration, although fish accounts do not usually disaggregate these other changes because there is not sufficient information to provide reasonable estimates.

241. Time trends of stocks, catches and other changes due to natural causes, are useful in understanding a fishery, both from an ecological perspective as well as an economic perspective. A highly volatile stock often has a highly volatile catch or TAC, which can make the industry unattractive for investment, affecting the economic efficiency of fishing. It may be difficult for a developing country to attract foreign investment in fishing, unless the investors are given very attractive deals such as low taxes, etc. This

may result in much of the economic benefit of fishing accruing to foreign operators and not to the country with jurisdiction over the fishery resources, reducing the ability of fishing to contribute to generate revenues for government to support economic development.

242. Volatility of fish stocks also tends to make employment unstable which, in countries with high unemployment, can be an added difficulty for fisheries managers. There may be considerable pressure to allow high levels of TAC not only from fishing companies, but also from unions in order to maintain jobs, even when the stock may be declining.

Figure IV.1 Biomass of hake, pilchard, horse mackerel in Namibia, 1963 to 2001



Note: Figures represent fishable, adult biomass. Figures prior to 1990 were estimated using different methods and are not entirely comparable with figures after 1990.

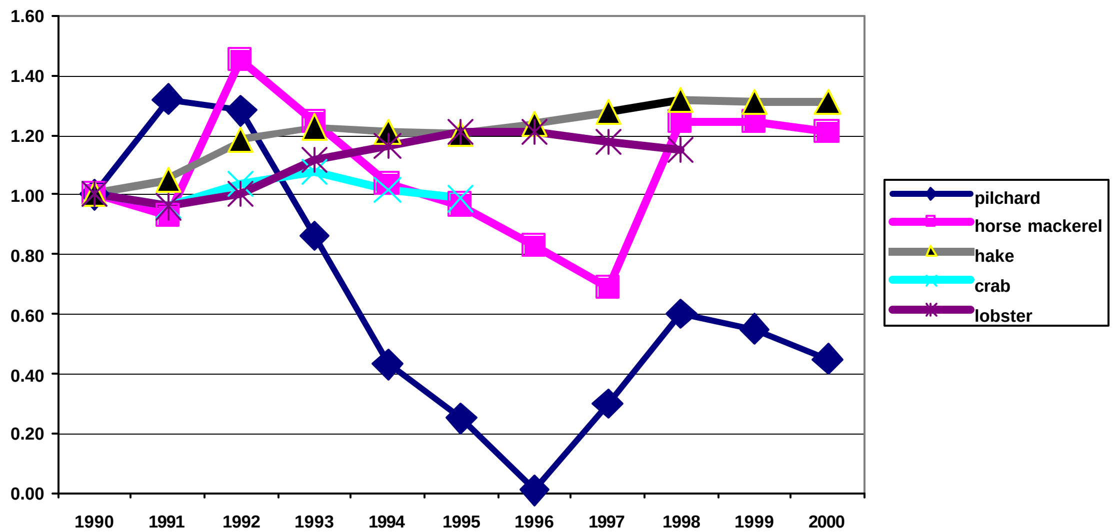
Source: Based on data from Lange 2003 and Marine Research and Information Centre (MFMR) 2001.

243. Many fish stocks, especially small pelagic species, exhibit a great deal of inter-annual variation in abundance. Figure IV.2 shows trends of fish biomass for the years 1990 to 2000. In order to compare internal variation, the time series is scaled so that the base year is the same for all species. Comparison of volatility among species is one indication of the differing amount of economic risk associated with each one. Among five major species fished by Namibia, hake, a demersal species, has shown little of the volatility so often experienced in small pelagic fisheries, it has been continuously growing over the period 1990 to 2000, albeit at an unsteady rate. The stock levels for crab and lobster varied within a fairly narrow range, no more than 20 per cent of the 1990 value, and crab remained within 8 per cent of its 1990 value. By contrast, horse mackerel and pilchard, both small pelagic species, have shown enormous volatility, growing rapidly in the early 1990s, then plunging to quite low levels - for pilchards, near zero - followed by at least a partial recovery. While some of the reasons for the

volatility are well known - environmental disturbances affecting fish behaviour (both migration patterns and spawning, recruitment patterns), they are largely unpredictable at this time, making these fish stocks much more difficult to manage. It is not certain at this time how much of the volatility may have been exacerbated by overfishing.

Figure IV.2 Index of biomass for major fish species in Namibia, 1990 to 2000

(1990 = 1.00)



Note: Data not available for crab after 1995 and for lobster after 1998.

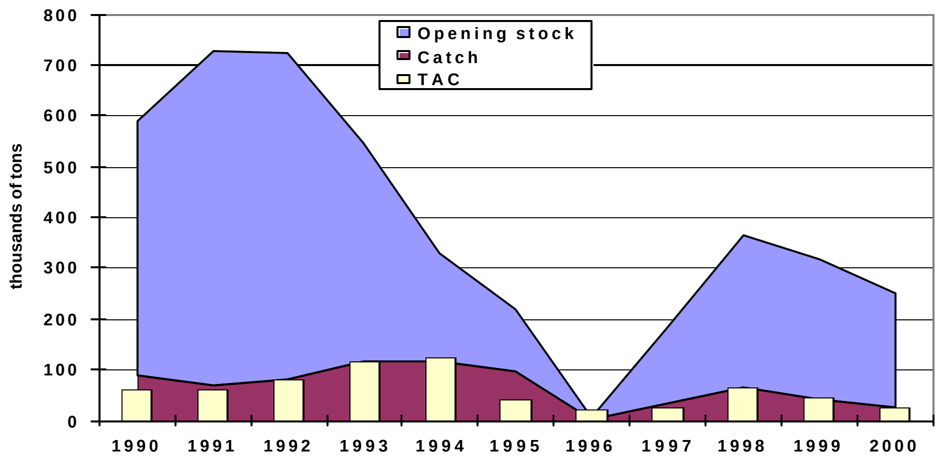
Source: Marine Research and Information Centre 2001.

244. When TAC is included in the fish accounts as a memorandum item, trends in biomass, TAC, and catch can be compared to see how fisheries managers have responded to changes in fish stocks. Figure IV.3 illustrates this comparison for pilchard in Namibia for the years 1990 to 2000. Pilchard biomass increased slightly in the early 1990s and then crashed precipitously, all but disappearing by 1996. Interestingly, TAC and catch continued to increase, even as the biomass was falling, until 1995 when the TAC was reduced by more than two-thirds. Fishing companies experienced considerable economic hardship and disputed estimates of declining stocks. In 1996, pilchard fishers claimed that the pilchard had not been depleted, but had only migrated to the northern extreme of the Benguela marine ecosystem in Angolan waters. The fishing vessels went to Angolan waters, which accounts for the above-TAC catch in 1995. Since 1996, TAC and catch have matched the trend in fish biomass more closely.

245. In addition to the commercial fisheries, there are other fishery and aquatic resources that clearly yield economic benefits, although it may be difficult to quantify them, even in physical terms. For examples, there are species which are necessary as prey for commercially exploited species but are not themselves exploited for direct use; straddling stocks or species which seasonally migrant into the high seas beyond a country's jurisdiction and are not effectively managed by a single country or agency, and other species important for non-consumptive purposes such as tourism (e.g., the

myriad species that make coral reefs attractive to divers) or for other purposes such as biodiversity preservation (e.g., whales). For such assets, for which economic valuation might be impossible or inappropriate, physical accounts could be prepared to inform policy-makers and fisheries managers.

Figure IV.3 Biomass, TAC, and catch for pilchard in Namibia 1990 to 2000



Source: Marine Research and Information Centre 2001.

246. Effective fisheries policy requires not only management of fisheries, but also the management of the broader environment, which supports fisheries. Degradation of habitat due to human actions elsewhere can lead to depletion of a commercially exploited fish stock no matter how carefully the stock is monitored and managed through quotas (TAC) or license limits. For broader monitoring of conditions affecting the health of commercial fisheries, it may be useful to develop accounts for resources closely linked to fisheries, such as:

- mangrove forests, which provide habitat and breeding grounds for many fish;
- water accounts including both volume, quality for freshwater resources;
- water emission accounts for coastal areas, or areas adjoining rivers which feed into fish habitat;
- ecosystem accounts for marine reserves to monitor biodiversity.

247. There are, as yet, no examples of countries that have constructed a set of environmental accounts for fisheries management that extend beyond the commercial species themselves. Environmental accounting and in particular SEEAF could serve as a useful tool for integrated coastal area management (ICAM), which requires to take a comprehensive approach to coastal fisheries management (see Text Box IV.1).

Text Box IV.1: Coastal area linkages

The manifold interactions between marine fisheries and the various economic sectors in coastal areas have been well recognized internationally (e.g. Agenda 21 (UN 1992); Code of Conduct for Responsible Fisheries (FAO 1995)) as well as nationally. This is evident from the fact that many governments have started in recent years to address the management of marine fisheries within broad-based integrated coastal area management programmes. In densely populated coastal areas in particular, the sustainability issues of marine fisheries cannot be addressed in isolation of the pressures on the coastal environment caused by economic activities and by urbanisation. Moreover, in many countries, especially in Asia, marine capture fisheries continue to serve as a source of income and employment of "last resort" due to the widespread open access conditions. The sustainability of marine fisheries involve issues that go beyond the fisheries sector and depend on other sectors in the economy. For these reasons, an integrated analysis is necessary to address the issues of sustainability of marine fisheries.

Ideally, integrated economic and environmental accounts should be developed for entire coastal regions where various economic sectors share common environmental services and natural resources. In this scenario, the relative and aggregate uses of environmental services and resources by these sectors could be shown and predictions made how these uses would change as a result of an expansion or contraction of different economic activities. SEEAF could serve as a tool for identifying areas in need of specific management measures and in particular that can achieve the greatest protection and conservation impacts at lowest cost.

Integrated economic and environmental accounting of coastal areas appears especially relevant in situations where, in order to achieve sustainable marine harvesting levels, significant reductions of fishing fleets would be required as well as the re-allocation of fishers into other economic activities. The expansion of the latter could result in unsustainable harvesting levels of other coastal resources such as, for example, mangroves and other coastal forests whose degradation could subsequently impact on marine fisheries. Similarly, the expansion of activities such as tourism and industries could contribute to increased levels of water pollution affecting fisheries.

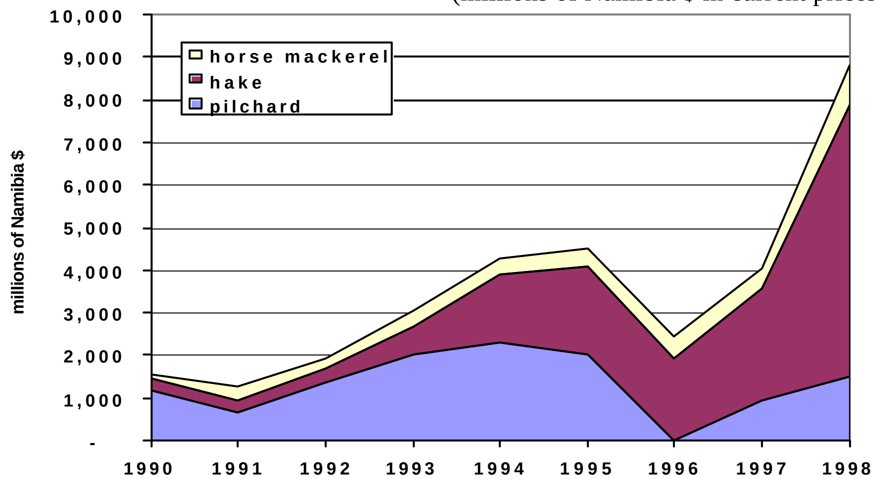
Source: Willmann (2000).

Monetary accounts: asset value, depletion, and total national wealth

248. The physical accounts are essential for monitoring ecological sustainability. However, a more complete assessment of assets requires that the economic value of a resource also be understood. In making the sometimes politically difficult argument to preserve fish stocks for future exploitation, it can be useful to show the economic gain from doing so and the loss that would result from not preserving the stock. An example of the value of fish stocks for Namibia is shown in Figure IV.4. Total fish wealth rose from Namibia N$1.5 billion in 1990 to N$8.8 billion by 1998, due to the recovery of hake stocks and improved economic management, which increased unit rent. At the same time, there was tremendous loss of pilchard wealth, such that total wealth generated by pilchard dropped markedly after 1995 and did not fully recover until 1998. (This example is described in greater detail in Chapter V).

Figure IV.4 Asset value for fish in Namibia, 1990 to 1998

(millions of Namibia $ in current prices)



Source: Lange 2003.

249. The relatively few fish accounts that have been constructed do not generally include a measure of depletion, even though there may have been substantial losses of wealth from one year to the next. The reason for this is that depletion is defined as loss of wealth due to economic activity, mainly over-harvesting. Losses due to other causes such as the impact of an El Niño event, are not considered depletion. The inability to clearly distinguish between the impact of possible over-harvesting and other effects make it very difficult to measure depletion for fisheries. Although losses such as those seen in Figure IV.4 cannot be unambiguously termed depletion, they do provide a warning to policy-makers of what a country stands to lose if the fish stock is depleted.

250. Total national wealth can be analysed to assess the diversity of wealth, its ownership distribution, and its volatility due to price fluctuations, an important feature for economies dependent on primary commodities. Diversity is important because, in general, the more diverse an economy is, the more resilient it will be to economic disturbances. Volatility is also important in planning for the future - lower volatility contributes to more stable economic development. The distribution of the ownership of assets - between public and private sector, the concentration among different groups in society, and between domestic and foreign - can have significant economic implications and can influence the sustainable management of resources.

251. The value of fish stocks is not only useful to fisheries managers, but also to other policy-makers responsible for economic development by providing a more complete measure of national wealth. One of the fundamental macro-economic indicators of a country's well being is its wealth over time. The discussion of sustainability indicated that there are different views about how wealth should be measured, i.e., if all forms of wealth can be measured in monetary terms (weak sustainability) or if wealth must be measured in some combination of monetary and physical units (strong sustainability). Although non-declining, national wealth does not guarantee sustainable development, declining national wealth almost certainly is a cause for concern. Better, more

comprehensive accounts for national wealth can only improve the ability of researchers and policy-makers to make informed decisions.

252. Namibia's wealth accounts indicate that, as a share of total, fisheries accounted for 5 per cent in 1990 and in 1998, up from virtually zero in 1980. Table IV.1 shows the distribution of total national wealth on Namibia across produced (according to ownership, government and private) and non-produced capital (mineral and fisheries), for the years 1980, 1990 and 1998. Namibia's wealth increased dramatically at independence in 1990 when it established a 200-mile Exclusive Economic Zone, which brought its abundant fisheries under national control and added this asset to the national wealth.

Table IV.1 Distribution of national wealth by asset in Namibia 1980, 1990 and 1998

(per cent)

	1980	1990	1998
Produced Capital			
Government	37	42	42
Private sector	45	41	49
Natural Capital			
Minerals	18	11	4
Fisheries	*	5	5
Total	100	100	100

*less than 1%

Source: Lange 2003.

253. Of course, sustainability requires that real, per capita wealth is non-declining over time. Even though total wealth and per capita wealth are useful macro-economic indicators, not many countries compile such figures yet, so it is difficult to make comparisons among countries.

2. Assessing fisheries management

254. In managing a public resource like fisheries, government policy can be guided by either of two alternative objectives: the promotion of commercial exploitation to maximise resource rent, or the promotion of a combination of socio-economic objectives in which economic efficiency plays a more limited role. Some countries may adopt a mix of these policy objectives for different fisheries. In the early days of environmental accounting, resource rent was calculated in order to derive the value of assets, but its usefulness as a resource management tool was not always recognized. More recently, rent has been analysed to assess resource management in terms of economic efficiency, sustainability, and other socio-economic objectives, such as employment and equity. Some of these applications are described below.

Government appropriation of resource rent

255. In many countries, fisheries belong, by law, to the state. As the owner of the resource, the government has a right to charge for the exploitation of fisheries by private companies, and the responsibility to ensure proper use of the rent. Often, fisheries taxes do not recover the full rent, or even the full cost of managing the resource. Full recovery of fisheries resource rent could achieve several desirable objectives:

- recovery of rent contributes to the *ecologically sustainable management* of fisheries by increasing the private cost of fishing, which lowers the economic incentive for overfishing;
- set at the appropriate level, fisheries taxes to recover rent also create incentives for the most *economically efficient* (most profitable) level of fishing, based on both biological and economic criteria;
- recovery of rent promotes *equity* by paying the owner of the resource, the state, for utilisation of its asset. This is particularly important in the case of large-scale commercial fisheries because these revenues can then be used for development that benefits all citizens, not just the small minority involved in the fishing industry.

256. In practice, achieving full rent recovery through taxes is difficult and may cause undesirable short-term responses from the fishing industry. This is for several reasons: first, the resource rent is likely to change from year to year because of variability in the abundance of fish stocks and variability in fish prices and harvesting costs. As a consequence, full rent recovery would necessitate a yearly revision of the tax and obtaining accurate information to set the tax rate at the right level. Both obtaining the needed information and getting timely political agreement for a tax revision are difficult in practice. Second, there is no certainty about the short-term response of the fishing industry to a change in taxes, as against the desirable long-term response of limiting investments in harvesting capacity. In the short term, the fishing industry may increase harvesting effort in response to an increase in taxes to make up for the loss in revenues as a result of the introduction or increase of the tax.

257. For these reasons but especially because of the year-to-year variability in rent, full rent recovery through taxes may not be appropriate in many circumstances (Hannesson 1993). From this follows that fisheries management based exclusively on rent extraction is unlikely to work well in practice. However, the extraction of some rent through taxes in combination with other management measures such as license limits and transferable quotas may be desirable in most situations for the three reasons mentioned above.

258. Table IV.2 presents a comparison of resource rent and government appropriation rent for Norway, Namibia, and the Philippines. This is a good example of how the analysis of rent can be used to compare very different approaches to fisheries management. Norway's fisheries are managed in a way that generates no positive rent - rent from fisheries has been negative except in 1995, and, rather than collecting revenue, government has provided the industry with considerable subsidies. The management

regime has promoted exploitation of fish stocks by relatively small, inefficient vessels in order to support Norway's regional economies, rather than maximizing rent. The economic value of the fishery resources under this management regime has been zero. (See Chapter V for further discussion of Norway's fisheries). However, a change is clearly taking place in Norway's fisheries management: fishing subsidies have been gradually reduced over time and in 1995 the industry actually made a net payment to government. Part of this change is the result of the growing economic importance of fish farms, which have generated positive rents.

259. By contrast, Namibia's fisheries policy has been to promote efficient commercial operations and to tax the rent. Rents have always been positive and the fishing industry has always paid part of the rent to government in the form of quota levies. However, the share of rent paid to government has declined: when quota levies were first introduced in the early 1990's, government appropriated roughly half the rent. Its share has now fallen to about 10%, with the result that most of the economic benefit from exploiting this national resource is accruing to a relatively small number of fishing companies. The figures on rent can provide a basis for setting resource pricing; the analysis for Namibia was one of several factors prompting a review of quota levies.

260. The Philippines has constructed preliminary accounts for its two principal fishing sectors, called commercial and municipal fisheries. Both sectors are estimated to generate positive economic rent, although commercial fishing generates more than municipal fishing. However, the combined rate of rent recovery is quite low, averaging only 11% over the period 1988 to 1993 (Lange 2000).

261. In assessing the contribution of fisheries to the economy, it is also useful to calculate the contribution of fisheries taxes to total government revenues, and the extent to which fisheries taxes at least cover the costs of fisheries management. These uses of SEEA for resource management are fairly recent recommendations in the SEEA and have not been carried out routinely by all countries compiling asset accounts. Fisheries typically do not make a significant contribution to government tax revenues, if any at all, in many countries, partly because the sector is so small relative to other sectors, and partly because so many countries do not tax fisheries. Namibia is an exception where fisheries taxes have contributed around 3% of government revenue, more than covering the costs of resource management. (See Chapter V for a detailed discussion of fisheries management costs in Namibia.) Licensing fees obtained from the operations of foreign fishing vessels have also resulted in significant contribution to government revenues in some countries in the South Pacific and West Africa.

Table IV.2 Resource rent and government appropriation of rent in Norway, Namibia, and the Philippines

	Norway (millions of NOK)		Namibia (millions of N$)		Philippines (millions of pesos)	
	Rent	Govt. Approp.	Rent	Govt. Approp.	Rent	Govt. Approp.
1985	-1,231	-1,033				
1986	-1,180	-977				
1987	-938	-647				
1988	-1,954	-451			3,837	313
1989	-3,899	-601			3,980	433
1990	-3,478	-911	153	44	4,270	534
1991	-2,491	-722	125	64	5,106	655
1992	-2,815	-475	192	87	5,318	502
1993	-2,107	-103	306	96	5,669	558
1994	-381	-32	429	115		
1995	51	63	449	98		
1996			243	53		
1997			406	79		
1998			881	85		

Note: Blank means information not available.

Government appropriation is measured as taxes minus subsidies. Negative government appropriation indicates a net subsidy.

Exchange rates: The NOK ranged from US$0.11 to US$0.16 between 1985 and 1995; in 1995, it was equal to US$0.11

The Namibia$ ranged from US$0.39 to US$0.18 between 1990 and 1989; in 1998, it was equal to US$0.18

The Philippine peso ranged from US$0.047 to US$0.036 between 1989 and 1993; in 1993 it was equal to US$0.037.

Source: Norway: Lindholt 2000, Statistics Norway 2000. Namibia: Lange, 2003. Philippines: National Statistical Coordination Board, 1998; Lange, 2000.

Economic efficiency: potential vs. actual value of assets

262. Resource management can be evaluated in terms of economic efficiency to determine if alternative policies might increase the income generated and, hence, the economic value of a resource. Inefficiency can occur for many reasons, for example vessel overcapacity, or inefficient target stock levels and associated surplus growth. Inefficiency can also occur when there are economies of scale and quota allocations are too small, or when quotas are spread out over inexperienced companies instead of creating incentives so that only the most efficient companies obtain quotas (e.g. through a bidding system or by making quotas freely transferable in the market). While no industry is perfectly efficient, it is useful to determine the value of a more efficient industry as a benchmark for the industry, or to provide government with an estimate of the cost of policies that do not promote efficiency.

263. A full analysis including assessment of optimal stock levels require bio-economic modelling. This was done in Iceland (see Chapter V). More simple studies

assume current levels of stock and catch and consider only changes in the economic efficiency of fishing for a given catch. One such study of Norway's herring fishery estimated the potential resource rent of 1,000 million Norwegian kroner. (See Chapter V). A similar observation was made of Namibia's hake fishery, where the rent generated by the three most profitable fishing companies was more than double the industry average (Manning 2000 and Lange 2003).

264. In both Norway and Namibia, fisheries policy has been guided by a combination of economic efficiency and other objectives. In the case of Norway, support to fishing communities has been a component of its strategy to promote equitable regional development. In Namibia, employment creation in fishing and fish processing, and the development of national fishing companies have been important components of its national development strategy. While the direct benefits of these policies can be easily measured in terms of employment and incomes, the costs are not always as apparent.

265. When the pursuit of socio-economic goals conflicts with economic efficiency, there is a cost, and policy is more effective when this cost is known. For example, the costs of a policy which distributes access to resources more widely in society, but results in less efficient exploitation, can be measured as the resource rent that has been sacrificed, and the corresponding, lower value of national wealth, i.e., as the difference between the potential rent and rent actually generated. An initial, static analysis of the trade-off might measure this loss of rent based simply on information from micro data sets of individual companies under an existing resource management regime, such as the study of Norway's herring fishery. More sophisticated modelling of an industry would be required to determine the long-term economic effects of alternative management strategies on the value of a resource, and the benefits obtained from achieving other goals. Economy-wide modelling would be necessary to take into account all the changes that would result from alternative resource management policies.

Resource rent and equity: who benefits from fisheries exploitation

266. There are a number of ways in which different groups may benefit from a productive fishing industry. For artisanal or subsistence fisheries, fish may provide an important component of diet which cannot be obtained elsewhere especially in developing countries with high unemployment rates. For commercial fisheries, private companies benefit from profits and resource rent, workers benefit from relatively well-paying employment, and the public benefits from resource rent collected by government, which can be used to support broad-based national development. There are indirect economic benefits to industries upstream and downstream from fishing.

267. If government does not appropriate the rent, it accrues to fishing companies where it primarily benefits private companies, and to a lesser degree, the small share of workers employed in the industry. It can be argued that it doesn’t matter whether rent accrues to the government or to the private sector as long as it is reinvested to promote further economic growth and employment creation. Some would even argue that it is better for the rent to accrue to the private sector because the private sector would make

more productive use of income than the public sector. However, the private sector usually under-invests in certain areas, such as human capital.

268. Furthermore, if foreign companies are given rights to fish in a country's waters, rent accruing to the private companies is unlikely to benefit the citizens of that country. The terms of access by foreign operators to a country's resources may have important implications for domestic employment and income. Monitoring this situation requires estimating the share of rent that accrues to domestic operators, to government through taxes, and to foreign operators. Where there are joint ventures between domestic and foreign companies, it may be exceedingly difficult to determine these shares.

269. Resource rent may be used to achieve a more equitable distribution of benefits from the use of fisheries, especially for economies that rely heavily on extractive industries like fisheries, forestry and minerals. Within the current generation, government appropriation of rent may support economic development that betters the lives of all citizens, extending the benefits of a national asset beyond the minority who may own fishing companies.

270. In the case of a fish stock that is being depleted, the rights of future generations need to be considered. This may be exceedingly difficult when subsistence fishing is responsible for depletion. The general guidelines for a non-renewable resource that is being depleted are to reinvest the rent from that resource in order to create alternative sources of income and employment. But in subsistence fisheries, there is often no rent generated and nothing to reinvest. On the other hand, if remunerative employment alternatives can be created for these fishers and an effective fisheries management regime put in place, the fish stock may recover and it may then generate a high resource rent.

Efficiency with multiple uses of a resource

271. The values for fish assets discussed so far have been based on a single use: commercial fish harvesting. The full economic value of an asset and the efficient management of the asset should be based on an accounting of the full range of environmental services that the asset can provide, as mentioned in Chapter III. Identification of some of these benefits is relatively easy: subsistence exploitation of fish stocks, recreational use, non-consumptive use by tourism such as diving and whale watching, etc. But valuation is not always easy, and the valuation of broader ecosystem benefits is exceedingly difficult. In practice, comprehensive valuation will be difficult to achieve.

Developing a consistent policy for resource management

272. Fisheries management may be motivated by different objectives and result in very different outcomes in terms of efficiency, sustainability, and equity. Countries may well use different resources to achieve a range of socio-economic objectives - some resources managed purely commercially and others not.

273. Norway provides a good example of how analysis of rent can be used to compare very different approaches to resource management that affect the value of three major natural assets - fisheries, oil and natural gas, and uncultivated natural forests. Table IV.3 shows the rent generated by each of these resources and the amount of that rent appropriated by the government. As mentioned above, Norway's fishing industry is currently managed in a way that generates little or no rent. However, its oil and natural forest resources are managed quite differently. Significant amounts of rent have been generated by the oil and natural gas industry of Norway and, on average, government appropriates most of this rent through taxes. Natural forests are also managed in a way that generates substantial rents, but, rather than contributing this rent to government, the rent accrues to the private sector which receives, in addition, large subsidies.

Table IV.3 Resource rent and government appropriation of rent in Norway 1985 to 1995

(Millions of NOK)

	Fisheries		Oil and natural gas		Natural forests	
	Rent	Govt appropriation	Rent	Govt appropriation	Rent	Govt appropriation
1985	-1,231	-1,033	60,949	51,388	203	-47
1986	-1,180	-977	16,983	19,007	513	-31
1987	-938	-647	10,497	15,413	558	-36
1988	-1,954	-451	-4,009	10,430	999	-51
1989	-3,899	-601	18,987	18,550	902	-58
1990	-3,478	-911	34,655	28,041	1,218	-51
1991	-2,491	-722	34,155	28,498	956	-72
1992	-2,815	-475	29,637	27,739	369	-70
1993	-2,107	-103	29,354	26,376	5	-85
1994	-381	-32	28,241	27,514	-163	-121
1995	51	63	29,122	29,198	690	-111

Note: government appropriation is measured as taxes minus subsidies.
Source: Lindholt 2000, Statistics Norway 2000.

C. Physical and monetary flow accounts for pollution

274. The flow accounts can be used to support two kinds of analyses that are important for fishery policy. One is to provide a more comprehensive understanding of the role of the fisheries sector in an economy, the other is to monitor the emission of pollution and the use of resources by fishing and related industries, or by industries which may impact on fishing.

275. Chapter III described the economic analysis of fishing and how this could be extended through analysis of the supply-and-use table (SUT) to measure the backward and forward linkages in the economy. A common set of economic indicators for the fisheries sector includes its percentage contribution to GDP, employment, and foreign

exchange. A more extended analysis considers the percentage contributions of the fish harvesting sector combined with its backward and forward linkages.

276. An example based on data from Canada is provided in Table IV.4. The term 'ocean industry,' that is, industries using ocean resources - fishing, offshore mining, shipping, tourism - and those directly serving such industries including parts of manufacturing and services and government. In 1996, the ocean industry generated a substantial income and number of jobs. Commercial fishing was the most important component of the ocean industry, excluding government, followed by shipping. Tourism was also important, though less so than the indirect contributions from manufacturing and services, which includes both upstream (e.g., shipbuilding) and downstream (e.g., fish processing) activities. Compared to other resource-based segments of the economy, ocean industries contributed more to GDP than forestry, but less than agriculture and mining.

277. A study by Arnason of Iceland in the 1980's found that the direct contribution of fishing to GDP was about 15%, and estimated that backward and forward linkages added another 4-5% of GDP, so that the total contribution of fishing was about 20% of GDP (Arnason 1994).

278. The flow accounts for fish indicate the final users of fish products, which can be analysed for the contribution of fish to human nutrition. In this analysis, it can be quite useful to distinguish the different contributions to nutrition of artisanal and commercial fishing in different regions of a country or among different population groups. Through the use of a SUT, the contributions can be measured both directly (direct consumption of fish) as well as indirectly (consumption of fish by animals which are then consumed by humans).

279. The physical flow accounts of the SEEA measure the use of resources and the emission of pollutants by industry. These accounts can provide information about fishing and related industries. The kinds of environmental burden that is likely to result from fishing and related industries include:

- water pollution and environmental degradation from aquaculture, fishing, fish processing;
- environmental degradation due to infrastructure: harbours, transport infrastructure;
- resource use, for example, fresh water.

280. The SEEA provides the information needed to construct indicators such as environmental-economic profiles that indicate the relative economic benefits (share of GDP, employment, exports, etc.) of fishing or related industries to the environmental burden (share of pollution generated, water used, etc.). With the use of the SUT, further analysis can be done to determine both the direct and indirect environmental impact of fishing and related industries, an analysis similar to measuring backward and forward economic linkages.

Table IV.4 Contribution of ocean industry to Canadian economy in 1996

A. Economic contribution of the components of the ocean industry

	Contribution to:	
	GDP (millions of C$)	Employment (number of jobs)
Commercial fishing	1,673	52,562
Offshore mining (Oil & gas)	780	1,564
Shipping	1,561	28,966
Tourism	364	12,640
Construction	464	5,780
Manufacturing and Services	756	18,950
Government	1,993	24,380
Total	7,591	144,842

B. Comparison of ocean industries to other resource-based activities in 1996

	(millions of C$)
Total GDP	551,025
Agriculture	11,877
Forestry	2,661
Mining, oil and gas	24,404
Ocean industry	7,591

Source: Department of Fisheries 1998.

281. Generally, fishing is not a heavily polluting industry compared to other industries in most economies. The SEEA flow accounts is probably more useful for fisheries management by providing information about the sources of pollution that affect fisheries. Geographic location of sources of pollution is important to connect pollution to fish habitat degradation. Because the SEEA accounts are typically constructed at the national level, some effort is required to determine the amount of emissions from industries into river, lake or coastal waters that affect fisheries. It is unlikely that fisheries related accounts would compile pollution accounts for other industries, but a more comprehensive environmental accounting effort would be able to provide this information for fisheries resource accounts.

D. Monetary flow accounts for environmental degradation

282. Effective environmental management is based not only on an understanding of the volume of pollution and material use, but also on an understanding of the economic implications. Policy makers need to know what the welfare loss of pollution is (damage costs) and where limited financial resources will be most effective in reducing environmental pressure, i.e., the relative benefits and costs of reducing different forms of environmental degradation from different sources.

283. Two different conceptual approaches to valuing environmental degradation are commonly used: the maintenance cost approach and the damage cost approach. The former shows policymakers the *cost* of certain actions to prevent or remediate degradation, and the latter shows the *benefit* of policy actions, that is, the value of the damages that will be prevented. In the absence of efficient markets, these measures are likely to be quite different. The damage cost is the theoretically correct approach for measuring changes in economic well-being and adjusting macroeconomic aggregates, but both measures provide useful information for environmental management.

284. Many of the indicators and descriptive statistics developed for the physical accounts can be used for the monetary accounts. Trends in aggregate monetary figures can be monitored as well as measures of pollution intensity by economic activity. Various environmental-economic profiles can be constructed, and the monetary accounts can be analysed to determine direct and indirect industry emissions, and how these may have changed over time. An advantage of the monetary accounts is that they allow aggregation of different kinds of environmental problems into a single figure to represent the total environmental burden from each sector.

285. Information about relative economic contributions and environmental burdens is essential for policy-makers when identifying industries that will play a key role in economic development. In the absence of such information, incentives to promote growth of a specific industry, such as pulp and paper manufacturing, or agriculture, may result in levels of environmental damage to fisheries that outweigh apparent economic gains.

286. In cases where environmental policy takes the form of setting emission standards without regard for balancing economic costs and benefits, the policy challenge is to find the most cost-effective opportunities for pollution reduction, represented by the maintenance cost approach. This approach was used in the Philippines.

287. The Philippines constructed environmental degradation accounts for a range of pollutants to air and water from selected industries, as well as nutrient loss in agriculture and soil loss in forestry (NSCB 1998, 2000). Some results from the accounts for biological oxygen demand (BOD) are shown in Table IV.5. The results are instructive: although aquaculture is responsible for 64% of total BOD emissions, the cost of pollution abatement in that industry is extremely small - less than 1% of total costs. By contrast, the hog industry produces 34% of BOD but accounts for nearly 80% of the

maintenance costs. The sugar industry contributes a tiny share of total BOD emissions, only 0.4%, but it would be quite costly to reduce these emissions: its share of environmental damage costs is 13%.

Table IV.5 Emissions of BOD and environmental damage by selected industries in the Philippines, 1993

	Percent of emissions	Percent of environmental damage	Ratio of cost shares to emission shares
Aquaculture	63.7	0.7	0.01
Hog Industry	34.2	79.7	2.33
Tuna Canning	0.1	0.3	2.86
Textile Industry	1.4	5.8	4.02
Leather Tanning	0.1	0.3	5.03
Sugar Industry	0.4	13.2	31.09
Total	100.0	100.0	Na
Level of emissions (MT) and total costs (thousands of pesos)	1,303,452	2,053,000	

Na: not applicable
Note: Environmental damage estimated using the maintenance cost approach. Emissions of BOD were not calculated for all industries.

Source: National Statistical Coordination Board 2000.

288. As mentioned earlier, emissions from fishing and related industries are likely to be less damaging than emissions from other industries that harm fisheries. Presently, there has been no systematic attempt to quantify the physical or monetary damage to fisheries resulting from other sources. Partly this may be because the exact causal relationship is too poorly understood to quantify. There may also be considerable time delays between the emission of pollution or habitat degradation and the impact on fisheries.

E. Resource management expenditures

289. In some countries, fishing is heavily subsidised; in other countries fishing may not be directly subsidised, but government may incur substantial costs in managing the fishery that are not recovered by taxes and fees. Accounts for fisheries management expenditures record management costs by both public and private sector. The management costs incurred by government are especially important because, together with private costs of fishing, they provide a more complete accounting for the costs of fishing. They also provide ways to assess whether fees paid by fishers to government cover the full costs of fisheries management.

290. The Namibian case study in Chapter V provides an example of such an analysis. Table IV.6 shows that, for the years 1994 to 1999, taxes and other fees more than

covered government's management costs. Some of the taxes are earmarked for specific purposes, e.g., the observer fund is intended to pay for observers on every vessel, while others go into government's general revenues, e.g. quota levies. Further analysis would reveal the extent to which targeted fees and taxes cover the costs of the activities they are intended for.

Table IV.6 Fisheries resource management costs and revenues received by government in Namibia, 1994 to 1999

	1994	1995	1996	1997	1998	1999
Ratio of total taxes and fees paid to government resource management costs	2.53	2.05	1.04	1.23	1.18	1.81

Notes: Resource management costs do not include contributions by foreign donors.
Taxes and fees include quota levies, by-catch fees, Sea Fisheries Fund levies, license fees, and observer fund fees.

Source: See Chapter V

291. Another major component of resource management expenditures is the capacity reduction programmes instituted in a number of countries. There is no comprehensive estimate of expenditures for vessel buy-back and license retirement, but the examples in Table IV.7 indicate that these programmes are not uncommon. In the EU, the Multi-Annual Guidance Program (MAGP) requires that member countries set capacity reduction targets that, once met, allow access to funds for restructuring national fleets. However, there has been disagreement about different measures of vessel capacity, which has hampered implementation.

292. While most of the capacity reduction programmes have been paid for by government, the purchase of Faroe Island fishing licenses was undertaken by a private organisation of sport anglers from a number of Northern European countries, whose catch was adversely affected by overfishing of the North Atlantic salmon in the Faroe Islands.

F. Concluding remarks

293. Threats to sustainable fisheries come from two sources: from fishing itself, mainly as a result of poor management and over-fishing, and from outside fisheries as a result of policies that affect directly or indirectly fish habitats. Fisheries accounts provide a framework for assessing the economic value of fishing, as well as a framework for linking information about fisheries to the broader economy, integrating fisheries policy with national development, and monitoring interactions and feedback across different industries. Fisheries accounts can be useful both to fisheries managers responsible for sustainable management of the resource, and to managers concerned with the macro-economy.

Table IV.7 Examples of programmes to reduce fishing capacity

Country	Fishery	Amount spent	Years (or initial year)
A. Vessel Buy-Back			
United States	New England groundfish	US$27 million	1994-1996
	Washington salmon	IS$5.4 million	1976
Canada	British Columbia salmon	C$3.4 million C$2.9 million	1972 1981
UK	Not specified	US$28 million in the first 2 years of the programme	1993
Norway	Purse-seine vessels, target species not given	18% of vessel capacity retired, cost not given	1979 to 1984
B. License Retirement			
Australia	Australian northern prawn	A$40 million	1986 to 1994
	South Australia rock lobster	A$6.5 million	1987
Faroe Islands	North Atlantic salmon	Cost not given. Paid for by sport fishers rather than government	1991

Source: Congressional Research Service Report 1997.

294. Fisheries managers may not gain any additional information about fisheries itself, rather, the SEEAF puts the information they normally produce and work with in the context of the national economy. The SEEAF provides them with a tool to identify and address threats to fisheries resources and their habitats that originate outside the fishing industry, which can improve their ability to protect this resource.

295. Policy-makers outside the fishing industry benefit from the SEEAF in several ways: better monitoring of national wealth including fishery resources, a tool for comparing policy across different natural resources including the extent to which the 'user pays' principle is applied, but perhaps most importantly, a method to integrate fisheries into macro-economic policy and planning tools.

296. Sustainable economic development requires anticipating the interaction and feedback from one part of the economy to another, weighing alternative development strategies in a manner that anticipates the full, direct and indirect, costs and benefits incurred throughout the economy. In the past, sectoral policies may have been designed with relatively little emphasis on economy-wide impacts. Agricultural policy or forestry policy may have been formulated with little concern for impact on fisheries, even though these policies may have had major impacts, indirectly, through changes in land

use, use of agricultural chemicals, etc. Other policies, such as trade liberalization or various fiscal policies may influence urbanization in developing countries, most of which occurs in coastal areas that may affect near-shore fish habitats. Policies that result in high unemployment may increase pressure on small-scale fisheries.

297. Approaches such as integrated coastal zone management attempt to address some of these shortcomings, but they have not been designed primarily as economic tools and are not well integrated with national level economic data and analysis. Hence, their ability to provide a full economic assessment is limited. The SEEAF provide a useful tool for overcoming these limitations.

298. There are four main areas in which the use of fisheries accounts for policy analysis needs to be improved:

- While some countries have begun to compile fisheries resource accounts, there are still very few countries with such accounts. This is partly because of the small economic role of fisheries in most countries and partly because of large uncertainties regarding stocks, future stocks, and the value of stocks.

  Initially, an important motivation for compiling environmental accounts was to better measure the depletion of natural capital. But the uncertainty over how much of the inter-annual physical changes can be attributed to fishing and how much to other causes makes it difficult to measure depletion. An inability to unambiguously measure depletion from the fish accounts may also be a deterrent.
- Most of the hitherto limited work on fisheries accounts has focused on commercial fisheries and little has been done on artisanal and subsistence fisheries. In some instances, this is because the economic value of subsistence fishing is relatively low and the target fish populations can be very difficult to measure. Often, these fisheries are not well-monitored or regulated making compilation of accounts difficult.

  Although the economic value of small-scale and subsistence fisheries may often be low, they may be critical for the livelihoods of many communities in both industrialized and developing countries. However, as small-scale and subsistence fisheries expand because of population growth and access to more powerful fishing craft and gear, and as competition between small-scale and large-scale exploitation grows, the importance of accounting for this component of fishing will increase.
- The value of fisheries resources and their habitats includes many services provided by the fish stocks and the associated ecosystem, such as recreation and tourism, as well as existence value. Sustainable fisheries management requires addressing all these environmental services, not just the provision of fish for the commercial or subsistence sectors. There has been little work done so far to provide a comprehensive valuation of fish and aquatic ecosystems, or to monitor these ecosystems in a way that is integrated with fisheries accounting and would support sustainable fisheries management.
- Accounts for straddling and highly migratory stocks have not yet been fully established except in the case of a few stocks for Norway and Iceland. Even in

these cases, there is only partial accounting for these straddling stocks because accounts are not yet compiled by all of the co-managing countries. Accounts for the entire stock, the sum of the value of the stock for each country, would indicate the different rents earned and the different economic value of the same stock under each country. Compilation of such accounts would require agreement on methods and assumptions for valuation.

Similarly, accounts for high seas fish stocks, outside EEZs, would be very useful. At present there is very little information about the value of these fish stocks. Since these stocks do not belong to any one country, they might best be compiled by regional fisheries management organisations such as Northwest Atlantic Fisheries Organisation (NAFO) or South East Atlantic Fisheries Organisation (SEAFO), or the International Commission for the Conservation of Atlantic Tunas (ICCAT) for tuna stocks.

Although some countries are using the fisheries accounts for policy analysis, the accounts are still under-utilised. Even simple analysis, such as comparison across different resources of rent recovery and the user-pays principle, is not routinely carried out. Some of the analyses of fisheries supported by the SEEAF may already be carried out by fisheries managers as part of their normal responsibilities. But, as described above, both fisheries managers and macro-economic policy-makers may be more effective in protecting fish stocks and promoting sustainable development if they have a better understanding of the role of the fishery sector in the economy.

CHAPTER V: CASE STUDIES OF ACCOUNTS FOR FISH

A. Introduction

299. This chapter includes four case studies of accounts for fish constructed by Norway, Namibia, Iceland, and the United States. The case studies discuss the methodological and data problems encountered by each country in compiling the accounts and the solutions to these problems. Additional analysis of the accounts has been carried out depending on the interest and priorities of each country.

300. The Norwegian case study focuses on methods to estimate resource rent from national accounts and survey data when a large share of the operations is undertaken by owner-operators. It also compares the actual value of cod stock under current management to the potential value of cod under more economically efficient management. The Namibian case study focuses on the success of the government in recovering resource rent through a system of quota levies, and the extent to which quota levies and other fees cover government's cost of managing fisheries. It also includes some observations on the potential problems that can arise from a strong foreign presence in the fishing industry of a developing country. The Icelandic case study focuses on different approaches to valuation of fish stocks, assessing the three alternative methods of valuing fish stocks that were described in Chapters II and III. The case study of the Atlantic sea scallop fishery in the United States of America provides an example of an age-structured asset valuation approach, based on a well defined fisheries management plan to increase the fishable biomass and the future sustainable harvest. The value of the fisheries asset under the new plan is compared to the value under current management.

B. Fisheries accounts for Norway[4]

1. Introduction

301. The NOREEA (*NOR*wegian *E*conomic and *E*nvironmental *A*ccounts) Project is a joint project between the Division for National Accounts and the Division for Environmental Statistics at Statistics Norway. The main, long-term goal of the NOREEA Project is to develop integrated economic and environmental accounts. To accomplish this overall goal, a series of smaller projects have been designed which will be the building blocks to achieve this larger goal. The first phase of the NOREEA project began in the second half of 1997 and consists of two major areas of work: constructing satellite capital accounts for natural resources and linking the national accounts and the air emissions data in a national accounting supply and use matrix.

302. The development of capital accounts involves the valuation of oil and natural gas, fish and forests, and the development of opening balances, depletion, adjustment and closing balance values. This work has been primarily conducted by members of the Division for National Accounts. The methodology used for this work is based largely on the 1993 SNA satellite analysis and accounts framework. However, the SNA framework and natural resource valuation methods provide several different options for calculations. A number of these different valuation and calculation methods were tested in the course of the oil and natural gas, fish and forestry projects. When calculating the fish wealth, several ways of valuing the income for the fishermen are possible. Another wider consideration is how to define a resource that freely moves across boundaries in the national accounts of a single country.

303. Norway was one of the first countries to implement the 1993 SNA and is starting to implement satellite accounts of the environment and for natural resources as part of the SEEA. Such extensions are becoming increasingly important due to the attention devoted to natural resource accounting and to the need for reliable sustainability indicators and indices.

304. The main purpose of this case study was to discuss the principles for assessing the value of ocean fishing. In this report, accounts are constructed only for marine capture fisheries, although Norway also has a significant aquaculture. The most important species for the Norwegian fisheries are cod, haddock, herring, spring spawning herring, capelin, saithe and mackerel. Of these species, cod provides the highest income to the fishermen. Statistics Norway together with the Institute of Marine Research, publishes figures for the most important fish stocks in the Barents Sea, the Nordic Sea and in the North Sea.

305. The 1993 SNA states:

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[4] Based on Sorenson, K. and J. Hass. 1998. *Norwegian economic and environmental accounts project*. Final report to Eurostat. Statistics Norway: Oslo.

"The assets recorded in the balance sheets of the System are economic assets. These are defined as entities:

a) *Over which ownership rights are enforced by institutional units, individually or collectively; and*
b) *From which economic benefits may be derived by their owners by holding them, or using them, over a period of time".* (1993 SNA para 10.2)

306. In Norway wild marine fishery resources are not considered part of the SNA asset boundary even though the Norwegian government takes responsibility for fisheries management such as negotiations for quotas etc. In fact it may not seem appropriate to say that the Norwegian government enforces ownership rights over the actual fishery resources, nor does the government derive income from these resources. Management of fisheries contrasts with management of oil, where government owns the reserves and receives benefits from its own contractors as well as royalties from other contractors. In other countries, the government is also viewed as the owner of wild marine resources and it recovers part of the resource rent generated by fishing, just as the Norwegian government does from oil.

2. Physical accounts: methods, data and results

307. The Institute of Marine Research estimates stock sizes in order to supply the authorities and the fishing industry with background data for the management of the fisheries. Table V.1 shows estimates for four species important to the Norwegian fishing industry. The estimates are based on statistical methods and the lack of good data leads to uncertainties in the results. The Institute does not supply any measurement of these uncertainties, only point estimates for the stock size.

308. The basis for stock estimates is the annual recursive calculations of stock size. The stock size at one point is evaluated several times. Catch data are of great importance in these calculations, and the reliability of the estimate of one year class increases relative to the amount of catch from this year class. Each year the catch reports provide new information about the number of individuals in each year class and thereby about the stock size for as many years before as the age of the oldest year class. The new information produces the basis for the revision of the last stock size estimates for these years. This revision process in the case of the North-arctic cod stock (three years and older) is shown in Table V.2 below.

309. The first estimate of a year-class is the most uncertain, but it is not unusual to have major revisions also for older year-classes. Figure V.1 shows the variation in the estimate of the 1990, 1992 and 1995 year-class. In order to incorporate physical accounts in the national accounts framework, a decision has to be made on how to treat these revisions.

Table V.1 Stock estimates for major commercial species in Norway 1985 to 1997

(thousands of tonnes)

Year	North-arctic haddock [1]	North saithe [2]	Capelin in the Barents Sea [3]	North- arctic cod [1]
1985	140	370	860	1,010
1986	270	350	120	1,250
1987	240	370	100	1,060
1988	160	360	430	820
1989	120	330	860	920
1990	120	400	5,830	960
1991	150	510	7,290	1,510
1992	250	650	5,150	1,940
1993	540	690	800	2,510
1994	600	580	200	2,340
1995	600	610	190	2,100
1996	550	570	500	2,040
1997	540	520	910	1,940

[1]Fish aged 3 years and over;

[2]Fish 2 years and over;

[3]Fish aged 1 year and over.

Source: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research.

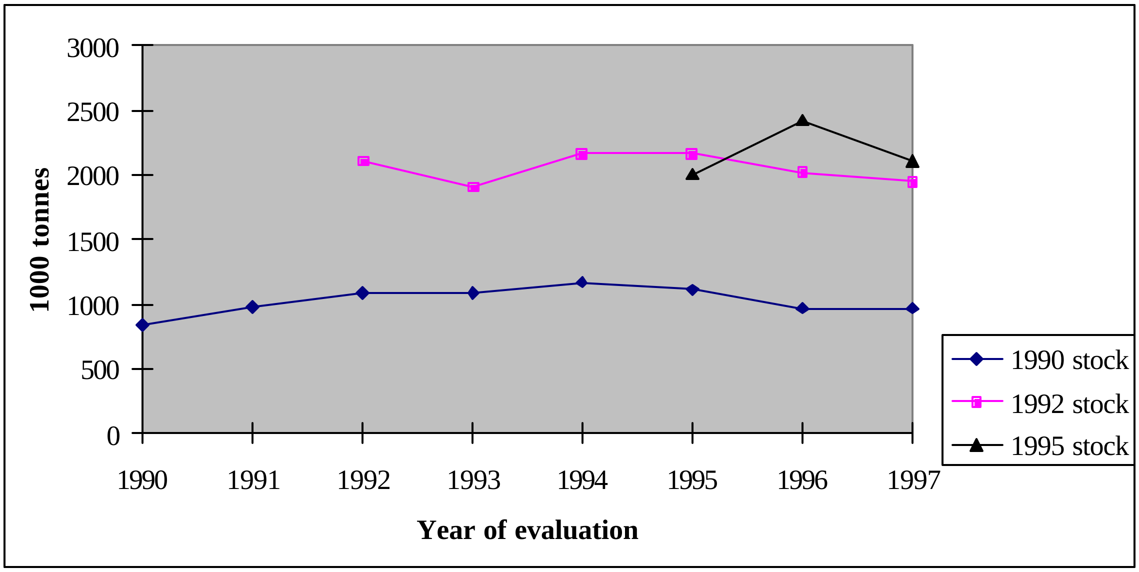
Table V.2 Size of North-arctic cod stocks depending on the year of evaluation

(thousands of tonnes)

	Year of evaluation												
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1985	1,020	1,380	1,450	1,000	990	1,000	1,010	1,010	1,010	1,000	1,000	1,000	1,010
1986		1,880	1,790	1,300	1,220	1,250	1,290	1,300	1,240	1,240	1,270	1,240	1,250
1987			1,500	1,170	1,020	1,060	1,120	1,130	1,120	1,120	1,100	1,080	1,060
1988				900	690	750	810	830	820	830	800	780	820
1989					680	770	870	930	900	1,020	970	910	920
1990						830	980	1,080	1,080	1,170	1,110	970	960
1991							1,220	1,420	1,560	1,690	1,690	1,520	1,510
1992								2,100	1,910	2,170	2,170	2,020	1,940
1993									2,340	2,620	2,840	2,720	2,510
1994										2,280	2,410	2,620	2,340
1995											2,000	2,430	2,100
1996												2,540	2,040
1997													1,940

Sources: International Council for the Exploration of the Sea (ICES) and the Institute of Marine Research

Figure V.1 Variation in estimates of North-arctic cod stock sizes



310. The full set of physical accounts includes information for opening stocks, catch, other changes in volume and closing stocks. Other changes in volume includes:

- recruitment, which is the annual stock increase due to the inclusion of a new age group that is old enough to be counted in the stock size (a positive entry).
- natural mortality, which covers causes of death other than catch (a negative entry).

311. Using data from the most recent year, 1997, as an evaluation year, a simple balance account for the North-arctic cod stock can be constructed with opening and closing stocks for each year as well as figures for landings and other changes in volume (Table V.3).

Table V.3 Stock of North-arctic cod, 1990-1996

(thousands of tonnes)

	1990	1991	1992	1993	1994	1995	1996
Opening stock	960	1,510	1,940	2,510	2,340	2,100	2,040
Total landings	-187	-269	-384	-532	-746	-740	-722
Other changes in volume	737	699	954	362	506	680	622
Closing stock	1,510	1,940	2,510	2,340	2,100	2,040	1,940

312. When Other changes in volume are smaller than landings, the stock size will decline. The stock of North-arctic cod has been highly erratic, growing from 1990 to 1993, but declining since then. The main reasons for this decline include heavy catch rates, increased cannibalism and poor individual growth among the cod. Another reason

has been the decrease in the capelin stock in the Barents Sea, an important prey species for the North-arctic cod stock. Despite the decline, the closing stock in 1996 was roughly double the opening stock in 1990, and 1996 catch was nearly three times the 1990 catch volume.

3. Monetary accounts: methods, data and results

313. The economic value of fish stocks can be estimated as the present value of the discounted stream of resource rent they will provide in the future, as described earlier in this manual. Applying the present discounted value methodology requires assumptions about future catch, prices and costs. The method used here, called the "constant catch approach," assumes that base-year stock, catch, unit prices and costs remain constant in the future. Under these assumptions, resource rent will be constant in perpetuity and figures for fish stock are not required to estimate fish wealth. Even on the basis of such strong assumptions, valuation is useful and desirable to inform policy-making.

Measuring resource rent

314. Resource rent represents the profit due to scarcity: scarcity is due to limits of fish stock and restricted access to fishing. In the Norwegian fisheries accounts, resource rent is defined as:

Resource rent = Output - Intermediate consumption - Compensation of employees - Consumption of fixed capital - Normal return on the capital stock

315. The rate of return on fixed capital used in this calculation is 8 percent. This choice was based on official Norwegian guidelines (NOU 1997:27). These guidelines recommend a 3.5 per cent rate for risk-free investment, and suggest a risk premium of 4.5 percent, which gives a total of 8 percent. Such a high risk premium may be justified since the results indicate that the resource rent is far from stable in the fishing industry. Initial calculations of resource rent were based entirely on data obtained from the Norwegian national accounts, shown in Table V.4.

Table V.4 Resource rent of North-arctic cod based on data from the Norwegian National Accounts

(Million kroner)

	1990	1991	1992	1993	1994	1995	1996
Output	5,257	6,247	6,115	6,126	7,539	8,275	9,116
Intermediate consumption	2,119	2,232	2,243	2,341	2,682	2,900	2,928
Compensation of employees	1,272	1,442	1,529	1,478	1,627	1,812	1,884
Consumption of fixed capital	1,723	1,650	1,634	1,760	1,685	1,554	1,538
Normal return on capital	1,851	1,726	1,748	1,860	1,785	1,660	1,626
Resource rent	-1,708	-803	-1,039	-1,313	-240	349	783

316. In the period 1990 to 1996, rent varied widely from one year to another. Rent appears to have been increasing gradually over this period, except for 1992 and 1993, which were very bad years for fishing. The positive trend seems to have occurred because the value of fish catch has been growing more rapidly than the cost of all inputs except for compensation of employees.

317. The interpretation of the negative resource rent is that the costs of harvesting are higher than the revenues, so that revenues were not sufficient to cover the normal return to fixed capital. Two factors are rather critical in the calculation of the resource rent: the normal return on capital, which was discussed above, and the compensation of employees, which is discussed below.

Compensation of employees

318. In Norway, the fishing industry is dominated by relatively small, family run operations, unlike the large-scale commercial operations in countries like Namibia. The most common means of payment for most Norwegian fishermen is not a fixed wage, but a share of the catch. How much each person is paid during the year then depends on the amount and value of the catch. The majority of Norwegian fishermen are self-employed and their income is included in the national accounts as mixed income rather than compensation of employees. The mixed income of the self-employed includes a portion which is compensation for their labour, and another portion which is other income, profits and rent. The Norwegian national accounts estimate that 35 per cent of the total full-time occupied fishermen are employees, and the remaining 65 per cent are self-employed. Consequently, the figure for compensation of employees only includes the earnings of the 35 per cent of fishermen working as employees. An accurate measure of compensation of employees should include both forms of remuneration for labour: the wages of employees and the portion of mixed income of the self-employed that represents compensation for their labour. Without an adjustment for the full cost of labour, resource rent will be overestimated.

319. In order to provide a more accurate measure of rent, the NOREEA project attempted to estimate the labour component of the earnings of the self-employed. Various data were used for this estimation, notably the profitability survey on Norwegian fishing vessels that is published annually by the Budget Commission of Fishery. This survey presents figures for an item called “Total labour costs and shares to the crew.” This figure includes shares defined as gross landings minus common expenses, and occasional extra shares. In addition, the total labour costs and shares to crew include provisions that have to be deducted in order to get an estimate for compensations for labour. The estimate is supposed to cover all crew, independent of whether they own the vessel or not.

320. Since the profitability survey presents figures as averages per boat, it was necessary to multiply these figures by the number of vessels to estimate totals. The survey results were adjusted further because of a discrepancy in the value of landed fish between the survey and official fisheries statistics, which were used for other parts of the

fisheries accounts. An adjustment factor, based on the ratio of reported landings in the two sources, was used to scale the labour cost figures.

321. There was concern that the value of a crew's total share reported in the profitability survey may contain part of the resource rent, so that simply adding these estimated labour costs to compensation of employees might overestimate the compensation of employees and, consequently, underestimate the rent. Several alternative calculations were carried out to check the feasibility of the labour cost figures from the survey. These alternative labour costs were estimated by multiplying average wages in three related industries to total hours worked in fishing, obtained from the profitability survey (Table V.5). The industries used for the alternative calculations for compensation are (numbers are the classification of industries in Norwegian National Accounts based on NACE):

- 23051 Fishing industry
- 23152 Processing and preserving of fish and fish products
- 23613 Inland water transport

Table V.5 Alternative calculations for compensation for labour including self-employed fishermen

(Million kroner)

	1990	1991	1992	1993	1994	1995	1996
No. of man-years in fishery, thousands	15,2	14,9	14,7	14,1	14,1	14,3	13,8
Alternative 1: Industry 23051 Fishing industry	3,634	4,120	4,369	4,223	4,649	5,177	5,382
Alternative 2: Industry 23152 Preserving of fish etc.	2,473	2,662	2,689	2,664	2,734	2,864	2,889
Alternative 3: Industry 23613 Inland water transport	3,697	3,851	4,381	4,228	4,354	4,525	4,538
Alternative 4: Labour costs estimated from survey data	1,931	2,313	1,709	1,783	2,829	3,170	3,199
Compensation of employees from the National Accounts	1,272	1,442	1,529	1,478	1,627	1,812	1,884

322. The first row of Table V.5 shows the total number of man-years in the fishing industry including self-employed. This is followed by the four alternatives that could be used to replace the Norwegian national accounts estimates: labour costs estimated on the basis of wages in related industries (Alternatives 1 to 3) and labour costs estimated from the survey (Alternative 4). The labour costs reported in the survey are significantly lower than what they would be if all fishermen received the average hourly pay in the fishing industry (Alternative 1), or in inland water transport (Alternative 3). Except for the last few years, the survey labour costs are also lower than what they would be if all fishermen were paid the same hourly wage received in the preserving fish and fish products industry (Alternative 2). For comparison, the compensation of employees from the national accounts is presented in the last row; not surprisingly, it is considerably lower than all four alternative labour cost estimates.

323. It is interesting that actual earnings (survey results) are considerably lower than those estimated by imputing wages from related industries. The implicit average wage of the self-employed is quite low. This may result partly from the structure of the fishing industry. As mentioned earlier, the majority of boats are small, often family-owned and family-run. They are based in fishing villages, where there are few alternatives for work, which may accounts for the relatively low wages. Interestingly, the difference between the survey labour costs and the other alternatives has declined over time, which may indicate a increasing mobility of the labour force in these fishing villages.

324. Survey labour costs provide direct measures of actual earnings and result in higher estimates of the compensation of employees. Figures based on these labour costs, denoted as "Labour costs, (Lc)", will be used for the revised estimates of resource rent. Table V.6 shows the compensation of labour from the survey and the corresponding resource rent in the fishing industry. In contrast to the results based on national accounts data alone in Table V.4, the more comprehensive measure of labour cost results in negative rents for all years. While some fluctuation in the rent is to be expected, if negative rents persist in the long term, then there is a question of whether fishing contributes positively to the economy. Although the negative rents vary considerably from year to year, they appear to be declining. A longer time series including more recent years might show a more profitable fishery.

Table V.6: Labour costs from survey data and the corresponding resource rent

(Million kroner)

	1990	1991	1992	1993	1994	1995	1996
Labour costs calculated with survey data (Lc)	1,931	2,313	1,709	1,783	2,829	3,170	3,199
Resource rent (Lc)	-2,367	-1,674	-1,219	-1,618	-1,442	-1,009	-532

Value of fish stocks

325. Calculations of wealth are one way of summing up a nation's prospects for the future. The wealth represented by natural resources is equal to the present value of the income they generate in the future. The most important assumptions when calculating the fish wealth concern future prices and catches. The assumptions used for the Norwegian fisheries accounts are that both prices and catch will remain constant in the future. This assumes sustainable management and relatively stable economic conditions. While the stock accounts have shown considerable inter-annual variation from 1990 to 1996, it is assumed that in the long run, the stocks will be relatively stable. Under these assumptions, the present value formula is reduced to resource rent divided by discount rate. The discount rate used in calculating the wealth is 3.5 per cent.

326. The value of fish stocks using labour costs in Table V.6 is always negative. In the balance sheet the value of the fish stocks is reported as zero. In other words, under the assumption of unchanged fishing technology, stable costs and prices and current fisheries management system, fish stocks do not contribute to Norway's national assets.

Table V.7 Estimates of monetary fish assets

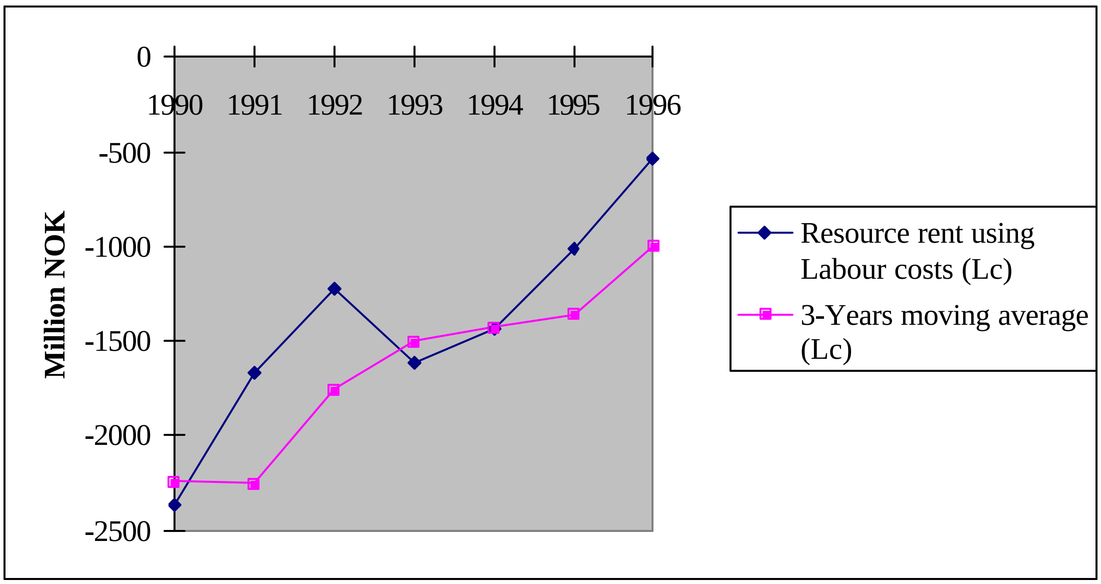
(Million kroner)

	1990	1991	1992	1993	1994	1995	1996
Resource rent (Lc)	-2,367	-1,674	-1,219	-1,618	-1,442	-1,009	-532
Estimated asset (Lc)	-67,628	-47,834	-34,837	-46,232	-41,214	-28,840	-15,204

Note: Values based on the labour costs calculated with survey data.

327. Short-term phenomena can result in a high degree of variability of the resource rent from one year to the next, but economic decisions are best made on longer-term considerations. It is often the practice, when estimating expected wealth, to use a moving average for the rent estimate. This will result in a smoother trend in the wealth estimate, which better reflects long-term prospects (Figure V.2).

Figure V.2 The resource rent in current prices and calculated with three-years moving average compared



Value of cod

328. While the aggregate results for all Norway's marine capture fisheries indicate that rent is negative and the value of stock is zero, there can be a great deal of variation among Norway's individual fisheries even though all of them have negative resource rent. The resource rent and associated value of the cod stock, the most valuable fishery, is presented here using the same methods and assumptions reported for the aggregate fishing industry.

329. A stock is a group of individuals within a species that is functionally separated from other individuals of the same species, usually by the fact that spawning takes place in different areas and, consequently, the stocks may display different patterns of

migration. Norway mainly harvests two distinct cod stocks, the North-arctic cod and the Coastal cod. The North-arctic cod spawns in Lofoten and lives in the Barents Sea. An international agreement exists between Russia and Norway to share this fish stock. Physical accounts for the North-arctic cod were presented in Table V.2 and Table V.3. Monetary accounts for the North-arctic cod are discussed here.

330. The asset value for cod includes the total value of cod, North-arctic and Coastal cod, landed by Norwegian fishers in Norway. Price statistics are available only for the two combined cod fisheries so we assume the same average price is paid in both fisheries. Under the further assumption that the costs of fishing are proportional to the income from landing cod, an estimate of costs per kilogramme of cod can be calculated. The figures for prices and costs, and the resulting unit rent are presented in the Table V.8 below. Using this method, rent and wealth for cod are both negative, as for the total of Norway's fisheries.

Table V.8 Price, cost and unit rent for cod

(kroner)

	1990	1991	1992	1993	1994	1995	1996
Price, NOK per kg	9,55	10,28	8,84	7,26	7,61	7,67	7,02
Cost, NOK per kg	20,50	16,23	11,26	9,47	8,09	8,53	8,84
Unit rent, NOK per kg	-10,95	-5,95	-2,42	-2,21	-0,48	-0,85	-1,82

331. In Norway, the fishing industry is regulated partly for political reasons. The access to participate in fishing is restricted in order to maintain a geographic structure in the fishing fleet and preserve settlements along the coast. This policy has clearly resulted in low average economic efficiency.

4. Actual and potential value of fish stocks

332. Under the above mentioned assumptions Norway does not have a positive fish wealth. Explaining this to the fishermen would be difficult. These calculations are made with mainly aggregate national accounts figures and they show the average situation in the fishing industry in Norway. There is a large efficiency difference between the large and small fishing vessels that only micro-level survey like the profitability survey can reveal. Although the actual resource rent and value of the fish stock is negative under current management, it is possible that the *potential* resource rent would be positive under alternative management. Some estimates of potential rent have been made for herring and cod.

333. In 1990, Flåm (1993) calculated the rent for herring that would be generated if the fishing fleet was organised in the most economically efficient way. In addition to assumptions about the number of boats, Flåm estimated the yearly wages in the herring fishery to be 125,000 NOK, based on an hourly earnings equal to 75 NOK. This is 19 per cent lower than the earnings of the average industrial worker, 9 per cent lower than

earnings in the preserving of fish and fish products industry, and 27 per cent lower than the earnings in the herring meal industry. Based on these assumptions, Flåm found a potential "herring-rent" estimated at 1,000 million NOK, which would yield a value for herring wealth of 28,571 million NOK at a discount rate of 3.5%. The size of this potential resource rent varies, of course, with the assumptions about the number and efficiency of the boats in the herring fishery.

334. A measure of potential cod rent and wealth was provided by Kjelby (1993), using the same general methodology as Flåm, but based on a different method to estimate costs in the cod fishery. Kjelby divided the boats in the cod fishery into five different groups according to the type of equipment in use. For each group she estimated total catch based on information about total operating time. She then calculated the minimum number of boats that would be needed for this catch by dividing catch by catch-capacity in each group. This assumes full capacity utilization of boats within each group. The resulting estimate of the minimum number of boats needed for a given catch was much lower than the number of boats currently engaged in cod fishery as reported by the profitability survey. This implies considerable economic inefficiency in the cod fishery. Kjelby estimated the cost of operating the lower, more efficient number of boats and found the costs were much lower than the actual costs reported in Table V.8. Costs were low enough to generate a positive resource rent for cod. Assuming a 5 per cent rate of return on fixed capital, the value of the North-arctic cod was estimated to be 14,5 billion NOK.

335. One further issue regarding valuation of fish concerns the treatment of straddling stocks. For a straddling fish stock such as the North-arctic cod, which is shared between Russia and Norway, a means must be devised to assign shares of the wealth to each country. One solution would be to use Norway's proportion of the total catch, which has varied from 41 to 47 per cent during the 1990s. The change in the proportion from year to year results from swapping quotas for different species among participating countries.

C. Fisheries accounts for Namibia[5]

1. Introduction

336. Namibia began its Natural Resource Accounting (NRA) Programme in 1995, headed by the Ministry of Environment and Tourism. The NRA for Namibia includes fisheries, water, minerals, land, livestock, wildlife and energy. Fisheries accounts are particularly important for Namibia for two reasons: fishing and fish processing constitute a large share of GDP, employment, and exports, and Namibia's fish stocks only came under control of the country in 1990, when it achieved independence from South Africa.

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[5] Based on Lange et al. (2003) *Accounting in Action: Case Studies from Southern Africa*. Edward Elgar: Cheltenham, UK.

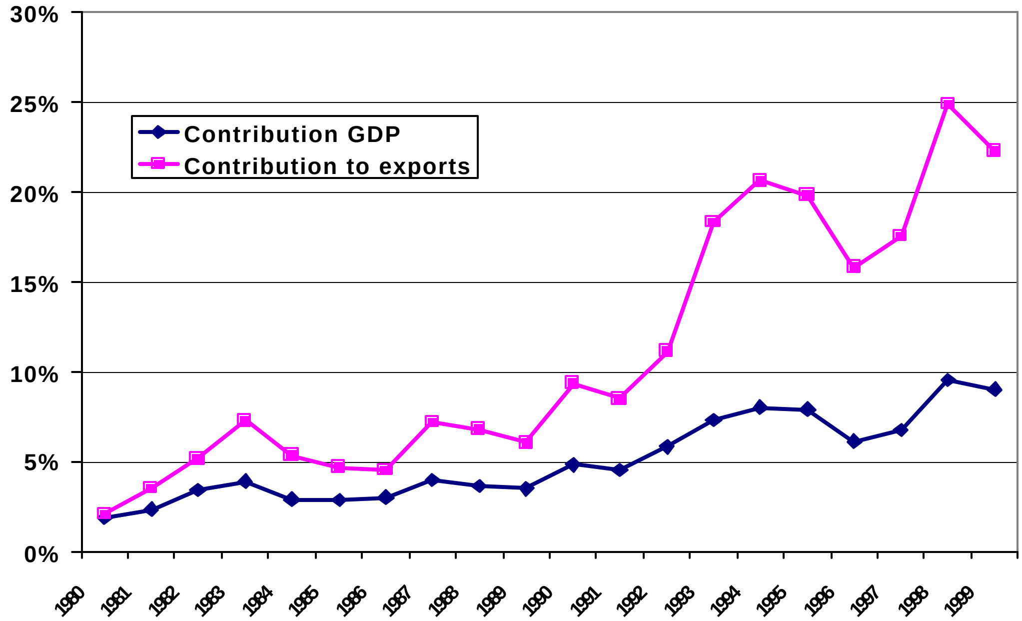
337. Namibia has one of the world's richest fisheries based on a productive eastern ocean boundary upwelling system, the Benguela ecosystem, which extends more than 2,000 kilometres from the Cape of South Africa past Namibia and up to southern Angola. Namibia's fisheries are predominantly large-scale commercial operations with a small recreational fishing industry. Unlike many countries with rich fisheries, small-scale, non-commercial fishing did not develop in Namibia, largely due to geographic and climatic considerations. Namibia's coast has always been sparsely populated because it is a desert region. In addition, the coastal waters are quite rough and provide few good harbours, especially for the small craft that have formed the basis for small-scale indigenous fishing industries in many other countries (O'Toole 1998).

338. The commercial fisheries are dominated by three species: hake (*Merluccius capensis* and *Merluccius paradoxus),* horse mackerel (*Trachurus capensis*) and pilchard (*Sardinops ocellatus*). Anchovies (*Engraulis capensis*) were important in earlier decades, but the stock has been so depleted that it is no longer a major component of the catch. Other commercial species include rock lobster (*Jasus lalandii*), monkfish (*Lophius vomerinus*), kingklip (*Xiphiurus capensis*), sole *(Austroglossus microlepis*), snoek (*Thyrsites atun*), tuna (*Thunnus alalunga*, *Thunnus obesus*) and deep sea crabs (*Chaceon maritae*). Since 1990, hake has accounted for an average of about 50% of the value of output, horse mackerel 20%, and pilchards another 16%, though there has been considerable variation from one year to the next depending on the state of the fish stocks and the TAC. In recent years deep-water fishing has developed, mainly orange roughy (*Hoplostethus atlanticus*) and alfonsino (*Beryx splendens*), accounting for as much as 16% of the value of output (Ministry of Fisheries and Marine Resources, 2000), but these fish may have been overexploited and catch has recently been reduced.

339. Prior to independence in 1990, Namibia was administered by South Africa and had little control of fisheries outside its 12-mile territorial limit. Outside the 12-mile limit, Namibia's fisheries operated essentially as open-access fisheries and, as a consequence, were severely depleted despite the attempts by ICSEAF (International Commission for South East Atlantics Fisheries) to oversee these fisheries. The combined biomass of the three major commercial species fell from a peak of nearly 14 million tons to around 2 million tons, where it has remained during the past decade. The off-shore fisheries were dominated by foreign fleets, particularly those of Spain, South Africa, and the former USSR. With an apartheid system like South Africa's, the majority of Namibians were excluded from participation in the industry.

340. At the peak of production in the 1960s and 1970s, the Namibian fisheries sector, consisting then of only the pelagic and the rock lobster fisheries, contributed about 10% to GDP and 15% to exports. However, the economic contribution of fisheries collapsed thereafter, falling to 2% of GDP and exports by 1980, which reflected both the decline in fish stocks and the uncontrolled operation of foreign fleets (Figure V.3).

Figure V.3 Contribution of fisheries to GDP and exports in Namibia 1980 to 1999



Source: Based on Lange, 2003.

341. After independence, Namibia established control over its 200-mile EEZ and a new fisheries policy was introduced by the Ministry of Fisheries and Marine Resources (hereafter referred to as the Ministry of Fisheries) to ensure sustainable management of fisheries and to ensure that exploitation of fisheries would benefit all the Namibian people. To ensure sustainability, annual TACs are set for the major commercial species. To ensure that Namibians benefit economically, quota levies were introduced to recover resource rent (with subsidies for Namibians) and criteria for allocation of rights of exploitation were established that favoured Namibian ownership, especially Namibians previously excluded under the South African regime.

342. Under this system, a remarkable transformation of the industry was achieved in a relatively short time. The fish stock stabilized and increased their economic contribution, accounting for 9% of GDP and 30% of exports in 1998 (CBS 1999). Employment in the industry in Namibia more than doubled between 1991 and 1998 (Ministry of Fisheries and Marine Resources 2000). The Namibian industry operates without subsidies and increased its contribution to state revenue dramatically after independence, rising from virtually nothing to Namibia $93 million (US$18m) in 1998 (CBS 2000). This last point is all the more remarkable because of the global trend for massive government subsidies for the fishing industry in most countries (FAO 1993; Milazzo 1998).

343. Fish have become one of Namibia's most valuable economic assets and proper management is essential. Government must balance the pressure from industry for higher TAC, and with it the danger of further collapse, against the goal of rebuilding the

fish stock by restraining fishing activity to prudent levels. An assessment of the economic value of the fish stock, the economic loss incurred through over-exploitation and depletion of the stock, and the potential value of the stock under different management regimes is an essential tool for government. This assessment is provided by environmental accounts for fisheries.

344. Namibia's fish resource accounts are based on the SEEA-2003 (United Nations *et al.* 2003) and, so far, accounts have been constructed for the three most important commercial resources: hake, pilchard, and horse mackerel. The recreational fishing sector is important for tourism, but its estimated value is less than 5% of the commercial industry, so it is not included in the fisheries accounts at this time. Namibia has other marine resources, cultivated and non-cultivated, and freshwater fisheries that are important for subsistence in the northern part of the country. In the future, some of these resources will be added to the accounts.

2. Physical accounts: methods, data and results

345. As with all asset accounts, fish accounts are constructed for four components: opening stocks, catch, other changes, and closing stock. While information on opening stocks, catch, and closing stocks is available, other changes are calculated as a residual because there is not enough information to quantify them. These other changes include recruitment, mortality, and phenomena such as the migration of fish stock out of the country's exclusive economic zone due to environmental events.

346. Stocks are estimated using population models combined with two independent survey approaches for each species. Direct survey methods provide one approach: swept-area trawl surveys for hake, and acoustic surveys for horse mackerel and pilchard. Analysis of commercial landings for catch, effort, and biological information such as age structure provide additional information. There are a number of well-known limitations to these methods, which will not be discussed here. Confidence intervals for stock estimates are calculated only for hake; point estimates are provided for other fish stocks.

347. Some of Namibia's fish stocks are migratory within the Benguela Marine Ecosystem, especially in response to environmental disturbances. However the circumstances under which fish migrate are not well understood and there is no agreement yet for joint management among the three counties sharing the ecosystem. A regional fisheries management body, South East Atlantic Fisheries Organisation (SEAFO) is being set up but does not yet play a management role. Consequently, Namibia estimates its own fish stock, but without a separate estimate for migration, a factor which may account for some of the large inter-annual fluctuations.

348. The physical accounts for hake, pilchard, and horse mackerel are shown in Table V.9 for the years 1990 to 2000. Full accounts cannot be constructed prior to 1990 because foreign operators, who dominated the industry at that time, were not required to

report their catch. The physical accounts show that the stock has increased only for hake: in 2000 the hake stock was 30% higher than in 1990. The confidence intervals for hake are quite large, ranging from 27 to 36 per cent of the stock estimate, and exceeding the total catch in all years. Pilchard was less than half its volume at the beginning of the decade, and horse mackerel, which improved during the late 1990s, fell below the 1990 level in 2000. The dramatic inter-annual variation in stock indicates how difficult it is to manage Namibia's fisheries.

349. TAC is shown as a memorandum item to the fisheries accounts and an examination of trends in biomass, TAC, and catch for each fishery provides an indication of the response of fisheries managers to changes in fish stock. TAC for hake were initially set at a low share of fishable biomass and cautiously increased over the decade as the stock grew. When horse mackerel stocks began to fall, TAC and catch were not reduced and, in fact, were increased for several years. Pilchard biomass increased slightly in the early 1990s and then crashed precipitously, all but disappearing by 1996. Interestingly, TAC and catch continued to increase, even as the biomass was falling, until 1995 when the TAC was reduced by more than two-thirds. Fishing companies experienced considerable economic hardship and claimed that the pilchard had not been depleted, but had only migrated to Angolan waters. The fishing vessels went to Angolan waters, which accounts for the above-TAC catch in 1995.

3. Monetary accounts: methods, data and results

350. As described earlier, the value of fish, like any other asset, is the net present value of the stream of income (rent) it is expected to generate in the future. Constructing monetary accounts has two components: 1) defining how rent is to be calculated and 2) making projections about the future rent a fishery is likely to generate.

Measuring resource rent

351. Rent is defined as the value of production minus the marginal exploitation costs. As in Norway, also in Namibia, rent is estimated using the residual method based on data obtained from the national accounts, which provides average rather than marginal costs (Table V.10). The chief advantage of the national accounts is that the data are comprehensive, covering all fisheries and all years from 1990. The major disadvantage is that most of the data are based on constant, average production costs estimated with a model developed by the Ministry of Fisheries. These costs may differ from actual production costs in any given year.

Table V.9 Physical accounts for hake, pilchards, and horse mackerel in Namibia 1990-2000 (thousands of tons)

A. HAKE

	Opening stock	Catch	Other changes in volume	Closing stock	Net annual change	Memorandum Items: Confidence interval for closing stock	Memorandum Items: TAC
1990	906	55	100	951	45	(751,1151)	60
1991	951	56	176	1,072	120	(860,1284)	60
1992	1,072	87	127	1,112	40	(887,1337)	90
1993	1,112	108	90	1,094	-18	(860,1328)	120
1994	1,094	112	108	1,090	-4	(851,1329)	150
1995	1,090	130	158	1,118	28	(873,1363)	150
1996	1,118	129	170	1,159	41	(903,1415)	170
1997	1,159	110	145	1,194	35	(923,1465)	120
1998	1,194	141	136	1,188	-5	(902,1474)	165
1999	1,188	161	159	1,186	-2	(888,1484)	210
2000	1,186	160	143	1,170	-17	(858,1482)	194

B. PILCHARD

	Opening stock	Catch	Other changes in volume	Closing stock	Net annual change	Memorandum Item: TAC
1990	500	89	249	660	160	63
1991	660	68	49	641	-19	60
1992	641	82	-128	431	-210	80
1993	431	116	-100	215	-216	115
1994	215	115	25	125	-90	125
1995	125	95	-25	5	-120	40
1996	5	2	147	150	145	20
1997	150	32	182	300	150	25
1998	300	65	40	275	-25	65
1999	275	42	-8	225	-50	45
2000	225	27	-108	90	-135	25

C. HORSE MACKEREL

	Opening stock	Catch	Other changes in volume	Closing stock	Net annual change	Memorandum Item: TAC
1990	1,450	409	309	1,350	-100	410
1991	1,350	434	1,184	2,100	750	410
1992	2,100	426	126	1,800	-300	450
1993	1,800	479	179	1,500	-300	450
1994	1,500	360	260	1,400	-100	500
1995	1,400	314	114	1,200	-200	400
1996	1,200	319	119	1,000	-200	400
1997	1,000	306	1,106	1,800	800	350
1998	1,800	258	258	1,800	0	375
1999	1,800	288	238	1,750	-50	375
2000	1,750	320	-180	1,250	-500	410

352. On average, intermediate costs, mainly fuel, account for about 40% of the value of output. Because there is no reliable information about labour costs, factor income is evenly split between compensation of employees and gross operating surplus in all fisheries. For a stable fishery, the assumption of cost proportions that do not vary over time may provide a reasonable approximation. Indeed, analysis of the survey of fishing companies for two years (described below) found these proportions reasonably accurate for all fisheries and fish processing, but not for individual fisheries, which fluctuated significantly between the two years. Environmental disturbances, which are not uncommon, can reduce catch rates by as much as 50%. Consequently, production costs may be underestimated in a bad year and overestimated in a good year.

353. Alternative sources of information for calculating rent include company surveys and the average annual trading price for renting quota. Namibia conducts an annual survey of fishing companies, but reliable results are yet available for more than a few years so it is not yet used for calculating rent. Quota trading prices may provide a reasonable measure of the value of fish, but only when there is a well-functioning competitive market for fish quota established under an Individual Transferable Quota (ITQ) system. Since Namibia does not have an ITQ system, imperfect market conditions exist and the trading prices for quota are unlikely to provide an accurate estimate of rent. Despite its disadvantages, the national accounts provide the best source of data for estimating resource rent at this time.

354. In calculating fisheries resource rent, the boundary between the fishing and fish processing industries was relaxed. This was done for two reasons. First, much of the fish is processed off-shore on factory trawlers (40% in 1998) whose continuous-process operation make the separation of fishing from fish processing somewhat arbitrary. Secondly, there is a high degree of vertical integration in the industry, which makes the separation very difficult.

355. All data needed for calculating rent are provided from the national accounts except for the rate of return to fixed capital. There is little long-term borrowing in the fishing industry that might indicate an appropriate cost of capital for that sector. The Ministry of Fisheries recommended that a 30% return on fixed capital should be used because unpredictable environmental disturbances make fishing is a very high-risk activity. This is much higher than is used for most calculations so a 20% return was used. Sensitivity analysis using a 30% return indicated that the rent estimate was not very sensitive to the rate of return (Table V.10). While this may reflect an underestimate of the fixed capital in the national accounts, three years' data from the fishing company survey support this result.

356. Rent for all fishing activities is shown in Table V.10 and rent by the major commercial species in Table V.11. Pilchard generated the most rent at the beginning of the decade, but was eventually surpassed by hake. This is not surprising since Namibia already had an established pilchard fishery prior to independence and only achieved control over the other fisheries over the past decade. The rent per ton for hake has been steadily rising, reflecting both improvements in the industry and also the devaluation of the Namibian dollar over time, which has a major impact on earnings because most

Namibian hake is sold to the lucrative European market. Pilchard has shown the greatest volatility of rent over the decade. Rent became negative in 1996 when virtually no pilchard was caught that year and the industry suffered considerable losses. Horse mackerel, though harvested in higher volumes than either of the others, generates the least rent; its unit rent has been positive, but much lower than hake and pilchards.

Table V.10 Resource rent for fisheries, 1990-1998

(millions of Namibian dollars)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Output	597	722	1,052	1,357	1,712	1,897	2,010	2,261	3,076
Minus									
Intermediate consumption	304	416	584	721	874	975	1,188	1,253	1,605
Compensation of employees	77	101	138	186	241	233	288	310	377
Consumption of fixed capital	6	9	19	27	32	36	38	42	44
Normal return on capital, 20%	15	26	68	102	119	132	139	148	153
Normal return on capital, 30%	22	39	103	153	179	198	209	222	230
Resource rent:									
at 20% normal profit	195	171	243	322	445	522	357	508	896
at 30% normal profit	187	158	208	271	385	456	287	434	819

Table V.11 Resource rent for pilchards, hake, and horse mackerel, 1990-1998

(millions of Namibian dollars)

	Pilchard	**Hake**	**Horse Mackerel**
1990	117	27	9
1991	65	30	30
1992	135	36	20
1993	201	68	37
1994	229	159	40
1995	201	209	39
1996	0	192	51
1997	95	261	49
1998	150	640	91

Note: Calculated using normal return to capital = 20 per cent

Value of fish stocks

357. The value of each fish stock is the net present value of the rent it will generate in the future. The present value calculations require projections of future prices, technology, costs of production, fish stock levels, and catch. In the absence of alternative information, the convention has been to assume constant prices, technology,

and production costs. The calculation then relies on the remaining variables, levels of stock and exploitation in the future.

358. In some relatively well-understood fisheries, a bioeconomic model can be used to assess the likely future stocks under a consistent management regime (see, for example, Danielsson (2000) on Iceland's fisheries). However, it is exceedingly difficult to assess the biological status of Namibia's fish stocks in the Benguela Ecosystem and to determine whether they will, in the long term, remain at current levels, increase to previous higher levels, or collapse further. Each of these possibilities has different implications for future rent and the value of the asset. If fish stocks remain constant, then rent and asset value will remain constant. If there is a recovery from depletion and fish stocks increase, the rent will increase over time and the present value of the asset is much higher, than under the constant-stocks assumption. If, on the other hand, fish stocks decline, then the asset value will be much lower.

359. Although the decline of Namibia's fish stock has been halted, there has been tremendous inter-annual variation and little evidence that fish stocks will recover rapidly in the near future, despite the Ministry of Fisheries' goal of restoring the fish stock to previous higher levels. Hence, for the calculation of monetary accounts for fish, it has been assumed that the stocks have stabilized at current levels and that current rent will continue into the future. While the fluctuation of rent over the past ten years shows that this is an unrealistic assumption on a year-to-year basis, this assumption is used for lack of any other information at this time. Under this assumption, the net present value formula is simply the resource rent divided by the discount rate. A social discount rate of 10% is used, which is the medium rate used by a number of governments in Southern Africa for project evaluation.

360. Table V.12 reports the monetary value of fish stock in current and constant prices. Over the past decade, there has been a remarkable 61 per cent increase in the value of fish stocks from N$5,463 million to N$8,813 million in 1998 (in constant 1998 prices), even though there was a decline in physical stocks of pilchard and horse mackerel over that period. This increase in value is attributable to the increase in the stock of hake. The emergence of hake as the most valuable fish stock represents a success for government policy which targeted the development of the hake fishery, controlled almost entirely by foreigners prior to independence.

Table V.12 Monetary accounts for hake, pilchards, and horse mackerel in Namibia 1990-1998

A. Asset value in current prices

(millions of Namibia dollars)

	Pilchards	Hake	Horse Mackerel	Total
1990	1,168	268	90	1,526
1991	646	304	301	1,250
1992	1,348	365	204	1,916
1993	2,008	683	365	3,056
1994	2,292	1,591	402	4,285
1995	2,011	2,089	389	4,489
1996	3	1,918	509	2,431
1997	950	2,615	493	4,057
1998	1,500	6,402	911	8,813

B. Asset value in constant 1998 prices

(millions of Namibia dollars)

	Pilchards	Hake	Horse Mackerel	Total
1990	1,935	2,334	1,195	5,463
1991	1,478	2,380	1,268	5,126
1992	1,783	3,709	1,244	6,737
1993	2,522	4,585	1,399	8,506
1994	2,522	4,757	1,066	8,345
1995	935	5,527	908	7,370
1996	22	5,766	938	6,725
1997	609	5,003	882	6,494
1998	1,500	6,402	911	8,813

Note: Constant values measured by applying the 1998 unit rent to the present discounted value estimates of wealth.

Cost of depletion

361. Depletion has been defined as the loss of asset value due to economic activities, in the case of fishing, mainly to over-harvesting. While both the physical biomass and the asset value of two of the major species, pilchard and horse mackerel, have clearly declined, the loss of value cannot be called depletion in the SNA sense of the term. Fisheries managers have attributed the decline in stocks entirely to unforeseeable environmental conditions rather than over-fishing, so the loss in asset value is part of other changes in volume rather than depletion.

4. Resource management costs: divergence of private and social asset value

362. In calculating the resource rent and the value of fisheries, only the private costs are generally taken into account. Several factors can cause the social costs of harvesting to diverge from the private costs, including the costs of managing fisheries. These costs are included in the Resource Management Expenditure (RME) accounts. While it is not always possible to determine how much of the costs of managing fisheries should be considered part of total costs (and, hence, subtracted in the calculation of rent), it is important to construct the accounts for these expenditures.

363. RME accounts have been constructed for costs incurred by government from 1994 to 1999, divided into three components: Monitoring, control and surveillance, Research, and Other (Table V.13). The accounts exclude support to fisheries management by foreign donors on the grounds that while foreign contributions are useful they may not all be essential for fisheries management.[6]

364. In all years, most of the resource management budget was spent for monitoring, control and surveillance, or for research. Resource management costs have accounted for anywhere from 10% to 37% of resource rent earned a not insignificant amount. But even if fishing companies were to pay the full costs of resource management, they would still earn high rents. The taxes paid by the fishing companies include quota fees to recover rent, levies to support research (Sea Fisheries Fund), levies to pay for on-board observers on all boats (Observer Fund), by-catch fees to discourage by-catch, and other license fees. In many countries, fees, if applied at all, rarely cover the costs of management. In Namibia, total taxes have covered RME, but fees were significantly greater than costs in only three out of the six years for which there is information.

5. Recovery of resource rent

365. In managing a public resource like marine fisheries, government policy can be guided by either of two alternative objectives: the promotion of commercial exploitation to maximise resource rent, or the promotion of a combination of socio-economic objectives in which economic efficiency plays a more limited role. Some countries may adopt a mix of these policy objectives for different fisheries. Namibian policy has primarily adopted the first objective, commercial exploitation. Namibian policy also has socio-economic goals, notably the Namibianisation of the fishing industry, as well as a more general objective of utilising this national resource for the broader benefit of all Namibians. Namibia seeks to achieve these socio-economic objectives within an economically efficient, commercial fishing industry, but designing policy to achieve both objectives is difficult.

[6] Foreign donor contributions have been significant, but declining, accounting for 56% of government expenditures in 1996 and 25% in 1999 (Wiium and Uulenga, 2001).

Table V.13 Fisheries resource management costs and revenues received by the government, 1994 to 1999

	1994	1995	1996	1997	1998	1999
Monitoring, control and surveillance	47%	58%	65%	59%	59%	52%
Research	44%	31%	25%	31%	29%	34%
Other	9%	10%	10%	10%	12%	14%
Total	100%	100%	100%	100%	100%	100%
Total in millions of Namibian dollars	52.1	54.3	69.3	73.9	82.4	66.0
Resource mgmt costs as % of rent	14%	14%	37%	21%	10%	Na
Ratio of total taxes paid to Resource management costs	2.53	2.05	1.04	1.23	1.18	1.81

Notes: Resource management costs do not include contributions by foreign donors.
Taxes and fees include quota levies, by-catch fees, Sea Fisheries Fund levies, license fees, and observer fund fees.
There is not enough information to calculate resource management costs prior to 1994, or to determine the cost associated with each fishery.

Source: Based on data from Wiium and Uulenga 2001 and Lange 2003.

366. The Namibian fishing industry generates substantial amounts of resource rent. Recognising that marine fisheries are a public resource from which the public should benefit, the government established a system of quota levies in order to recover this rent. The quota levies go into government's general revenue fund where they can potentially be used to support economic development that would benefit all citizens. As discussed in Chapter IV, full recovery of fisheries resource rent creates economic incentives for sustainable management of fisheries, for economically efficient fishing which maximize rent, and for both intra- and inter-generational equity.

367. A comparison of the rent generated and the taxes levied indicates that relatively little rent is being collected (Table V.14). In the first few years after independence, when quota levies were first established, more than 50% of the rent was recovered by government. The share has since dropped precipitously to only 11% in 1998. The problem of low recovery of rent has two sources: first, an increasing share of Namibian-owned companies, which are eligible for up to 50% subsidies on their quota levies; secondly, the failure to index quota levies to inflation, a common problem faced by governments who find it politically difficult to adjust taxes for inflation.

368. Because taxes do not recover much of the resource rent, the system of quota levies does not contribute in a strong way to sustainability, economic efficiency, or equity in the fishing industry. However, despite a low rate of resource rent recovery, Namibia is doing extremely well by international standards. As noted in the introduction, global fishing is marked by large subsidies. By contrast, Namibia's fishing industry operates at a profit, receives no subsidies, and contributes to government revenues.

Table V.14 Taxes paid by fishing companies, 1990 to 1998

	Taxes by fishery				Percent of rent recovered by the government
	Pilchard	Hake	Horse Mackerel	Total Taxes	
1990	Na	Na	Na	44	30%
1991	Na	Na	Na	64	56%
1992	Na	Na	Na	87	54%
1993	11	60	25	96	38%
1994	15	72	28	115	32%
1995	6	67	25	98	26%
1996	1	38	13	53	32%
1997	5	58	16	79	26%
1998	9	57	19	85	11%

Note: Taxes are not broken down by species for 1990-1992
Taxes include quota levies and Sea Fisheries Fund Levies, but not other fees.

6. Economic efficiency: potential versus actual value of assets

369. Resource management can be evaluated in terms of economic efficiency to determine if alternative policies might increase the income generated and, hence, the economic value of a resource. Inefficiency can occur because of overcapacity, such as under-utilised vessel or fish-processing factory capacity. Inefficiency can occur when quota allocations are too small to take advantage of minimum economies of scale, or when quotas are spread out over inexperienced companies instead of creating incentives so that only the most efficient companies obtain quotas. Evidence of overcapacity and inefficiency in the industry has been found by Arnason (1994) and Manning (1998, 2000).

370. The analysis of the annual survey of fishing companies, while incomplete until 1996, indicates substantial variation in the rents earned by company. In 1995, the unit rent for hake earned by the three top-earning companies was N$1,815 per ton, more than double the average for all 18 companies. The South African hake fishery generated similar rent in 1996: N$ 1,840 per ton (Strydom and Nieuwoudt 1998). Since the hake fisheries are fairly similar in South Africa and Namibia, it is reasonable to expect that any difference in rent would be largely attributable to the structure of the industry. The South African hake industry was dominated by two companies, who together controlled nearly 80 per cent of the quota in 1996, creating significant economies of scale, greater economic efficiency and high rents.

371. The above evidence suggests that Namibia's fisheries could generate even higher average rents under a policy regime that consolidated fishing activities among fewer, more efficient companies. If hake were fished so that the average rent were N$1,815 in 1995 and N$1,840 in 1996, the value of hake stock in those years would be roughly N$18 million, three times the actual value in those years. However, although Namibia's fisheries policy seeks to create an efficient fishing industry, employment creation is an

important national objective. The national unemployment rate in 1997 was, 20-30 per cent depending on how broadly unemployment is defined (Ministry of Labour 2001) and greater efficiency in fisheries would have a negative impact on employment, an important consideration for government.

D. Fisheries accounts for Iceland[7]

1. Introduction

372. The work presented here is based on the work that has been done at the National Economic Institute (NEI) in Iceland. This institute collects and processes accounting data from the fisheries as well as producing the national accounts. The fisheries accounts presented here utilize physical estimates, produced by the Marine Research Institute (MRI) in Iceland, on all economically important fish stocks. This study will briefly discuss physical accounts and will focus on monetary accounts for commercially exploited fish stocks.

373. The value of an asset can be measured alternatively from the market price or by estimating the Net Present Value (NPV) of future rents from exploiting the asset. The fisheries management in Iceland is based on Individual Transferable Share Quotas (ITSQ). Each fishing vessel has certain share quotas that specify the percentage of the total annual quota of each species allocated to the given vessel (vessel-owner). Both the annual quotas and the quota shares are tradable and there are markets for these rights to exploit the fish stocks. It is therefore possible to measure the value of many fish stocks in Icelandic waters on the basis of data on the prices of the ITSQs. This method is used below.

374. The study argues that prices of ITSQs do not provide accurate estimates of the value of fish stocks in Iceland and that instead estimates based on the NPV of future rents should be used for obtaining estimates of the values of the fish stocks to be included in the national accounts. In many cases the measured rents are the best estimates of future rents. In such cases, the NPV of future rents is the measured rent divided by the appropriate discount rate.

375. If there is some additional information that can be used for estimating future rents from the exploitation of some fish stock, this information should of course be utilised. The use of information on expected future growth of the cod stock in Icelandic waters and its effect on future rents in the cod fisheries to estimate the future rents from fishing cod will be discussed below. This approach taken by the Working Group on the Rational Exploitation of Fish Stocks that estimated and recommended an efficient catch

[7] Based on Danielsson A., (2000) *Integrated Environmental and Economic Accounting for Commercial Exploitation of Wild Fish Stocks*, a paper presented at the A paper presented at the X-th Biennial IIFET Conference, Corvallis, Oregon, USA, 10-14 July 2000 and Danielsson, A., *National Economic Accounting for the Exploitation of Wild Fish Stocks*, unpublished working paper.

rule for cod in 1994, where efficient refers to the catch rule that maximizes economic benefits (or economic welfare) from the fisheries.[8] Some of the work presented in this study started during the work of this Working Group, a co-operative effort by NEI, MRI and the Ministry of Fisheries.

376. The different methods used to value fish stocks produce different estimates of the value of fish stocks. Part of these differences can be explained by increases in productivity, however there still remains a big part which is unexplained and may reflect the uncertainty involved in the estimation methods. This study does not intend to provide a definitive assessment on the usefulness of each method, but to provide and indications of the situations, depending on data availability and use of information, in which the different methods are appropriate. These issues are further discusses below.

2. Estimates of the value of fish stocks using prices of quota shares

377. Since 1991 the system of ITSQs has covered most of the fishing in Icelandic waters. For some species (capelin, herring, off-shore shrimp, plaice), all access rights are in the form of ITSQs. For other species a significant portion of the Total Allowable Catch (TAC) is taken by vessels outside the main ITSQ system. Of these species, the most important is cod: since 1994, more than 14% of the TAC for cod has been allocated to vessels outside the main ITSQ system, mostly to vessels below 6 gross registered tons (GRT) that use only hand-line and/or long-line. Foreign vessels take a small catch.

378. Table V.15 shows the value of rights to exploit the most important fish stocks in Icelandic waters: capelin and Greenland halibut, which are shared by Iceland and other countries. The exploitation of capelin is regulated by an agreement between the governments of Iceland, Greenland and Norway. The figures for the value of capelin in Table V.15 are estimated from the value of the quotas of Icelandic vessels. The Greenland halibut stock is exploited by vessels from Iceland, Greenland and Faero Islands without any agreement. The Icelandic government determines quotas for Icelandic vessels fishing out of this stock. The figures for the value of this stock reflect only the value of the Icelandic quota rights.

379. The end-of-year prices of the quota shares have been used to estimate the value of all access rights for each species. The access rights of vessels outside the main ITSQ system were estimated by assuming that the share of the total catch allocated to these fishers in a given year would remain the same in future years. The value of this share was then estimated assuming that it had the same price as the quota shares in the main ITSQ system.

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[8] See Vinnuhópur um nýtingu fiskistofna, *Hagkvæm nýting fiskistofna* (Efficient exploitation of fish stocks), Reykjavik, 1994.

Table V.15 Value of fishing access rights for major commercial species in Iceland, 1994 to 1999

(billions of IKR)

	1994	1995	1996	1997	1998	1999
Cod	32.2	62.0	86.3	131.8	131.2	134.2
Haddock	4.2	5.8	8.8	12.1	13.2	15.7
Saith	3.6	3.4	3.4	5.3	6.4	7.8
Redfish	6.2	10.4	15.0	20.8	22.1	21.5
Catfish			1.5	2.2	2.2	2.3
Greenland halibut	4.4	3.0	3.0	4.8	4.6	4.8
Plaice	1.4	1.5	1.6	1.7	2.5	2.9
Shrimp	6.5	21.4	24.0	33.0	25.7	19.5
Nephrops	1.2	1.0	0.9	1.0	1.2	1.4
Herring	1.4	3.5	8.0	8.8	8.2	7.6
Capelin	5.5	6.0	15.0	19.0	22.8	26.5
Total	66.5	117.9	167.5	240.4	239.9	244.1

Notes: Rights are valued as the end-of-year prices for permanent quota shares.
The exchange rate of USD was 72 IKR in 1999.

Source: Data on the prices of quota shares were obtained from the Quota Exchange of the Federation of Vessel Owners.

380. The total value of the fish stocks in Table V.15, represented by the price fishers are willing to pay for these access rights, increased rapidly from 1994 to 1997 but remained fairly stable during 1997-1999. The total value of access rights grew by some 360%, from IKR 67 billions in 1994 to IKR 240 billions in 1997. Prices for access rights grew for all fish over the six years. Hake, herring and capelin values grew the most rapidly. Cod remained the single most important fish over the period, accounting for 50% or more of the total value. It is difficult to explain the rapid increase in the price of access rights since it has not been matched by similar increases in the profitability of the fisheries or increases in fish abundance. This suggests that the price of access rights may not provide a good estimate of the value of the fish stock.

381. There are three main reasons why prices of quota shares might give misleading information about the monetary value that wild fish stocks have for commercial fisheries. First, while the permanent entitlements to the exploitation of some stock in the form of quotas and licences may have many characteristics of property-rights, their legal status in Iceland is very much inferior to that of property rights to other assets. The laws on fishery management do not give the same constitutional guarantees to holders of quota shares as owners of other types of property have. The first paragraph of the Fisheries Management Law in Iceland explicitly states that the fish stocks in Icelandic waters are “the common property of the Icelandic nation.” The prices of these rights are bound to reflect the (political) risks associated with the access rights, including possible future changes in their taxation. Second, it is frequently observed that the prices of the entitlements to fish from some stocks tend to reflect marginal short run profits rather than marginal long run profits. There are cases showing that this state of affairs can last for a long period of time.

382. The third main reason for expecting that the price of quota shares might not reflect the efficient price of the natural resource is that the quota prices will reflect inefficiency in the fisheries management.

383. One way to estimate the economic value of the stock is to calculate the optimal fisheries management. This estimation should be done by the managers of the fisheries and could then be used by the national accountants.

Estimates of the value of fish stocks using NPV of future rents

384. An alternative way to using prices of quota shares to the value of fish stocks is to estimate the NPV of future rents. Current rent can be derived from reported revenues and costs. Revenues for each species can be estimated from information on landings and prices. It is more difficult to measure the costs by species because survey data are available by vessel and most vessels are used to fish for more than one species. The following method to estimate costs by species was used:

- Data on catches and costs and earnings were gathered. Data were grouped into 5-7 classes defined by the type of vessel[9] and used to estimate aggregate accounts for each class of vessels.
- The total cost was divided between operating costs, and capital cost. The operating cost was further divided between variable costs (e.g. fuel cost, gear cost and labour cost) and fixed costs (e.g. cost of the office and insurance).
- Gross operating surplus or mixed income is defined as the difference between revenue and operating costs. It was assumed that gross operating surplus per unit of catch of each species was proportional to the relative prices for the quota rentals for each species. In a well-functioning system of transferable quotas, the relative rental prices of quotas should reflect the relative marginal (short-run) profit from fishing for the different species.
- For all species fixed costs (fixed operating costs and consumption of fixed capital) were assumed proportional to the revenue.
- For each species the rent was calculated as gross operating surplus minus the consumption of fixed capital and the normal rate of return on all capital.

385. Several additional adjustments were made to this approach. As the data did not distinguish between vessels in the main ITSQ system and vessels outside this system, the estimation method described above was also used for estimating the variable costs of fishing for the different species for vessels outside the main ITSQ system. For those species for which there is no quota or there is insufficient data on the quota prices, the share in cost was assumed to be proportional to the share in revenue. In most cases these species make up a small fraction of the catches.

386. Table V.16 shows the figures for the resource rent. The fishing industry as a whole generated positive rent for all years, but for many species, rent was negative, in

[9] The number of classes depended on data availability in each year.

some cases, for all years. Only cod generated positive resource rent throughout the entire period.

Table V.16 Resource rent for major commercial species in Iceland, 1992 to 2000

(Millions of IKR)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cod	1,605	2,883	4,008	3,792	2,111	1,978	4,742	5,697	4,826
Haddock	-301	-716	-1,461	-1,163	-1,203	-653	-841	-536	-99
Saith	116	-296	-527	-642	-505	-447	-231	-63	67
Redfish	495	487	-25	218	438	-36	460	324	397
Catfish					-245	-222	-245	-169	-120
Greenland halibut	391	678	-259	-1,012	-975	-439	166	252	407
Plaice	12	-134	-186	-194	-263	-309	-143	-88	24
Shrimp	-1,017	-909	-728	1,271	1,462	-54	-948	-905	-523
Nephrops			-24	-32	-62	-40	-31	-56	-68
Herring		-33	493	841	1,183	627	49	1	47
Capelin		-504	-565	-804	-295	312		-1,174	-1,023
Other	331	214	54	210	350	-528	137	-474	-332

387. When no further information is available about future levels of catch, fish prices and costs of fishing, it is common to assume that fish stocks will continue to generate the current year's rent in future years. The value of the fish stocks is thus the present discounted value of future rent (Table V.17). A discount rate of 8% was used in these calculations. The catch by foreign vessels in the Icelandic EEZ was not taken into account in the calculation. The error caused by this omission is negligible (in most cases zero and in all cases less than 0.5%). Considering the large uncertainty associated with most fishing, the discount rate is rather low also as compared to 20% of the Namibia case study. The corresponding estimates of the asset values are rather high. Where rent is negative, a zero value is assigned to the fish stock. When there are large year-to-year fluctuations in the rent it may be appropriate to average the unit rent over several years, as it is often done in mineral accounts.

388. There has been an increase in the value of fish stocks over time, but not nearly as much as the increase in the value of access rights (Table V.15). The total value of fish stocks in Table V.17 doubled over nine years, compared to a nearly four-fold increase in only six years for the value of access rights. In all years, the current-rent value of fish stocks is lower than the value of access rights. In 1994, the first year for which the value of access rights was calculated, the current-rent value of fish stocks was 76% of the value of access rights, and in 1995, it was 67%. The big gap between the two measures appeared in the years after 1996. By 1999, the current-rent value was only one-third of the value of access rights. The issue is what valuation is most suitable for valuing fish stocks, the value of the access rights or the NPV of resource rent.

Table V.17 Asset value of major commercial fish species in Iceland, 1994 to 2000

(Billions of IKR)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cod	20.1	36.0	50.1	47.4	26.4	24.7	59.3	71.2	60.3
Haddock	0	0	0	0	0	0	0	0	0
Saith	1.5	0	0	0	0	0	0	0	0.8
Redfish	6.2	6.1	0	2.7	5.5	0	5.7	4.1	5.0
Catfish					0	0	0	0	0
Greenland halibut	4.9	8.5	0	0	0	0	2.1	3.1	5.1
Plaice	0.1	0	0	0	0	0	0	0	0.3
Shrimp	0	0	0	15.9	18.3	0	0	0	0
Nephrops			0	0	0	0	0	0	0
Herring		0		10.5	14.8	7.8	0.6	0.0	0.6
Capelin		0	0	0	0	3.9		0	0
Other	4.1	2.7	0.7	2.6	4.4	0	1.7	0	0
Total	36.9	53.3	50.8	79.1	69.4	36.4	69.4	78.4	72.1

Note: Zero indicates negative rent. Blank indicates that it was not possible to estimate the rent for the given species. The value of the stock for all other species has been lumped together in "Other".

NPV of future rents using bio-economic information

389. If there exists some information that can be used to improve the forecasts of future rents this information should be used in the calculations of the NPV of future rents. This section discusses the use of biological information for improving estimates of future rents. It is believed that the biological knowledge of the growth potential of the Icelandic cod and the economic knowledge of the impact of the growth of the cod stock on the rent from cod fisheries is sufficiently reliable to be used in the forecasting of future rents. This was assumed when the Working Group on the Rational Exploitation of Fish Stocks devised its efficient catch rule for cod. The modelling required for forecasting future rents using biological information is closely related to the modelling required for estimating the optimal fisheries management.

390. The optimal fisheries management in a catch quota system is based on a rule which is used to decide the catch quota in each period. In this study a very simple catch rule is used: the allowable catch in each year is the average of last year's catch and 23% of the fishable biomass estimated at the beginning of the year.[10] There are several reasons for adopting a simple catch rule. First, simplicity is an advantage when communicating the rule to the fishers. Second, it is very difficult to model the various

[10] The mathematical expression for this harvest rule is given in the Appendix. The Working Group on the Rational Exploitation of Fish Stocks concluded that the optimal value was 22% of the fishable biomass (See Danielsson *et al*., Utilization of the Icelandic Cod Stock in a Multi-species Context, Marine Resource Economics, 12 (4), 329-344). In 1995 the Icelandic government decided on a catch rule for cod where the TAC for the next quota year should be 25% of the estimated size of the fishable stock. This has been interpreted as 25% of the average of the estimated size of the stock at the beginning of the year, and the forecasted size of the stock a year later.

adjustment costs, therefore smooth catch rules may be justified. Third, the economic objective functions tend to be fairly flat around the optimum. Simple rules that may not be the perfectly optimal outcome from a mathematical point of view, but they will lead to small economic losses.

391. The study uses data from the MRI on the fishable biomass. Forecasting of future stock sizes has been done with a logistic growth function with intrinsic growth rate (r) of 0.5242 and carrying capacity (K) of 2,720,000 tonnes. This function gives the same maximum sustainable yield of 356,000 tonnes when the stock is 1,360,000 tonnes as the MRI cohort model.

392. Estimations of catch and cost functions in fisheries show that the catch, which can be fished by some given volume of capital and labour, depends on the size of the stock. In most cases the productivity of labour and capital in groundfish fisheries increases very much when the stock increases. In this study, the elasticity of the catch per unit effort (CPUE) with respect to the size of the stock is assumed to be 0.8. The standard deviation of this estimate is large. Together with the biological growth function (the recruitment function in the cohort model) this elasticity is the source of the largest errors in the model.

393. In this study it is assumed that the future price of cod changes slightly with changes in the supply (catch). Given this price function, the optimal catch rule, the biological growth function and the cost function, it is possible to estimate future rents. The value of the stock at each point in time can now be calculated as the present value of the estimated future rents from the fishery Table V.18 shows the value of the cod stock at the beginning of each year valued at current prices (i.e. average prices during the year) and using a discount rate of 8%. This table is based on the estimates of rents from fishing cod given in Table V.16 above.

Table V.18 Biomass and economic value of Icelandic cod stock, 1992 to 2000

(Volume in thousands of tons; value in billions of IKR)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Fishable biomass	640	630	590	560	675	889	975	1,031	756
Value of stock:									
at current prices	116	132	180	181	122	101	138	152	182
at 1992 prices	116	117	114	115	126	141	146	148	129

Note: Figures are estimated using a bio-economic model described in the text.
Figures are given for beginning of each calendar year.

394. There are considerable variations in the estimates of the value of the cod stock at current prices in Table V.18 but it is not possible to detect a trend as was the case in the estimates inTable V.15 and to lesser degree in the estimates in Table V.17. The estimates obtained for cod using the bio-economic information (Table V.18) are much higher than the estimates obtained from the current-rent approach (Table V.17). On the other hand, the estimates are close to the prices of ITSQs (Table V.15). From 1997 to 1999, the ratio fluctuated between 86% and 106%.

395. The estimates in Table V.18 depend on what is known at a given time about future profitability of the fisheries exploiting the stock and its future growth. These estimates will be adjusted as new information becomes available.

396. Estimates of the value of fish stocks at a given point in time are frequently made some years later. The estimation of the value of the cod stock in this study utilises information about the price of cod and the cost of fishing for it in the year after the point in time, which the stock estimate refers to. The estimate uses only information about the profitability of the cod fisheries in the first year. The profitability of all later years are based on predictions assuming that prices change according to changes in Icelandic supply, with the price elasticity of demand of 10, and the cost of fishing changes with the size of the cod stock. MRI's estimates of the size of the fishable stock of cod, at the end of each year, become available in May of the following year.

397. It is possible to use the model above to estimate the value of the Icelandic cod stock at different points in time using the same data for unit price and cost. The bottom row in Table V.18 shows the value of the stock at the beginning of each year valued at 1992 prices and costs using the estimate of the size of the stock at the beginning of each year from MRI.

Cost of depletion

398. The cost of depletion refers to reduction in the value of the stock of fish as a result of over-fishing. As discussed in chapters II and III, the estimation of depletion costs is difficult especially because of the difficulties in the estimation of the fish stocks as well as the large variations in the growth rates of most fish stocks and in some cases adverse of the environmental conditions which may lead to negative growth in a year.

399. MRI uses Virtual Population Analysis (VPA) to estimate the stock of cod. Cod is considered relatively stable and the best researched fish stock in Icelandic waters. As discussed in chapter III, this method uses the size of the different cohorts in the stock and re-estimates the stocks each year when new information on catch becomes available. Each cohort appears as part of the catches for more than 10 years. This means that the estimates of the stock may change even after 10 years. The estimates obtained with the information on the cohort 10 years old and older are considered more accurate.

400. Table V.19 shows some of the re-estimations of the size of cod. All estimates given in the table will be revised further during coming years. The first five rows of Table V.19 (S_t^t) indicate the size of the stock at the beginning of year t, as it is estimated (or forecasted) at the beginning of year t. The different stock estimates lead to different growth of the cod stock in a given year.

Table V.19 Stock, growth and depletion of cod estimated at different periods, 1992 to 2000

(Thousands of tons)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
S_t^t	640	630	590	560	675	889	975	1031	756
S_t^{t+1}	611	570	632	620	694	950	952	843	527
S_t^{2001}	547	580	577	553	672	786	710	709	527
S_{t+1}^{t+1}	630	590	560	675	889	975	1031	756	577
S_{t+1}^{2001}	580	577	553	672	786	710	709	527	577
Growth $A_t = S_{t+1}^{t+1} - S_t^t$	-10	-40	-30	115	214	86	56	-275	-179
Growth $B_t = S_{t+1}^{t+1} - S_t^{t+1}$	19	20	-72	55	195	25	79	-87	50
Growth $C_t = S_{t+1}^{2001} - S_t^{2001}$	33	-3	-24	119	114	-76	-1	-182	50
Catch	268	252	179	169	182	203	243	260	235
Depletion A	-278	-292	-290	-54	32	-117	-187	-535	-414
Depletion B	-249	-232	-251	-114	13	-178	-164	-347	-185
Depletion C	-235	-255	-203	-50	-68	-279	-244	-442	-185

Table V.19 shows three different estimates of the growth of the cod stock. The first estimate is Growth $A_t = S_{t+1}^{t+1} - S_t^t$, i.e. the difference between the stock estimates at the beginning and the end of each year as estimated at the time. The revision of the estimated size of the opening stock made at the end of the year is included in other changes in volume. The second estimate is Growth $B_t = S_{t+1}^{t+1} - S_t^{t+1}$, i.e. the growth in the year, estimated at the beginning of the following year. The last estimate is Growth $C_t = S_{t+1}^{2001} - S_t^{2001}$, i.e. the growth in the year, estimated at the beginning of 2001. The last section in provides estimates of depletion given the different estimates of the growth of the stock and of the catch. Depletion A = Growth A – catches of cod in the year.

401. Table V.19 shows that there are large annual variations in the growth of the cod stock. For a long-lived species like cod, it is important, economically and biologically, that the multi-annual (long-run) catches of cod do not exceed the multi-annual (long-run) growth of the cod stock so that the cod stock is allowed to grow to its optimal size. The study suggests that depletion should not be calculated on the basis of estimated annual growth as in Table V.19 but as the difference between the long-run average growth of the stock (or the expected growth of the stock) and the actual catch in the year. When forecasted growth is used the revisions are included in the Other changes in volume.

402. This method of estimating depletion and the cost of depletion can be justified further by pointing out that the depreciation of an asset is the change in value as a result of (normal) use. If the forecast of net growth is based on the best available information, the cost of using the fish stock should be based on the forecasted growth of the stock in the period rather than the *ex post*, actual growth which may have been influenced by many factors. For this reason, it is recommended to distinguish between what is ordinary and what is not. Decline in some fish stock, caused by some extraordinary environmental events, are not considered depletion, but are included under a separate category, Other changes in volume. This is similar to the treatment in the SNA of losses in fixed capital due to natural disasters or wars.

403. Because wild fish are generally considered not to be under the direct control of humans, except for fishing, it is assumed that any increase in fish stock is not attributable to human actions, only to natural growth and a more favorable environment. This introduces an asymmetry: human actions (i.e. fishing) can cause depletion, but not an increase in the fish stock. In this study these recommendations will be ignored and increases and decreases in the fish stocks will be treated in a symmetric manner. Associated with a decrease in the fish stock is a positive depletion cost, while an increase in the fish stock is associated with a negative depletion cost.

404. Table V.20 includes estimates of the cost of depletion based on the difference between the value of the stock at the end of the year and the value of the stock at the beginning of the year. The estimations are based on NPV of future rents and use bio-economic information as described above and the prices and cost in the present year. includes two estimates of the cost of depletion. They differ in the way the size of the stock at the end of the year is calculated. Cost I reflects the depletion cost obtained by valuing the reduction in stocks as a result of catch in excess of forecasted growth. The size of the stock at the end of the year is equal to the size of the stock at the beginning of the year plus forecasted growth in the year as it was forecasted by the beginning of the year minus the actual catch. This estimate of the cost of depletion is considered to be the most appropriate one and will be used further below. The second case (Cost II) is presented for comparison. In this case the size of the stock at the end of the year is equal to the size of the stock at the beginning of the year plus the growth in the year as it was estimated by the end of the year minus the actual harvest.[11] This means, of course, that all revisions of the estimates of the actual depletion in the given year made after the end of the year will be included in Other changes in volume. Revisions of depletion in the given year because of re-estimations of the size of the stock at the beginning of the year are also included in Other changes in volume. This is the case in both Cost I and Cost II.

[11] Let $V_t(S)$ be the estimated value of a stock of size S using data on prices and costs in year t. Then Cost I = $V_t(S_{t+1}^t) - V_t(S_t^t)$, where S_{t+1}^t is size of the stock at the beginning of year $t+1$ as it was forecasted at the beginning of year t, while Cost II = $V_t(S_{t+1}^{t+1}) - V_t(S_t^t)$.

Table V.20 Depletion costs for Icelandic cod using different methods, 1992 to 2000

(Billions of IKR)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cost I	-3.4	-1.1	-12.8	-8.4	-5.8	-5.3	-4.1	-4.7	-7.1
Cost II	-1.5	3.5	-1.2	-14.0	-14.1	-4.1	-2.3	25.6	22.5

Note: Cost I = $V_t(S_{t+1}^t) - V_t(S_t^t)$, where S_{t+1}^t is size of the stock at the beginning of year $t+1$ as it was forecasted at the beginning of year t, while Cost II = $V_t(S_{t+1}^{t+1}) - V_t(S_t^t)$.

405. The SNA records the actual rent in fishing as part of the annual production. But that part of the income which consists of a decrease or an increase in the value of the environmental asset is not included. This omission should be corrected by recording depletion in the environmentally adjusted satellite accounts. But a fish resource can be inefficiently exploited even if there is no depletion. Sustainable overfishing is common. Neither the SNA nor the SEEA record this cost. The framework here can be used to calculate the inefficiency costs. Estimates for these costs are given in Table V.21 while the formulas are given in the Annex IV.

406. The first row in Table V.21 shows the size of the stock at the beginning of the year as it was estimated at the time. The next two rows show catch: first the actual catch followed by the optimal catch given by the catch rule. Next, the rent corresponding to actual catch and to optimal catch are shown. Finally the last two rows show depletion cost (Cost I) and inefficiency cost.

Table V.21 Depletion and inefficiency cost for the Icelandic cod stock

(Thousands of tons and billions of IKR)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Stock size	640	630	590	560	675	889	975	1,031	756
Catch:									
Actual catch	268	252	179	169	182	203	243	260	235
Optimal catch	228	206	194	154	162	193	214	240	217
Rent:									
Actual	1.6	2.9	4.0	3.8	2.1	2.0	4.8	5.7	4.9
From optimal catch	1.4	2.4	4.4	3.5	1.9	1.9	4.2	5.3	4.5
Depletion cost	-3.4	-1.1	-12.8	-8.4	-5.8	-5.3	-4.1	-4.7	-7.1
Inefficiency cost	4.1	6.4	-2.7	2.0	1.7	0.6	1.8	1.3	2.2

Complete accounts for Cod

407. It is now possible to set up the complete account for the Icelandic cod stock. Table V.22 shows the physical accounts for the Icelandic cod stock.

Table V.22 Physical accounts for Icelandic cod, 1992 to 2000

(Thousands of tons)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Opening stock	640	630	590	560	675	889	975	1,031	756
Forecasted growth	257	254	242	233	266	314	328	336	286
Catch	-268	-252	-179	-169	-182	-203	-243	-260	-235
Depletion (-)	-11	2	63	64	84	111	85	76	51
Other changes in vol.	1	-42	-93	51	130	-25	-29	-351	-230
Closing stock	630	590	560	675	889	975	1,031	756	577

408. Table V.23 shows the monetary accounts for the Icelandic cod stock for the period 1992-2000. The closing stock and the holding gains/losses are not available for 2000 as they require accounting data for 2001.

409. Table V.23 shows that Other changes in volume are large compared to the depletion costs (that are included with a minus sign). This indicates the limits to the control over the growth of the Icelandic cod stock.

Table V.23 Monetary accounts for Icelandic cod, 1992 to 2000

(Billions of IKR)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Opening stock	116	132	180	181	122	101	138	152	182
Depletion cost (-)	3	1	13	8	6	5	4	5	7
Other changes in volume of asset	-2	-5	-12	6	8	-1	-2	-30	-30
Closing stock at previous year's prices	117	129	181	195	136	105	141	127	159
Holding gain/loss	15	51	0	-73	-35	33	12	55	
Closing stock	132	180	181	122	101	138	152	182	
GDP	400	412	439	451	484	524	579	623	672

410. All estimates of the value of the cod stock above are based on prices and costs in one year. The large decline in the value of the cod stock in 1995 and 1996 is caused by a sharp decline in the profitability of the cod fisheries in these years as shown in the accounts by large holding losses. It may be better to use the prices and costs during some recent years to forecast future profits. The resulting estimates would then be smoother than those in Table V.23. The bottom line in Table V.23 shows GDP at current prices for comparison.

E. Fisheries accounts for Atlantic sea scallops in the United States of America[12]

1. Background

Accounting for natural resource assets

411. Significant limitations in the system of national accounts have long been recognized, including its exclusion of non-market production and its failure to treat natural resources as economic assets. Thus, for example, rebuilding commercial fish stocks is not counted as a form of capital formation, though rebuilding stocks leads to a higher future income stream at the cost of a current economic sacrifice.

412. Efforts to deal with these limitations also have a long history in government and academic research. In the United States, in response to a directive from the Clinton administration in 1993, the Bureau of Economic Analysis (BEA) undertook a work program that led to the publication in 1994 of a preliminary set of capital accounts for some natural resources. First-phase results covered land and sub-soil minerals. That program was halted shortly thereafter by a Congressional directive pending an independent review of the methodology and data used in the estimates.

413. The independent review has been provided by a committee organized by the National Research Council under the chairmanship of William Nordhaus of Yale University. That committee strongly supported the development of environmental and natural resource accounts as extensions to the core national accounts and emphasized their policy importance. Its report states "There are many examples of how comprehensive economic accounts can bring benefits. These include better estimates of the impact of regulatory programs on productivity, improved analysis of the costs and benefits of environmental regulation, and more effective management of the nation's public lands and resources. Augmented national accounts would also be valuable as indicators of whether economic activity is sustainable." (Nordhaus and Kokkelenberg 1999, p. 15)

414. However, the Panel report expressed doubt regarding the feasibility of constructing resource accounts for wild fish, since "data on fish stocks are unreliable because wild fish are fugitive assets and there is no reliable census of the fishes." (*ibid.* p. 168) This is essentially the reason why the Bureau of Economic Analysis had not included fisheries in its initial work program, even though marine fisheries are one of the few important natural resources of which stocks have significantly declined. This omission motivated the research project behind this report, which is intended as a case study to test whether such accounts can be compiled for a significant commercial fishery with reasonable accuracy and at reasonable cost.

[12] Based on R. Repetto (2002), "Creating asset accounts for a commercial fishery out of equilibrium: a case study of the Atlantic sea scallop fishery."

The Atlantic sea scallop fishery

415. The Atlantic sea scallop fishery is one of the nation's most important, consistently within the top ten in the value of landings. It provides employment to more than 3,000 full-time fisherman in New England and the Mid-Atlantic region, though this level of effort far exceeds that required to harvest the resource efficiently. The fleet of about 250 large off-shore scallop dredges that accounts for 80-90 per cent of the catch operates mainly out of New Bedford, Cape May, Hampton Roads and Newport News. These boats sail with a crew of up to 7 men, staying at sea for days and shucking their catch on board. The fishery grew rapidly over the 1970s and 1980s but, like many others, was crippled by excess capacity and over-harvesting and was forced by regulation and by low profits to retrench.

416. The Atlantic sea scallop (*Placopecten magellanicus*) is potentially a highly renewable resource because of its great fecundity. Once through its drifting larval stages and settled onto old shells or rocky bottom at depths of 20-100 meters, the scallop grows rapidly. Most reach sexual maturity at around age three, when a fertile female will release 2 million eggs at spawning. Egg production increases with the scallop's size, which will double between ages three and four and again by age five. Survival of offspring is highly variable due to predation, uncertain fertilization, and the vagaries of ocean current and bottom conditions when larval scallops settle to the bottom as spat, so recruitment of young scallops into the harvestable resource at about age three is quite variable. No firm stock-recruitment relationship has been established for the Atlantic sea scallop.

417. Large populations of sea scallops are found on the George's Bank, in the New York Bight, in the mid-Atlantic Del Marva region, and, to a lesser extent, in the Gulf of Maine. These do not appear to be separable populations, since larval scallops can be transported long distances, and they are now managed as one resource area. The fishery has been managed by the New England Fisheries Management Council since 1982 under a series of management plans and amendments. Initial management efforts set minimum weight and shell height restrictions on the catch but these measures failed to prevent increasing excess capacity and over-fishing. Revisions in 1994 imposed limits on new entry into the fishery, restrictions on the number of days that permit holders could spend at sea, and restrictions on crew size, along with gear restrictions intended to reduce harvests of immature scallops. In addition, incidental to the collapse of groundfish stocks and closure of most of George's Bank to bottom fishers, large areas of the traditional scallop dredging grounds were put off limits. This has led to rapid recovery of stocks in the closed areas but more intensive over-fishing outside them. Despite these measures, fishing mortality was found to be far above the level implied by the 1996 Sustainable Fisheries Act as constituting over-fishing, requiring further reductions of about 70 per cent to permit the stock rebuilding required by the law. These drastic requirements for effort reductions have been staved off by the industry, at least temporarily, by gaining limited access to the closed fishing grounds, where stocks rebounded substantially when fishing ceased.

418. The Atlantic sea scallop fishery was selected for a case study on other criteria as well. Recreational fishing for scallops is negligible. The bycatch of scallops by other trawlers and of other species by scallop boats is not too important. The fishery is fairly homogeneous with respect to gear types and the various management plan amendments have generated a considerable amount of accessible biological and economic information and research.

2. Methodology of the study

Physical stock assessment

419. Estimates of the numbers and weight of scallops subject to harvest (recruited) in the fishery have been estimated for many years by the National Marine Fisheries Service's (NMFS) Northeast Fisheries Science Center. These estimates are made principally to support the Stock Assessment Review Committee and the New England Fisheries Management Council in making fisheries management decisions. Consequently, both the estimation methods and the underlying data are subject to careful review and criticism by fishermen and others. Though estimation methods and data collection procedures have been refined over the years, the estimates are consistently based on two fundamental information series:

- Data on the scallop harvest, which are collected both at the port from dealer logs and on board from vessel trip reports. Records of the scallop catch are kept by size. Data on landings are supplemented by on-board sampling information of the ratio of discarded to kept scallops in the catch, also by size.
- Data on scallop abundance, which have been collected since 1975 through annual sampling. Sampling is conducted by means of carefully plotted and controlled tows of a scallop dredge in fishing areas. Following the same procedures each year, research vessels follow a stratified random sampling scheme, conducting tows in different geographical grids at various depths and latitudes. Results are averaged into indices of mean abundance, in numbers and biomass per tow. Size distributions are kept and used to distinguish new recruits from fully recruited scallops. Abundance data, particularly of scallops just large enough to be captured in permitted gear, are adjusted to reflect the selectivity of the mesh size of towed nets. Adjustments are also made for the time within the sample year at which the samples are taken.

420. Recruitment, stock size, harvests, and effort levels in the scallop fishery are all subject to short-term and longer-term change, violating the equilibrium assumptions in simple bioeconomic fishery models. Statistical estimation techniques are used to derive estimates of size and weight of the scallop population in fishing areas. The modified DeLury method (Conser 1991, 1995) that is used is based on a simplified population model. The model assumes that the harvestable scallop population at the start of year (t) consists of the harvestable scallops at the start of the previous year (t-1) plus scallops that became harvestable during the course of the previous year, both quantities

diminished by the natural mortality rate affecting harvestable scallops; and less the number of scallops in last year's catch. Or, to put it even more simply, this year's harvestable population is last year's harvestable population *plus* additions due to the recruitment of young scallops *minus* mortality due to fishing and natural causes.

421. The DeLury model thereby defines a set of recursive equations for the stock of catchable scallops and for the catch:

$$N_{t+1} = (N_t + R_t) \exp\left\{-\left(m_t^f + m_t^n\right)\right\} \qquad (1)$$

where

N_t is the number of catchable scallops in the population at the start of year t;

R_t is the number of newly catchable scallops (recruits) that enter the population during year t;

m_t^f is the instantaneous rate of fishing mortality during year t;

m_t^n is the instantaneous rate of mortality from natural causes during year t.

$$C_t = (N_t + R_r) \exp\left\{-m_t^f\right\} \qquad (2)$$

where C_t is the number of scallops caught in year t.

422. Since no stock-recruitment relationship for Atlantic sea scallops has been established, R_t is estimated for future years beyond the study period at its average value across years within the study period. Estimates for years during the study period are based on statistical estimates of the DeLury model.

423. For estimation purposes the DeLury model holds that equation (1) is subject to a proportional error. It then assumes that the numbers of mature scallops and new recruits in the population are proportional to their numbers in the abundance survey samples, aside from random measurement errors. A weighted least-squares regression analysis technique is used to estimate the population numbers and other parameters from data on sample abundance and the annual harvest. A full description of the methods used to estimate the Atlantic sea scallop's abundance, physical stock, and fishing mortality are presented in reports of the National Marine Fisheries Service. (Stock Assessment Review Committee 1997; Rago, Lai, and Correa 1997; Richards 1996).

424. Table V.24 presents estimates of the numbers of harvestable scallops and new recruits in the population from 1985 to 1995, along with estimates of the numbers of scallops harvested and lost through natural mortality. The physical accounts include only harvestable scallops because the economic resource consists of the stock that can *legally* be exploited at current prices and technology. Comparable estimates of the population weight are derived by applying survey estimates of mean weight per recruit and mean weight per full recruit to the population estimates.

425. The annual harvest has regularly exceeded the numbers of harvestable scallops in the population at the start of each year, showing that the fishery is highly dependent on the young scallops just reaching harvestable size during the year. This implies that both

the harvest and the scallop population are subject to the random fluctuations of scallop reproduction. It also implies that much of the harvest consists of three-year-old scallops that have not realized the impressive growth in size that occurs in the subsequent two or three years. Stocks were heavily depleted during the years 1992-94 but recovered somewhat during 1995 because of the strong recruitment class in that year and the reduced harvest that resulted from area closures. Over the eleven-year period as a whole, average recruitment roughly balanced the sum of natural and harvesting mortality, indicating an approximate sustainability.

Table V.24 Physical stock account for harvestable Atlantic sea scallops, 1985 to 1995

(Millions of scallops)

	Opening stock	Changes in stock			Closing stock	Net change
		Harvest	New recruits	Natural mortality		
1985	273.7	312.9	569.2	57.3	472.7	199.0
1986	472.7	545.1	599.1	97.9	428.8	-43.9
1987	428.8	623.6	753.0	52.8	505.4	76.6
1988	505.4	630.5	890.9	117.5	648.3	142.9
1989	648.3	733.5	823.2	199.3	538.7	-109.6
1990	538.7	985.9	1061.3	238.0	376.1	-162.6
1991	376.1	669.5	634.8	83.5	257.9	-118.2
1992	257.9	512.7	402.3	17.1	130.4	-127.5
1993	130.4	321.5	579.1	81.9	306.1	175.7
1994	306.1	497.1	483.9	76.1	216.8	-89.3
1995	216.8	394.1	733.7	137.6	418.8	202.0

Source: Based on Rago, Lai, and Correia, 1997.

Choice of valuation methods

426. Following the approach adopted by the BEA, physical stocks have been valued in accordance with two conceptually different measures, the current rent (called *marginal rent* in the original text by Repetto)[13] and the net present (discounted) value (NPV) of the rent (called *marginal user cost* in the original text). The current rent from an additional scallop harvested is its contribution to total revenues less the marginal cost of catching it and bringing it ashore in salable condition. Applying the current rent to value the entire stock is essentially equivalent to estimating the current liquidation price of the asset, analogous to the stumpage value of a commercially grown tree prior to felling. This valuation approach has been widely employed in the construction of natural resource asset accounts by the Bureau of Economic analysis and by other researchers, mainly because of its practical advantages. It can be implemented using only current market transactions data on prices and costs and requires no forecasts of future market conditions.

[13] The terminology of the original paper has been altered to be consistent with terminology used in the SEEA, which was introduced in Chapter II.

427. However, asset markets are intrinsically forward-looking. The value of a durable asset is derived from the stream of economic benefits that it is expected to generate, discounted back to the present period at a rate representing the opportunity cost of capital. The current rent approach to asset valuation can be justified in these terms only by appealing to the Hotelling principle that in competitive market equilibrium the marginal returns to holding a durable asset will be the same over all holding periods. The theory implies that if the current liquidation price is depressed, producers will withhold some of the resource from the market in order to sell it in a future period. Doing so depresses future returns and raises the current liquidation price until the rental income from the current harvest equals the present value of returns from harvesting in future periods. Under these assumptions of well-functioning asset and production markets, the current rent can be used as a proxy for an asset price based on discounted future returns.

428. The Hotelling theory must be qualified for all sorts of reasons and empirical support for it is weak. Its applicability is especially weak in the case of marine fisheries in which the absence of harvesting rights to the wild stock discourages potential investors from conserving the stock for future harvest even if it might be potentially profitable to do so. Should one fisherman forgo some present harvest, he would have no assurance of reaping the reward of higher future catches. Those fatter and more numerous scallops would probably be scooped up in another boat's dredge. Only if the fisheries management agency were able to impose an inter-temporally efficient level of harvesting on the collective fishery would the current rent and the discounted future value of future returns converge, and this achievement has so far been elusive. The absence of adequate conservation incentives suggests that scallops are harvested until their liquidation value has fallen well below their potential value as a resource for future exploitation, as with other marine fisheries. Nonetheless, the current rent value of the stock provides a useful benchmark for comparative purposes.

429. The alternative NPV is an estimate of the discounted value of the future rents that would result if a scallop were *not* captured in the current period but left to grow. Since scallops double and redouble in size between ages three and five, a growth rate exceeding any plausible rate of time discount, their discounted future harvest value tends to exceed their current value for three to four years after recruitment at age three. This imbalance is reinforced by the price premium enjoyed by larger scallops, in terms of dollars per pound, reflecting the preferences of restaurants and consumers. For example, in 1998 annual average prices ranged from $4.63 per pound for three year-old scallops, just large enough to be harvested, to $6.89 per pound for large seven year-old scallops. In truth, the imbalance should be further reinforced by their enormous fecundity, which increases with scallop size. A scallop left in the sea to grow and spawn will contribute mightily to the future stock. However, since no reliable stock-recruitment relationship has been established for the Atlantic sea scallop, because of the wide inter-annual variability in survival rates for scallop spat, this factor cannot be quantified.

430. The NPV measure is based on estimates of the increase in harvestable biomass in future years resulting from a marginal decrease in fishing mortality in the current year due to reduced fishing effort. NMFS staff biologists and economists make such

estimates when they conduct the economic analyses supporting fisheries management plan amendments. The increment in the future harvest and in the surviving biomass are both included in the NPV approach because an increase in unharvested biomass in a future year is valuable due to its growth and reproductive potential. Because the fishery is out of equilibrium and managed inefficiently, it cannot be assumed that the future stock and harvest will be at inter-temporally efficient levels.

431. This calculation makes use of empirical estimates of the relationship between scallop age, size, and weight. It also incorporates estimates of natural mortality rates, which will kill off a certain fraction of survivors each year. More significantly, this measure requires estimates of fishing mortality in future years. The value of a scallop left alive in the current year will depend on how much time in the future it will have to grow and reproduce before being harvested. Though future fishing mortality is uncertain, it is the principal target on which fisheries management restrictions on fishing effort are aimed. Therefore, the best available forecast of fishing mortality in future years is the target schedule set out in the most recently adopted fisheries management plan. The target mortality schedule, however, does not represent a trajectory toward economically optimal stock and harvest levels because the fishery management agency was directed by law to use biological concepts such as maximum sustainable yield and maximum yield per recruit, rather than economic concepts of optimality. Nevertheless, the target set by the fisheries management agency is closer to the economically efficient level of fishing than the current levels of stock and exploitation, which are near to open-access levels. The NPV estimation assumes the more economically efficient targets in calculations of future rent.

432. As before, future harvests and surviving biomass are valued in terms of their estimated current rental values. Monetary calculations have been carried out in constant prices and, accordingly, an inflation-adjusted real interest rate of 3 per cent per year has been used as a discount factor. Three per cent corresponds roughly to the annual yield on inflation-adjusted US treasury bonds, consistent with the discount rate applied by the regulatory agency in developing future harvest plans. The calculations were performed over a time horizon extending out through the year 2010.

(a) The current rent valuation method

433. The calculation of the current rent value of the harvestable scallops in the population at time t is as follows:

$$\boldsymbol{p}_t = \sum_w p_t^w w N_t^w - c_t \sum_w w N_t^w \qquad (3)$$

where:

$\boldsymbol{p}_t$ the current rent value

p_t^w the dockside price per pound of scallops of average weight w at time t;

N_t^w the number of scallops of weight w in the population at time t;

c_t the marginal cost of harvesting a pound of scallops at time t; and

$\sum_{w} wN_t^w$ the total population weight of harvestable scallops at time t.

434. Data on dockside scallop prices at various fishing ports are collected regularly by the National Marine Fisheries Services and used in their economic evaluation of management plan options. Since most scallops are harvested by dredgers and shucked at sea, prices are quoted in dollars per pound of scallop meat. Annual average prices were available for the entire period. Price premia for scallops of various sizes were available only for the single year 1998 but the percentage premia were assumed to have been stable throughout the period 1985-1995.

435. Marginal harvesting costs, in principle, are the incremental costs of capturing and marketing an incremental quantity of scallops – the total variable costs, in other words. Such costs are also collected and estimated by the National Marine Fisheries Service for use in their management plan evaluations. They have been defined in several different ways in NMFS documents. For this study, total variable costs are defined to include vessel operating costs, such as fuel, ice, supplies, and a portion of maintenance expenses, and vessel labor costs. The costs of vessel ownership, such as depreciation, interest, and insurance, are regarded as fixed costs because an increase in harvest within the range estimated in this study would require no increase in fleet capacity. The scallop fishery, like many others, is considerably overcapitalized. To illustrate, full-time scallop dredgers are restricted in the current management plan to 120 days at sea per year and a plan amendment under consideration would reduce that limit to 51 days at sea. It has been estimated that only 72 to 100 vessels operating at an economically viable rate of capacity utilization would be sufficient to bring in the harvest at the targeted levels of fishing mortality but there are more than 200 licensed scallop fishing boats in the industry.

436. Labor costs are considered variable because one limit on harvesting is crew size, since shucking at sea is a very labor-intensive process that has not been feasibly mechanized. Crew size is adjusted by vessel operators but an increase in harvesting does require an increased labor input. Estimation of labor costs in the scallop fishery is complicated by the fact that crews are traditionally rewarded by the "lay" system, which apportions the trip's revenues (net of some costs) to owner, captain, and crew. The specific allocation may vary across ports, boats, and time. However, since crews are drawn from a surprisingly wide geographical area, even as far away as Texas, and can be assumed to have alternative employment opportunities, their labor costs can be translated into an equivalent hourly or daily wage rate. Survey data have been used to express variable costs, so defined, as a percentage of revenues and this relationship is assumed to hold over future as well as current periods.

(b) The NPV method

437. The increase in future harvests and harvestable biomass that would result from a marginal increase in the current scallop population was estimated by comparing a base case in which future fishing mortality is regulated according to the existent fisheries management plan with an alternative case in which fishing mortality is marginally

reduced only in the current period and thereafter conforms to the same planned mortality schedule. The alternative case generates a higher estimated biomass and harvest in future years because of the scallop's potential for growth. Again, the rationale for assuming that future fishing mortality conforms to that scheduled in the existent management plan is that all management and regulatory measures are targeted to achieve that level of mortality. In the absence of an estimated stock-recruitment relationship, recruitment in each future year over a ten-year horizon was assumed to be equal to average annual recruitment in the 1985-1995 estimation period. Mean weight per recruit was assumed to be unchanged in future years from the average during the 1985-1995 period. Moreover, natural mortality was assumed to continue to be equal to that estimated for the 1985-1995 period.

438. The estimation procedure is detailed for the year 1995, the final year for which NPV was estimated generated. Using these assumptions, starting with data for 1995, the DeLury model outlined in equations (1) and (2) was used recursively to estimate biomass and catch in 1996 and future years, using figures for future fishing mortality from the plan schedule. The surviving stock numbers in each year after 1995, net of natural and fishing mortality, were incremented in average age by one year, starting from the 1995 stock.

$$a_t = \left(a_t^N N_t + a^R R_t\right)/\left(N_t + R_t\right) \tag{4}$$

where

a_t the average age of catchable scallops in the population at the start of year t;

a_t^N the average age of the already catchable scallops at the start of year t;

a^R the average age of newly catchable scallops (recruits), assumed constant in each year.

$$a_{t+1}^N = a_t + 1. \tag{5}$$

439. The average age of already catchable scallops at the start of year $t+1$ is equal to one plus the average age of newly recruited and already catchable scallops at the start of the previous year. This assumes that the fishing gear is not selective for scallops of different ages once the minimum recuitment size is reached. It also assumes that all recruitment occurs at the start of the year, since estimates of the numbers of recruits are already adjusted for recruitment that takes place within the year.

440. The change in biomass was estimated by using empirical relationships between age and shell height and between shell height and weight. These equations estimated by NMFS fisheries scientists can be used to establish a relationship between weight and age.

$$Ln(W) = -11.7656 + 3.1693 Ln(H) \tag{6}$$

where W is weight of scallop meat in grams and H is height of scallop shell in millimeters;

$$H = 145\left[1 - \exp\{-0.2783A - 0.755\}\right] \tag{7}$$

where A is the age of the scallop in years.

441. Over the relevant range of scallop shell heights, the resulting relationship is approximately linear, so that average scallop weight can be expressed as a function of average scallop age:

$$w_t = f(a_t) \tag{8}$$

442. The alternative estimate was generated using the same procedure with the single exception that fishing mortality in the initial year, 1995, was reduced by a small amount. Fishing mortality in subsequent years remained equal to that in the base case, which conformed to management plan targets. The differences in catch and surviving stock, both calculated in weight, were calculated for 1996 and future years out to 2010. A small reduction in the current harvest yields higher future harvests and biomass because of the scallop's significant unrealized growth potential when harvested shortly after recruitment, as has been typical in the fishery.

443. The increments in harvest and harvestable biomass were then valued according to the current rent method described above, assuming constant prices and a constant schedule of percentage premia for larger scallops. Then, the present value of the stream of incremental future values was calculated using an inflation-adjusted real interest rate of 3 per cent per year. Finally, this present value was divided by the reduction in the 1995 harvest of scallops due to the assumed marginal reduction in fishing mortality in that year. The NPV of the harvested and surviving biomass over the period $j = 0$ to $j = T$ is given by the equation:

$$V_0 = \sum_{j=0}^{T} \left\{ \frac{(p_j - c_j) w_j C_j + (p_{j+1} - c_{j+1}) w_{j+1} N_{j+1}}{(1+i)^j} \right\} \tag{9}$$

where

V_0 the discounted present rental value of future biomass stocks and harvests;

p_j the average price applicable to the population and catch in year j;

c_j the marginal harvesting costs in year j;

C_j the number of scallops caught in year j;

i the rate of time discount;

w_j the average weight of population and catch in year j; and

N_j the number of harvestable scallops in year j.

444. The augmented value of the NPV of biomass stock and harvest was estimated under the assumption of a small reduction in fishing mortality and catch during the initial year. Fishing mortality in the initial year was assumed lower by an amount $(m_0^f - \Delta m_0^f)$.

$$V^* = (p_0 - c_0)\, w_0 (C_0 - \Delta C_0) + (p_1 - c_1)\, w_1 N_1 + \sum_{j=1}^{T} \left\{ \frac{(p_j - c_j) w_j C_j + (p_{j+1} - c_{j+1}) w_{j+1} N_{j+1}}{(1+i)^j} \right\} \quad (10)$$

$$U = (1 / w_0 \Delta C_0)(V - V^*) \quad (11)$$

445. This rent estimate measures the discounted rental return from leaving an additional pound of scallops alive in the population to grow and augment future harvests and biomass. The NPV measures the marginal value of the scallop population as a "going concern", in contrast to the current liquidation value, represented by the current rent.

446. The NPV was constructed for each year in the period 1985-1995, using projected biomass and harvests out to the future year 2010. The estimating procedure has been described in some detail for the 1995 estimate. Estimates for earlier years 1985-1994 were derived by similar procedures, except that estimates of actual fishing mortality for those years were substituted for those prescribed in management plans.

3. Results of the analysis

447. Physical asset accounts constructed for the Atlantic sea scallop fishery for the period 1985-1995 are presented in Table V.24. They show a physical biomass that grows substantially until 1990 and then declines even more dramatically from that time until 1995. This fluctuation reflects the unusually high recruitment to the fishery during 1989 and 1990, as indicated in Table V.24.

448. Table V.25 shows a comparison between estimates of the monetary value of scallop stocks. In all years, the NPV of the scallop stock was greater than the current rent value. On average, the value of a scallop left in the ocean to grow and reproduce, thereby increasing future harvests and harvestable biomass, was three times greater than its liquidation value, its current rental value brought to the dock.

449. This imbalance is characteristic of an inter-temporally inefficient pattern of resource exploitation. It demonstrates that the potential gains from an additional investment in resource conservation in the scallop fishery throughout this period were great. In an inter-temporally efficient fishery, the current harvest would be curtailed until the returns from further stock conservation would be no greater than the rent from a marginal increase in the current year's catch. In the scallop fishery between 1985 and 1995, each dollar in net operating income sacrificed in the name of conservation would have brought a return in future harvests of three dollars, measured at its discounted present value.

Table V.25 Alternative estimates of the monetary value of scallop stock 1985 to 1995

	Fishable biomass	Rent per unit in a given year ($ per pound)		Estimate of value of the stock (millions of $)	
	(million pounds)	Current rent method	NPV method	Current rent method	NPV method
1985	20.29	1.40	4.48	28.41	90.90
1986	25.37	1.49	4.43	37.80	112.39
1987	30.70	1.08	4.22	33.16	129.55
1988	30.90	1.08	3.59	33.37	110.93
1989	35.07	0.95	3.09	33.32	108.37
1990	35.01	0.90	3.06	31.51	107.13
1991	25.35	0.98	2.95	24.84	74.78
1992	16.49	1.45	3.64	23.91	60.02
1993	18.85	2.20	3.36	41.47	63.34
1994	17.35	1.49	4.51	25.85	78.25
1995	22.62	1.59	5.49	35.96	124.18

450. It might be surmised that this difference can be explained by the use of the risk-free discount rate for estimation purposes, a rate lower than the risk-adjusted cost of capital facing fishermen in private markets, which would lead them to value future harvests less than calculated above. The use of a higher discount rate in the analysis would reduce the NPV estimate relative to the current rent estimate. However, the principal explanation is the much higher – nearly infinite – implicit discount rate facing individual fishermen as the result of insecure harvesting rights. Investments in stock conservation are highly discounted because no individual fisherman is assured of reaping benefits from his decision to forego an immediate harvest. This explanation is confirmed by the fact that Canadian scallop fishermen, who also face private market costs of capital but enjoy secure harvesting rights, harvest almost no immature three-year-old scallops and maintain a much lower overall exploitation rate on their scallop resource (Repetto 2001). The discrepancy between the current rental value and the NPV of the scallop resource is mainly the consequence of the management agency's past inability to create an inter-temporally efficient harvesting regime. This failure results from an emphasis on fishery management solely through controls on effort without addressing the underlying market failure brought about by insecure harvesting rights.

451. Both valuation measures move roughly in parallel to each other over the period and vary inversely to variations in the physical stock. Movements in the current rent value are governed primarily by changes in scallop prices, which vary inversely to the catch. Changes in the NPV of scallops, however, are more significantly affected by movement in fisheries mortality, since the return obtained from conserving the current rapidly growing stock depends on the rate at which it will be depleted by harvests in the ensuing years. The rise in the NPV measure in the final years of the period is influenced by the predicated decline in fisheries mortality during the period 1996-2005. Similarly, the decline in the NPV during the middle years of the 1985-1995 period is largely attributable to the heavy fishing mortality experienced during the early years of the

1990s. Thus, the NPV is inherently a forward-looking measure that capitalizes the fruits of future conservation investments and can be used to evaluate conservation policies. The higher the discount rate used in the calculation, of course, the less weight is given to stock increases in more distant future years.

452. Valued in 1995 by the NPV measure, the scallop fishery resource was an asset worth approximately 125 million dollars – not an insignificant amount. However, this represents a biomass stock at most 20 per cent as large as that stock which would produce the fisheries' maximum sustainable yield, according to the Fisheries Management Council's estimates. In other words, in rough terms the potential capital gain that would result by rebuilding the scallop stock to its most productive level is probably of the order of a half-billion dollars, exclusive of any additional increases in current rent values that would result from rationalization of fishing effort. Increases in current rent values would be expected as well because larger and more abundant scallops could be harvested with far more catch per unit effort than currently achieved in the fishery.

453. Some empirical indication of this potential gain is available from the experience in the closed areas of George's Bank, in which, according to sample survey data, scallop populations have evidently rebounded markedly in abundance and average size since fishing pressure was reduced. Partial opening of some of these closed areas to scallop boats has allowed an increased harvest with lower overall fishing mortality.

454. To summarize, this case study demonstrates that it is feasible to construct resource asset accounts for marine fisheries in accordance with accepted economic methodologies, relying mainly on data already available from National Marine Fisheries Service research and management studies. Such accounts shed light on important management and regulatory issues. Measures to rebuild stocks through effort reductions have been controversial and have encountered resistance from fishing interests reluctant to undergo short-term sacrifices. These accounts quantify rates of return on such investments.

455. Although there is no census of the fishes, fisheries scientists are able to estimate population sizes of important commercial stocks with reasonable accuracy, and do so for crucial management decisions. The results presented in Repetto (2001) encourage the Fisheries Service and statistical offices to consider extending such resource accounts to other fisheries as well and to adopt resource accounting for marine fisheries as a regular part of any future Integrated Economic and Environmental Accounting work program.

ANNEX I: SEEA ASSET CLASSIFICATION[14]

Asset Category	Within SNA Boundary	Outside SNA Boundary
EA.1 Natural Resources		
EA.11 Mineral and energy resources	(AN.212) [1]	[2]
EA.111 Fossil fuels (cubic metres, tonnes, tonnes of oil equivalent, joules)	(AN.2121)	
EA.112 Metallic minerals (tonnes)	(AN.2122)	
EA.113 Non-metallic minerals (tonnes)	(AN.2123)	
EA.12 Soil resources (cubic metres, tonnes)	not applicable [3]	
EA.121 Agricultural		
EA.122 Non-agricultural		
EA.13 Water resources (cubic metres)		
EA.131 Surface water	not applicable [4]	[16]
EA.1311 Artificial reservoirs		
EA.1312 Lakes		
EA. 1313 Rivers and streams		
EA.132 Groundwater	(AN.214)	
EA.14 Biological resources		
EA.141 Timber resources (cubic metres)		
EA.1411 Cultivated	(Part of AN.1221)	Not applicable
EA.1412 Non-cultivated	(Part of AN.213) [5]	[6]
EA.142 Crop and plant resources, other than timber (cubic metres, tonnes, number)		
EA.1421 Cultivated		Not applicable
EA.14211 Yielding repeat products (vineyards, orchards, etc.)	(AN.11142)	
EA.14212 Yielding one-time harvests (crops, etc.)	(Part of AN.1221)	
EA.1422 Non-cultivated	(Part of AN.213) [7]	[8]
EA.143 Aquatic resources (tonnes, number)		
EA.1431 Cultivated		Not applicable
EA.1432 Non-cultivated	(Part of AN.213) [9]	[10], [17]
EA.144 Animal resources, other than aquatic (number)		

[14] From SEEA -2003 (UN *et al*. 2003)

EA.1441 Cultivated		Not applicable
EA.14411 Livestock for breeding purposes	(Part of AN.11141)	
EA.14412 Livestock for slaughter	(Part of AN.1221)	
EA.1442 Non-cultivated	(Part of AN.213) [11]	[12]
EA.2 Land and surface water (hectares)	**(AN.211)**	**Not applicable [13]**
Of which, recreational land	(AN.2113)	
EA.21 Land underlying buildings and structures	***(AN.2111)***	
EA.211 In urban areas		
EA.2111 For dwellings		
EA.2112 For non-residential buildings		
EA.2113 For transportation and utilities		
EA.212 Outside urban areas		
EA.2121 For dwellings		
EA.21211 Farm		
EA.21212 Non-farm		
EA.2122 For non-residential buildings		
EA.21221 Farm		
EA.21222 Non-farm		
EA.2123 For transportation and utilities		
EA.21231 Roads		
EA.21232 Railways		
EA.21233 Electric power grids		
EA.21234 Pipelines		
EA.22 Agricultural land and associated surface water	***(AN.2112)***	
EA.221 Cultivated land		
EA.2211 For temporary crops		
Of which, drained		
Of which, irrigated		
EA.2212 For permanent plantations		
Of which, drained		
Of which, irrigated		
EA.2213 For kitchen gardens		
EA.2214 Temporarily fallow land		
EA.222 Pasture land		
EA.2221 Improved		

EA.2222 Natural		
EA.223 Other agricultural land		
EA.23 Wooded land and associated surface water	***(Part of AN.2112, AN.2113 and AN.2119)***	
EA.231 Forested land		
EA.2311 Available for wood supply		
EA.2312 Not available for wood supply		
EA.232 Other wooded land		
EA.24 Major water bodies	***(Part of AN.2119)***	
EA.241 Lakes		
EA.242 Rivers		
EA.243 Wetlands		
EA.244 Artificial reservoirs		
EA.25 Other land	***(Part of AN.2119)***	
EA.251 Prairie and grassland		
EA.252 Tundra		
EA.253 Sparsely vegetated/Barren land		
EA.254 Permanent snow and ice		
EA.3 Ecosystems [14, 15]	**not applicable**	
EA.31 Terrestrial ecosystems		
EA.311 Urban ecosystems		
EA.312 Agricultural ecosystems		
EA.313 Forest ecosystems		
EA.314 Prairie and grassland ecosystems		
EA.315 Tundra ecosystems		
EA.316 Dryland ecosystems		
EA.317 Other terrestrial ecosystems		
EA.32 Aquatic ecosystems		
EA.321 Marine ecosystems		
EA.322 Coastal ecosystems		
EA.323 Riverine ecosystems		
EA.324 Lacustrine ecosystems		
EA.325 Other aquatic ecosystems		

EA.33 Atmospheric systems		
EA.M Memorandum item – Intangible environmental assets		
EA.M1 Mineral exploration	(AN.1121)	not applicable
EA.M2 Transferable licences and concessions for the exploitation of natural resources	(Part of AN.222)	
EA.M3 Tradable permits allowing the emission of residuals	(Part of AN.222)	
EA.M4 Other intangible non-produced environmental assets	(Part of AN.222)	

Light shading indicates that monetary valuation is normally possible; dark shading that while physical valuation is possible, it may be doubtful that monetary valuation is possible.

Notes:

1. The mineral and energy resource assets that fall within the SNA boundary are those that are defined as proven reserves. In practice, though, some countries may include a wider class of resources even within the SNA accounts.
2. The mineral and energy resource assets that fall outside the SNA boundary are those that are defined as probable, possible and speculative reserves.
3. The value of soil resources cannot be separated from the value of the land of which they form an integral part. Therefore, only the physical extent of soil resources is measured in the SEEA.
4. The value of surface water as a natural resource cannot be separated from its value as an integral component of the national territory. Therefore, only the physical extent of surface water resources (measured in volumetric terms) is included in the natural resource category of the asset classification.
5. The non-cultivated timber resources that fall within the SNA boundary are those that are capable of producing a merchantable stand within a reasonable period of time, are accessible for logging purposes and are not protected from logging.
6. The non-cultivated timber resources that fall outside the SNA boundary are those that are not suitable for timber harvesting, either because of low productivity, inaccessibility and/or protection from logging.
7. The non-cultivated crop and plant resources that fall within the SNA boundary are those that provide harvestable materials that may be traded in the market or used for subsistence purposes, that are accessible and that are not protected from harvesting.
8. The non-cultivated crop and plant resources that fall outside the SNA boundary are those that potentially provide harvestable materials, but that are not suitable for harvesting because of inaccessibility or protection from harvesting.
9. The non-cultivated aquatic resources that fall within the SNA boundary are those that are the target of commercial or subsistence fishers, are found within the exclusive economic zone of the nation, are close enough to existing markets to be profitably exploitable and are not protected from harvesting.
10. The non-cultivated aquatic resources that fall outside the SNA boundary are those that are potentially harvestable, but that are not currently the target of fishers because they are not of commercial or subsistence interest, are located in remote fishing zones or are protected from harvesting.

11. The non-cultivated animal resources that fall within the SNA boundary are those that are the target of commercial, subsistence or sport hunters, are accessible for hunting and are not protected from harvest.
12. The non-cultivated animal resources that fall outside the SNA boundary are those that are potentially harvestable, but that are not currently the target of hunters because they are not of commercial, subsistence or sport interest, are located in remote areas or are protected from harvesting.
13. In principle, the entire national territory is included within the SNA asset boundary. For small densely populated countries, this should almost certainly be so. For large, sparsely populated countries, especially those with large areas which are remote and climatically hostile to mankind, there may be areas of land which are not thought to have any economic value. These would be included in this SEEA heading together with any recreational land not covered elsewhere.
14. In principle, ecosystems can be measured in both monetary and physical terms. In practice, valuing these systems may be extremely difficult and physical measures may be all that is possible.
15. Depending on the aspect of the ecosystem being measured, many different units of measure may be appropriate for describing environmental systems in physical terms. For example, biodiversity might be measure in terms of number of species or in terms of the area of suitable habitat. Waste assimilation capacity might be described in terms of the concentration of some key pollutant in the system. Other aspects will call for other units of measure.
16. With the increasing establishment of property rights over water, valuation may in some cases be possible.
17. Fish which are located outside a country's EEZ but over which internationally agreed quotas exist, may also be included.

ANNEX II: THE CLASSIFICATION OF ENVIRONMENTAL PROTECTION ACTIVITIES AND EXPENDITURE (CEPA 2000)[15]

with explanatory notes

A. Introductory notes

CEPA 2000 is a generic, multi-purpose, functional classification for environmental protection. It is used for classifying activities but also products, actual outlays (expenditure) and other transactions. The classification unit is often determined by the units of the primary data sources that are being classified and by the presentation formats used for results. For example, the analysis of government budgets and accounts requires the coding of items of government environmental protection expenditure into CEPA. Some of these expenditure items will be transfers such as subsidies or investment grants whereas others will be inputs into an environmental protection activity (for example, wages and salaries). The compilation of environmental expenditure accounts requires determining environmental protection activities and their output of environmental protection services by categories of CEPA.

Environmental protection activities are production activities in the sense of national accounts (see, for example, 1993 SNA paragraph 6.15 or ESA para 2.103); that is, they combine resources such as equipment, labour, manufacturing techniques, information networks or products to create an output of goods or services. An activity may be a principal, secondary or ancillary activity.
CEPA is designed to classify transactions and activities whose primary purpose is environmental protection. The management of natural resources (for example, water supply) and the prevention of natural hazards (landslides, floods, etc.) are not included in CEPA. Resource management and prevention of natural hazards are covered in broader frameworks (for example, SERIEE (Eurostat 1994) or the OECD/Eurostat (1999) environment industry manual). Separate classifications (for resource management for example) should be set up which, together with the CEPA, would be part of a family of environment-related classifications.

Environmental protection products are:

The environmental protection services produced by environmental protection activities; and

Adapted (cleaner) and connected products.

The expenditures recorded are the purchasers' prices of environmental protection services and connected products and the extra costs over and above a viable but less-clean alternative for cleaner products.

[15] From SEEA-2003 (UN *et al.* 2003)

Expenditure for environmental protection includes outlays and other transactions related to:

Inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to production, consumption of fixed capital);

Capital formation and the purchase of land (investment) for environmental protection activities;

Outlays of users for the purchase of environmental protection products;

Transfers for environmental protection (subsidies, investment grants, international aid, donations, taxes earmarked for environmental protection, etc.).

For the presentation of aggregate results and indicators of expenditure, care is needed when adding up expenditure of different types. Available frameworks such as the SERIEE or the OECD/Eurostat PAC framework offer ways to avoid double counting of items of expenditure. In particular, they offer guidance on how to avoid mixing transfer payments with the expenditure that are financed by the transfers and purchases of environmental products with the expenditure for their production.

B. Classification structure

The level 1 structure of CEPA (1-digit) shows the *CEPA classes*. CEPA classes 1 to 7 are also called *(environmental) domains*. The main function of most 2-digit and 3-digit headings in CEPA is to guide classification into the classes. Selected 2-digit and 3-digit headings may also be used for data collection and coding as well as for publication purposes. In statistical practice, countries will have to adapt the CEPA structure to some extent to reflect national policy priorities, data availability and other circumstances. Examples include separate 1-digit headings for traffic, international aid, energy-savings programmes, general administration of the environment or soil erosion. For international comparison purposes, the level 1 structure of CEPA should be fully adhered to.

1. General classification principles

Classification should be made according to the main purpose taking into account the technical nature as well as the policy purpose of an action or activity. Multi-purpose actions, activities and expenditure that address several CEPA classes should be divided by these classes. Classification under the heading "indivisible expenditure and activities" should only be made as a last resort.
Classification of individual items cannot be based solely on the technical nature of the items. For example, the purchase of double-glazed windows in warm countries will typically relate to issues of noise protection, whereas in colder countries they will be a standard energy saving device. Measures to reduce fertiliser use may primarily fall under CEPA 4 (protection of groundwater), CEPA 2 (prevention of runoff to protect surface waters) or CEPA 6 (prevention of nutrient enrichment to protect biotopes) depending on the main purpose of measures and policies. Measures against forest fires will be unimportant or purely serve economic purposes (and thus fall outside of CEPA) in some countries, whereas in others the main aspect of forest

fires will be an environmental one related to landscape and habitat preservation rather than protection of a natural resource.

2. Classification of transversal and indivisible activities and expenditure

Transversal activities are R&D, administration and management as well as education, training and information. All R&D should be allocated to CEPA 8. Administration and management as well as education, training and information should, to the extent possible, be allocated to the "Other" positions in CEPA 1-7. Ideally, transversal activities would be identified separately, as well as by CEPA class but primary data sources related to CEPA 1-7 often do not allow this. R&D, education and training or administration and management are often either not separable from other actions relating to another class (administration or training as part of waste management, for example) or cannot be split by class (R&D data collected by industry expenditure surveys, for example). If such identification problems are considered substantial, data on R&D, administration and management and on education, training and information should not be published at the 2-digit level.

The classification of R&D in CEPA 8 follows the NABS 1993 (the Eurostat Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets). CEPA 8 should be used when primary data following the NABS are available from R&D statistics. When this is not the case, other data sources employed (for example, budget analysis) may not allow a systematic separation of R&D from other actions and activities. R&D may then be included under several CEPA classes.

The above considerations will apply differently across countries, depending on the availability and level of detail of primary data sources. Often, differences in the main data sources will result in different practices for coding transversal activities and expenditure, and international comparability for these may be limited.

C. Classification of environmental protection activities and expenditure (CEPA 2000)

1. Protection of ambient air and climate

- 1.1 Prevention of pollution through in-process modifications
  - 1.1.1 for the protection of ambient air
  - 1.1.2 for the protection of climate and ozone layer
- 1.2 Treatment of exhaust gases and ventilation air
  - 1.2.1 for the protection of ambient air
  - 1.2.2 for the protection of climate and ozone layer
- 1.3 Measurement, control, laboratories and the like
- 1.4 Other activities

2. Wastewater management

- 2.1 Prevention of pollution through in-process modifications
- 2.2 Sewerage networks
- 2.3 Wastewater treatment
- 2.4 Treatment of cooling water
- 2.5 Measurement, control, laboratories and the like
- 2.6 Other activities

3. Waste management

- 3.1 Prevention of pollution through in-process modifications
- 3.2 Collection and transport
- 3.3 Treatment and disposal of hazardous waste
  - 3.3.1 Thermal treatment
  - 3.3.2 Landfill
  - 3.3.3 Other treatment and disposal
- 3.4 Treatment and disposal of non-hazardous waste
  - 3.4.1 Incineration
  - 3.4.2 Landfill
  - 3.4.3 Other treatment and disposal
- 3.5 Measurement, control, laboratories and the like
- 3.6 Other activities

4. Protection and remediation of soil, groundwater and surface water

- 4.1 Prevention of pollutant infiltration
- 4.2 Cleaning up of soil and water bodies
- 4.3 Protection of soil from erosion and other physical degradation
- 4.4 Prevention and remediation of soil salinity
- 4.5 Measurement, control, laboratories and the like
- 4.6 Other activities

5. Noise and vibration abatement (excluding workplace protection)

- 5.1 Preventive in-process modifications at the source
  - 5.1.1 Road and rail traffic
  - 5.1.2 Air traffic
  - 5.1.3 Industrial and other noise
- 5.2 Construction of anti noise/vibration facilities
  - 5.2.1 Road and rail traffic
  - 5.2.2 Air traffic
  - 5.2.3 Industrial and other noise
- 5.3 Measurement, control, laboratories and the like
- 5.4 Other activities

6. Protection of biodiversity and landscapes

- 6.1 Protection and rehabilitation of species and habitats
- 6.2 Protection of natural and semi-natural landscapes
- 6.3 Measurement, control, laboratories and the like
- 6.4 Other activities

7. Protection against radiation (excluding external safety)

- 7.1 Protection of ambient media
- 7.2 Transport and treatment of high level radioactive waste
- 7.3 Measurement, control, laboratories and the like
- 7.4 Other activities

8. Research and development

- 8.1 Protection of ambient air and climate
  - 8.1.1 Protection of ambient air
  - 8.1.2 Protection of atmosphere and climate
- 8.2 Protection of water
- 8.3 Waste
- 8.4 Protection of soil and groundwater
- 8.5 Abatement of noise and vibration
- 8.6 Protection of species and habitats
- 8.7 Protection against radiation
- 8.8 Other research on the environment

9. Other environmental protection activities

- 9.1 General environmental administration and management
  - 9.1.1 General administration, regulation and the like
  - 9.1.2 Environmental management
- 9.2 Education, training and information
- 9.3 Activities leading to indivisible expenditure
- 9.4 Activities not elsewhere classified

D Explanatory notes and definitions

1 Protection of ambient air and climate

Protection of ambient air and climate comprises measures and activities aimed at the reduction of emissions into the ambient air or ambient concentrations of air pollutants as well as to measures and activities aimed at the control of emissions of greenhouse gases and gases that adversely affect the stratospheric ozone layer.

Excluded are measures undertaken for cost saving reasons (e.g. energy saving).

1.1 Prevention of pollution through in-process modifications

Activities and measures aimed at the elimination or reduction of the generation of air pollutants through in-process modifications related to:

- cleaner and more efficient production processes and other technologies (cleaner technologies),

- the consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to reduce the generation of air pollutants during production, storage or transportation (e.g., fuel combustion improvement, recovery of solvents, prevention of spills and leaks through improving air-tightness of equipment, reservoirs and vehicles, etc.

Use of cleaner products

Prevention activities consist of modifying facilities so as to provide for the substitution of raw materials, energy, catalysts and other inputs by non- (or less) polluting products, or of treating raw materials prior to their use in order to make them less polluting (e.g., desulphuration of fuel. Expenditure under this position also includes the extra-cost of the use of cleaner products (low sulphur fuels, unleaded gasoline, clean vehicles, etc.).

1.2 Treatment of exhaust gases and ventilation air

Activities involving the installation, maintenance and operation of end-of-pipe equipment for the removal and reduction of emissions of particulate matter or other air-polluting substances either from the combustion of fuels or from processes: filters, dedusting equipment, catalytic converters, post-combustion and other techniques. Also included are activities aimed at increasing the dispersion of gases so as to reduce concentrations of air pollutants.
Exhaust gases are emissions into the air, usually through exhaust pipes, stacks or chimneys, due to the combustion of fossil fuels. Ventilation air is exhausts of air conditioning systems of industrial establishments.

1.3 Measurement, control, laboratories and the like

Activities aimed at monitoring the concentrations of pollutants in exhaust gases, the quality of air, etc. Included are measurement services of exhaust gases from vehicles and heating systems and the monitoring related to ozone layer, greenhouse gases and climate change. Weather stations are excluded.

1.4 Other activities

All other activities and measures aimed at the protection of ambient air and climate. Includes regulation, administration, management, training, information and education activities specific to CEPA 1, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

2 Wastewater management

Wastewater management comprises activities and measures aimed at the prevention of pollution of surface water through the reduction of the release of wastewater into inland surface water and seawater. It includes the collection and treatment of wastewater including monitoring and regulation activities. Septic tanks are also included.

Excluded are actions and activities aimed at the protection of groundwater from pollutant infiltration and the cleaning up of water bodies after pollution (see CEPA 4).

Wastewater is defined as water that is of no further immediate value for the purpose for which it was used or in the pursuit of which it was produced because of quality, quantity, or time of its occurrence.

2.1 Prevention of pollution through in-process modifications

Activities and measures aimed at reducing the generation of surface water pollutants and wastewater through in-process modifications related to:

- cleaner and more efficient production processes and other technologies (cleaner technologies),

- the consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to bring about a reduction of water pollutants or wastewater generated during production. It includes separation of networks, treatment and re-use of water used in the production process, etc.

Use of cleaner products

Prevention activities consist of modifying an existing production process so as to provide for the substitution of raw materials, catalysts and other inputs by non- (or less) water polluting products.

2.2 Sewerage networks

Activities aimed at the operation of sewerage networks; that is, the collection and transport of wastewater from one or several users, as well as rainwater, by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles, etc.), including maintenance and repair.

Sewerage networks are the systems of collectors, pipelines, conduits and pumps to evacuate any wastewater (rainwater, domestic and other wastewater) from the points of generation to either a sewage treatment plant or to a point where wastewater is discharged into surface water.

2.3 Wastewater treatment

Wastewater treatment designates any process to render wastewater fit to meet applicable environmental standards or other quality norms. Three broad types of treatment (mechanical, biological, and advanced treatment) are specified below. Alternative definitions of types of treatment may be used; for example, based on removal rates for BOD.

Mechanical treatment of wastewater designates processes of a physical and mechanical nature which result in decanted effluent and separate sludge. Mechanical processes are also used in combination and/or in conjunction with biological and advanced unit operations. Mechanical treatment is understood to include at least such processes as sedimentation, flotation, etc. The activity is aimed at separating materials in suspension by the use of screens (large solids) or through sedimentation eventually assisted by chemicals or flotation (elimination of sand, oil, part of the sludge, etc.).

Equipment includes screens for large solids, biological plants, equipment for filtration, flocculation, sedimentation; separation of oils and hydrocarbons; separation using inertia or gravity, including hydraulic and centrifugal cyclones, diaphragm floats, etc.

Biological treatment of wastewater designates processes which employ aerobic or anaerobic micro-organisms and result in decanted effluent and separate sludge containing microbial mass together with pollutants. Biological treatment processes are also used in combination and/or in conjunction with mechanical and advanced unit operations. This activity is designed to eliminate pollution from oxidisable materials through the use of bacteria: activated sludge technique or anaerobic treatment for specific concentrated wastewater. Biodegradable materials are treated with the addition of bacteria-enriched sludge in open or closed tanks.

Treatment of wastewater by advanced technologies designates processes capable of reducing specific constituents in wastewater not normally achieved by other treatment options. Covers all unit operations which are not considered to be mechanical or biological. Includes, for example, chemical coagulation, flocculation and precipitation; break-point chlorinating; stripping; mixed media filtration; micro-screening; selective ion exchange; activated carbon absorption; reverse osmosis; ultra-filtration; elector flotation. Advanced treatment processes may be used in combination and/or in conjunction with mechanical and biological unit operations. This activity is aimed at eliminating oxidisable non-biodegradable matter at a higher level, as well as metals, nitrate, phosphorous, etc. by using powerful biological or physical and chemical action. Special equipment is required for each depollution.

Septic tanks are settling tanks through which wastewater is flowing and the suspended matter is decanted as sludge. Organic matters (in the water and in the sludge) are partly decomposed by anaerobic bacteria and other micro-organisms. Maintenance services of septic tanks (emptying etc.) And other products for septic tanks (biological activators, etc.) are included.

2.4 Treatment of cooling water

Treatment of cooling water designates "processes which are used to treat cooling water to meet applicable environmental standards before releasing it into the environment. Cooling water is used to remove heat." Means, methods, facilities used may be: air cooling (extra cost compared with water cooling), cooling towers (to the extent they are required to reduce pollution, as distinct from technical needs), cooling circuits for processing water from work sites and for condensing released vapour, equipment for enhancing the dispersion of cooling water on release, closed cooling circuits (extra cost), circuits for use of cooling water for heating purposes (extra cost).

2.5 Measurement, control, laboratories and the like

Activities aimed at monitoring and controlling the concentration of pollutants in wastewater and the quality of inland surface water and marine water at the place wastewater is discharged (analysis and measurement of pollutants, etc.).

2.6 Other activities

All other activities and measures aimed at wastewater management. Includes regulation, administration, management, training, information and education activities specific to CEPA 2, when they can be separated from other activities related to the same class and similar activities related to other environmental protection classes

3 Waste management

Waste management refers to activities and measures aimed at the prevention of the generation of waste and the reduction of its harmful effect on the environment. Includes the collection and treatment of waste, including monitoring and regulation activities. It also includes recycling and composting, the collection and treatment of low level radioactive waste, street cleaning and the collection of public litter.

Waste are materials that are not prime products (that is, products made for the market) for which the generator has no further use for own purposes of production, transformation, or consumption, and which he wants to dispose of. Wastes may be generated during the extraction of raw materials, during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity. Residuals recycled or reused at the place of generation are excluded. Also excluded are waste materials that are directly discharged into ambient water or air.

Hazardous waste is waste that due to its toxic, infectious, radioactive, flammable or other character defined by the legislator poses a substantial actual or potential hazard to human health or living organisms. For the purposes of this definition, "hazardous waste" comprises for each country all those materials and products which are considered to be hazardous in accordance with that country's practices. Low level radioactive waste is included, whereas other radioactive waste is excluded (see CEPA 7).

Low level radioactive waste is waste that, because of its low radionuclide content, does not require shielding during normal handling and transportation.

Treatment and disposal of waste

<u>Treatment</u> of waste refers to any process designed to change the physical, chemical, or biological character or composition of any waste to neutralise it, render it non-hazardous, safer for transport, amenable for recovery or storage, or to reduce it in volume. A particular waste may undergo more than one treatment process.

Composting and recycling activities for the purpose of environmental protection are included. Often composting is a waste treatment method and the resulting compost provided free of charge or at a very low price. The manufacture of compost classified in division 24 of ISIC/NACE (in particular class 2412 - Manufacture of fertilisers and nitrogen compounds) is excluded.

Division 37 of ISIC Rev 3.1 defines ***recycling*** as "the processing of waste, scraps and other articles, whether used or not used, into secondary raw material. A transformation process is required, either mechanical or chemical. It is typical that, in terms of commodities, input consists of waste and scrap, the input being sorted or unsorted but normally unfit for further direct use in an industrial process, whereas the output is made fit for direct use in an industrial manufacturing process. The resulting secondary raw material is to be considered an intermediate good, with a value, but is not a final new product.

Compost and secondary raw materials (as well as products made of secondary raw materials) are not considered environmental protection products. Their use is excluded.

Disposal of waste is the final deposition of waste on or underground in controlled or uncontrolled fashion, in accordance with the sanitary, environmental or security requirements.

3.1 Prevention of pollution through in-process modifications

Activities and measures aimed at eliminating or reducing the generation of solid waste through in-process modifications related to:

> Cleaner and more efficient production processes and other technologies (cleaner technologies),
>
> The consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to reduce the toxicity or volume of waste produced during the production process, including by separation and re-processing.

Use of cleaner products

Protection activities consist of modifying or adapting the production process or facilities so as to provide for the substitution of raw materials, catalysts and other intermediate inputs by new, "adapted" inputs the use of which produces less waste or less hazardous waste.

3.2 Collection and transport

Collection and transport of waste is defined as the collection of waste, either by municipal services or similar institutions or by public or private corporations, and their transport to the place of treatment or disposal. It includes the separate collection and transport of waste fractions so as to facilitate recycling and the collection and transport of hazardous waste. Street cleaning is included for the part referring to public litter and collection of garbage from the streets. Excluded are winter services.

3.3 Treatment and disposal of hazardous waste

Treatment of hazardous waste comprises the processes of physical/chemical treatment, thermal treatment, biological treatment, conditioning of wastes, and any other relevant treatment method. Disposal of hazardous waste comprises landfill, containment, underground disposal, dumping at sea, and any other relevant disposal method.

Thermal treatment of hazardous waste refers to any process for the high-temperature oxidation of gaseous, liquid, or solid hazardous wastes, converting them into gases and incombustible solid residues. The flue gases are released into the atmosphere (with or without recovery of heat and with or without cleaning) and any slag or ash produced is deposited in the landfill. The main technologies used in the incineration of hazardous waste are the rotary kiln, liquid injection, incinerator grates, multiple chamber incinerators, and

fluidised bed incinerators. Residues from hazardous waste incineration may themselves be regarded as hazardous waste. The resulting thermal energy may or may not be used for the production of steam, hot water, or electric energy.
Landfill is an activity concerning final disposal of hazardous waste in or on land in a controlled way, which meets specific geological and technical criteria.

Other treatment and disposal of hazardous waste may consist of chemical and physical treatment, containment and underground disposal.

Chemical treatment methods are used both to effect the complete breakdown of hazardous waste into non-toxic gases and, more usually, to modify the chemical properties of the waste; for example, to reduce water solubility or to neutralise acidity or alkalinity.

Physical treatment of hazardous waste: includes various methods of phase separation and solidification whereby the hazardous waste is fixed in an inert, impervious matrix. Phase separation encompasses the widely used techniques of lagooning, sludge drying in beds, and prolonged storage in tanks, air flotation and various filtration and centrifugation techniques, adsorption/desorption, vacuum, extractive and azeotropic distillation. Solidification or fixation processes, which convert the waste into an insoluble, rock-hard material, are generally used as pre-treatment prior to landfill disposal. These techniques employ blending the waste with various reactants or organic polymerisation reactions or the mixing of the waste with organic binders.

Containment is the retention of hazardous material in such a way that it is effectively prevented from dispersing into the environment, or is released only at an acceptable level. Containment may occur in specially built containment spaces. Underground disposal includes temporary storage or final disposal of hazardous wastes underground that meet specific geological and technical criteria.

3.4 Treatment and disposal of non-hazardous waste

Treatment of non-hazardous waste comprises the processes of physical/chemical treatment, incineration of waste, biological treatment, and any other treatment method (composting, recycling, etc.).

Incineration is the thermal treatment of waste during which chemically fixed energy of combusted matters is transformed into thermal energy. Combustible compounds are transformed into combustion gases leaving the system as flue gases. Incombustible inorganic matters remain in the form of slag and fly ash.

Disposal of non-hazardous waste comprises landfill, dumping at sea, and any other disposal method.

3.5 Measurement, control, laboratories and the like

Activities and measures aimed at controlling and measuring the generation and storage of waste, their toxicity, etc.

3.6 Other activities

All other activities and measures aimed at waste management. It includes administration, management, training, information and education activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

4 Protection and Remediation of soil, groundwater and surface water

Protection and remediation of soil, groundwater and surface water refers to measures and activities aimed at the prevention of pollutant infiltration, cleaning up of soils and water bodies and the protection of soil from erosion and other physical degradation as well as from salinisation. Monitoring, control of soil and groundwater pollution is included.
Excluded are wastewater management activities (see CEPA 2), as well as activities aimed at the protection of biodiversity and landscape (see CEPA 6).

4.1 Prevention of pollutant infiltration

Activities and measures aimed at the reduction or elimination of polluting substances that may be applied to soil, percolate into groundwater or run-off to surface water. Included are activities related to sealing of soils of industrial plants, installation of catchment for pollutant run-offs and leaks, strengthening of storage facilities and transportation of pollutant products.

4.2 Cleaning up of soil and water bodies

Processes to reduce the quantity of polluting materials in soil and water bodies either *in situ* or in appropriate installations. It includes soil decontamination at former industrial sites, landfills and other black spots, dredging of pollutants from water bodies (rivers, lakes, estuaries, etc.), The decontamination and cleaning up of surface water following accidental pollution (e.g., through collection of pollutants or through application of chemicals, as well as the cleaning up of oil spills on land, inland surface waters and seas – including coastal areas. Excludes the liming of lakes and artificial oxygenation of water bodies (see CEPA 6). Excludes civil protection services.

Activities may consist of: measures for separating, containing and recovering deposits, extraction of buried casks and containers, decanting and re-storage, installation of off-gas and liquid effluent drainage networks, soil washing by means of degasification, pumping of pollutants, removal and treatment of polluted soil, biotechnological methods capable of intervening without affecting the site (use of enzymes, bacteria, etc.), Physical chemistry techniques such as pervaporation and extraction using supercritical fluids, injection of neutral gases or bases to stifle internal fermentation, etc.

4.3 Protection of soil from erosion and other physical degradation

Activities and measures aimed at the protection of soil from erosion and other physical degradation (compacting, encrusting, etc.). They may consist of programs intended to restore the protective vegetal cover of soils, construction of anti-erosion walls, etc. Measures may also consist in subsidising agricultural and grazing practices less harmful for soils and water bodies.

Excluded are activities carried out for economic reasons (e.g. agricultural production or protection of settlements against natural hazards such as landslides).

4.4 Prevention and remediation of soil salinity

Activities and measures aimed at the prevention and remediation of soil salinity. Concrete actions will depend on climatic, geological and other country-specific factors. Included are actions to increase groundwater tables; for example, through increased freshwater infiltration to avoid infiltration of seawater into groundwater bodies, lowering of groundwater tables (when groundwater contains high levels of salts) through long-term re-vegetation programmes, changes in irrigation practices, etc.

Excluded are measures that respond to economic purposes (agricultural production, reclamation of land from the sea, etc.).

4.5 Measurement, control, laboratories and the like

All activities and measures aimed at controlling and measuring the quality and pollution of soils, groundwater and surface water, measuring the extent of soil erosion and salinisation etc. Includes the operation of monitoring systems, inventories of "black spots", maps and databases of groundwater and surface water quality, of soil pollution, erosion and salinity, etc.

4.6 Other activities

All other activities and measures aimed at the protection and remediation of soil, groundwater and surface water. It includes administration, management, training, information and education activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

5 Noise and vibration abatement (excluding workplace protection)

Noise and vibration abatement refers to measures and activities aimed at the control, reduction and abatement of industrial and transport noise and vibration. Activities for the abatement of neighbourhood noise (soundproofing of dancing halls, etc.) as well as activities for the abatement of noise in places frequented by the public (swimming pools, etc.) are included.

Excluded is the abatement of noise and vibration for purposes of protection at the workplace.

5.1 Preventive in-process modifications at the source

Activities and measures aimed at the reduction of noise and vibration from industrial equipment, vehicle motors, aircraft and ships engines, exhaust systems and brakes, or noise level due to tyre/road or wheel/rail surface contact. Includes the adaptation of equipment, vehicles (buses, trucks, or train and power units in the case of rail transport, aircraft and ships) in order to make them less noisy: soundproofing of hoods, brakes, exhaust systems, etc. Includes also plant modifications, specially conceived foundations to absorb vibrations, extra cost for regrouping of buildings and/or of facilities in the interest of noise abatement, special facilities in building construction or reconstruction, equipment and machines conceived or constructed for low noise or vibrations, low noise level flares and burners, etc.
Other preventive activities consist of noise abatement through the modification of surfaces. As noise emissions from motors, engines, exhaust systems and brakes are lowered, those from other sources becomes more important and in particular noise that originates from the contact between tyres and road surfaces. Activities consist of substituting concrete by silent asphalt, multi-layered surfaces, etc.

5.2 Construction of anti noise/vibration facilities

Activities and measures aimed at the installation and management of anti-noise facilities. These may be screens, embankments or hedges. They may consist of covering sections of urban motor ways or railroads. As concerns industrial and vicinity noise they also consist of add-on facilities, covering and soundproofing of machines and piping, fuel regulation systems and sound absorption, noise screens, barriers, soundproofing of buildings, noise protective windows, etc. in order to limit noise perception.

5.3 Measurement, control, laboratories and the like

Activities and measures aimed at controlling the level of noise and vibration: installation and operation of stationary measurement and monitoring sites or mobile equipment in urban areas, observation networks, etc.

5.4 Other activities

All other activities and measures aimed at noise and vibration abatement. It includes administration, management, training, information and education activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other classes. It also includes, when separable, traffic management with noise abatement purposes (for example, lowering of speed limits, improvement of traffic flows), introduction of time and geographical restrictions for noisy vehicles, traffic detours at a distance from residential areas, creation of pedestrian areas, creation of construction-free buffer zones, restructuring of modal split (improvement of public transportation, use of bicycles). This covers a potentially large set of administrative measures which raise serious identification problems given their incorporation in integrated programmes of traffic control and urban planning and the difficulty of separating that part of measures and expenditure that, in these programmes, concern noise and vibration abatement from expenditure related to air pollution control, improvement of the living environment or traffic security.

In addition to regulation, other measures may consist of: financial incentives for the production and use of low-noise vehicles, labelling or information programmes for consumers so as to encourage the use of low-noise vehicles and the adoption of quiet driving behaviour.

6 Protection of biodiversity and landscapes

Protection of biodiversity and landscape refers to measures and activities aimed at the protection and rehabilitation of fauna and flora species, ecosystems and habitats as well as the protection and rehabilitation of natural and semi-natural landscapes. The separation between "biodiversity" and "landscape" protection may not always be practical. For example, maintaining or establishing certain landscape types, biotopes, eco-zones and related issues (hedgerows, lines of trees to re-establish "natural corridors") have a clear link to biodiversity preservation.

Excluded is the protection and rehabilitation of historic monuments or predominantly built-up landscapes, the control of weed for agricultural purposes as well as the protection of forests against forests fire when this predominantly responds to economic reasons. The establishment and maintenance of green spaces along roads and recreational structures (e.g., golf courses, other sports facilities) are also excluded.

Actions and expenditure related to urban parks and gardens would not normally be included but may be related in some cases to biodiversity – in such cases the activities and expenditure should be included.

6.1 Protection and rehabilitation of species and habitats

Activities and measures aimed at the conservation, reintroduction or recovery of fauna and flora species, as well as the restoring, rehabilitation and reshaping of damaged habitats for the purpose of strengthening their natural functions. Includes conserving the genetic heritage, re-colonising destroyed ecosystems, placing bans on exploitation, trade, etc. of specific animal and plant species, for protection purposes. Also includes censuses, inventories, databases, creation of gene reserves or banks, improvement of linear infrastructures (e.g., underground passages or bridges for animals at highways or railways, etc.), Feeding of the young, management of special natural reserves (botany conservation areas, etc.). Activities may also include the control of fauna and flora to maintain natural balances, including re-introduction of predator species and control of exotic fauna and flora that pose a threat to native fauna, flora and habitats.
Main activities are the management and development of protected areas, whatever the denomination they receive; that is, areas protected from any economic exploitation or in which the latter is subject to restrictive regulations whose explicit goal is the conservation and protection of habitats. Also included are activities for the restoration of water bodies as aquatic habitats: artificial oxygenation and lime-neutralisation actions. When they have a clear protection of biodiversity purpose, measures and activities related to urban parks and gardens are to be included. Purchase of land for protection of species and habitats purpose is included.

6.2 Protection of natural and semi-natural landscapes

Activities and measures aimed at the protection of natural and semi-natural landscapes to maintain and increase their aesthetic value and their role in biodiversity preservation. Included is the preservation of legally protected natural objects, expenditures incurred for the rehabilitation of abandoned mining and quarrying sites, renaturalisation of river banks, burying of electric lines, maintenance of landscapes that are the result of traditional agricultural practices threatened by prevailing economic conditions, etc. For biodiversity and landscape protection related to agriculture, the identification of specific state aid programmes to farmers may be the only data source available. Protection of forests against forest fires for landscape protection purpose is included.

Excluded are measures taken in order to protect historic monuments, measures to increase aesthetic values for economic purposes (e.g., re-landscaping to increase the value of real estate) as well as protection of predominantly built-up landscapes.

6.3 Measurement, control, laboratories and the like

Measurement, monitoring, analysis activities which are not classified under the preceding items. In principle, inventories of fauna and flora are not covered since they are classified under protection of species.

6.4 Other activities

All other activities and measures aimed at the protection of biodiversity and landscape. It includes administration, training, information and education activities specific to the domain, when they can be separated from other activities related to the same domain and similar activities related to other classes.

7 Protection against radiation (excluding external safety)

Protection against radiation refers to activities and measures aimed at the reduction or elimination of the negative consequences of radiation emitted from any source. Included are the handling, transportation and treatment of high level radioactive waste; that is, waste that because of its high radionuclide content requires shielding during normal handling and transportation.

Excluded are activities and measures related to the prevention of technological hazards (e.g. external safety of nuclear power plants), as well as protection measures taken at workplaces. Also excluded are activities related to collection and treatment of low-level radioactive waste (see CEPA 3).

Definition of radioactive waste

Any material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than the "exempt quantities" established by the competent authorities, and for which no use is foreseen. Radioactive wastes are produced at nuclear power plants and at associated nuclear fuel cycle facilities as well as through other uses of radioactive material; for example, the use of radionuclides in hospitals and research establishments. Other important wastes are those from mining and milling of uranium and from the reprocessing of spent fuel.

7.1 Protection of ambient media

Protection of ambient media groups together activities and measures undertaken in order to protect ambient media from radiation. It may consist of protecting measures such as screening, creation of buffer zones, etc.

7.2 Transport and treatment of high level radioactive waste

Any process designed for the transport, conditioning, containment or underground disposal of high level radioactive waste.

Collection and transport of high level radioactive waste consists of the collection of high level radioactive waste, generally by specialised firms and their transport to the place of treatment, conditioning storage and disposal.

Conditioning of high level radioactive waste consists of activities that transform high level radioactive waste into a proper and fit condition for transport and/or storage and/or disposal. Conditioning may occur as part of ISIC/NACE 23 (Class 2330 - Processing of nuclear fuels) activities.

Containment of high level radioactive waste designates the retention of radioactive waste in such a way that it is effectively prevented from dispersing into the environment, or is released only at an acceptable level. Containment may occur in specially built containment spaces.

Underground disposal of high level radioactive waste is the temporary storage or final disposal of high level radioactive waste in underground sites that meet specific geological and technical criteria.

7.3 Measurement, control, laboratories and the like

Activities aimed at measuring, controlling and monitoring ambient radioactivity and radioactivity due to high level radioactive waste by means of specific equipment, instruments and installations.

7.4 Other activities

All other activities and measures aimed at the protection of ambient media against radiation and transport and treatment of high level radioactive waste. It includes administration, training, information and education activities specific to the domain, when they can be separated from other activities related to the same class and similar activities related to other environmental protection classes.

8 Research and development

Research and development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this knowledge to devise new applications (see OECD, 1994b) in the field of environmental protection.

The class regroups all R&D activities and expenditure oriented towards environmental protection: identification and analysis of sources of pollution, mechanisms of dispersion of pollutants in the environment as well as their effects on human beings, the species and the biosphere. This heading covers R&D for the prevention and elimination of all forms of pollution, as well as R&D oriented towards equipment and instruments of pollution measurement and analysis. When separable all R&D activities even when referring to a specific class have to be classified under this position.

Environmental R&D is further classified in accordance with the 1993 NABS.

Excluded are R&D activities related to the management of natural resources.

9 Other environmental protection activities

Other environmental protection activities refers to all environmental protection activities which take the form of general environmental administration and management activities or training or teaching activities specifically oriented towards environmental protection or which consist of public information, when they are not classified elsewhere in CEPA. It also includes activities leading to indivisible expenditure, as well as activities not elsewhere classified.

9.1 General environmental administration and management

General administration of the environment designates any identifiable activity that is directed at the general support of decisions taken in the context of environmental protection activities, whether by governmental or by non-governmental units.

General administration of the environment, regulation and the like

Any identifiable activity within general government and NPISH units that is directed towards the regulation, administration of the environment and the support of decisions taken in the context of environmental protection activities. When possible such activities should be allocated to other classes. If this is impossible, they should be included under this position of the classification.

Environmental management

Any identifiable activity of corporations that is directed at the general support of decisions taken in the context of environmental protection activities. It includes the preparation of declarations or requests for permission, internal environmental management, environmental certification processes (ISO 14000, EMAS), as well as the recourse to environmental consultancy services. Activities of units specialised in environmental consultancy, supervision and analysis are included. When possible such activities should be allocated to other CEPA classes.

9.2 Education, training and information

Activities that aim at providing general environmental education or training and disseminating environmental information. Included are high school programs, university degrees or special courses specifically aimed at training for environmental protection. Activities such as the production of environmental reports, environmental communication, etc. are also included.

9.3 Activities leading to indivisible expenditure

Environmental protection activities that lead to indivisible expenditure; that is, those which cannot be allocated to any other CEPA class. International financial aid may be a case in point as it may be difficult for the donor countries to attribute international aid to individual classes. If international aid is important in volume and/or of specific political interest, a separate 2-digit heading under CEPA 9 could be adequate for national purposes.

9.4 Activities not elsewhere classified

This position groups together all these environmental protection activities that cannot be classified under other positions of the classification.

ANNEX III: BIO-ECONOMIC MODELS OF FISHERIES AND METHODS FOR STOCK ASSESSMENT

Bio-economic models

There are several approaches to bio-economic modeling. The most simple model, the Gordon-Schaefer model, is based on the assumption that the growth rate of a fish stock depends on the size of the stock. While the Gordon-Schaefer model provides a powerful expository tool for demonstrating some of the basic relationships between fisheries ecology and economics, the model has several limitations which limit its usefulness for fisheries management. An alternative modelling approach based on year classes addresses some of these limitations. Both model types are described below.

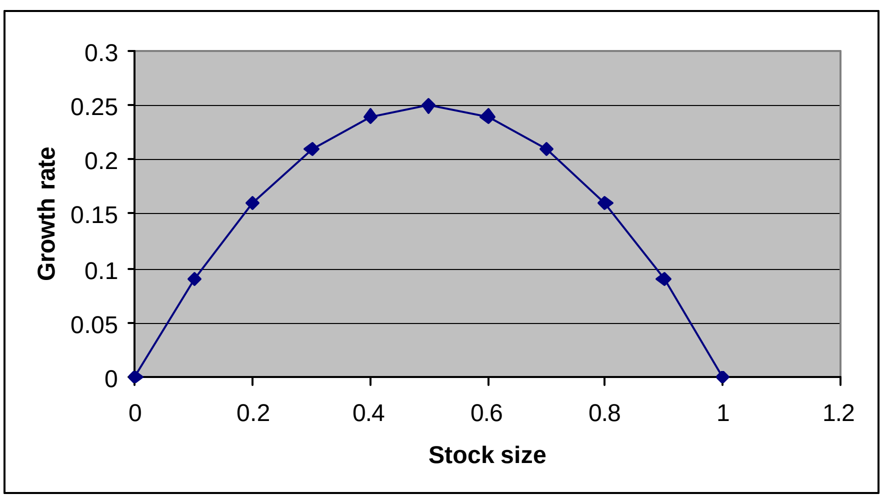
The simple bio-economic model

One of the most widely used biological models for the dynamics of fish stocks is the Schaefer surplus production model (Schaefer 1954). Schaefer's theory postulates that the growth of a fish stock depends on the size of the stock. Growth is hereby defined as the net increase in biomass between two points in time. The net increase in biomass is equal to recruitment (new young fish entering the stock) plus individual growth of fish already in the stock minus those fish which die due to natural causes (predation, old age, etc.).

As depicted in Figure A.III.1 at a small stock size, the growth is small. Growth increases with increasing stock size up to a maximum but declines thereafter and reaches zero due to the limits placed by environmental factors, i.e. the carrying capacity (k) (i.e. food, space, predators, etc.).

Figure A.III.1 Growth function of fish stock

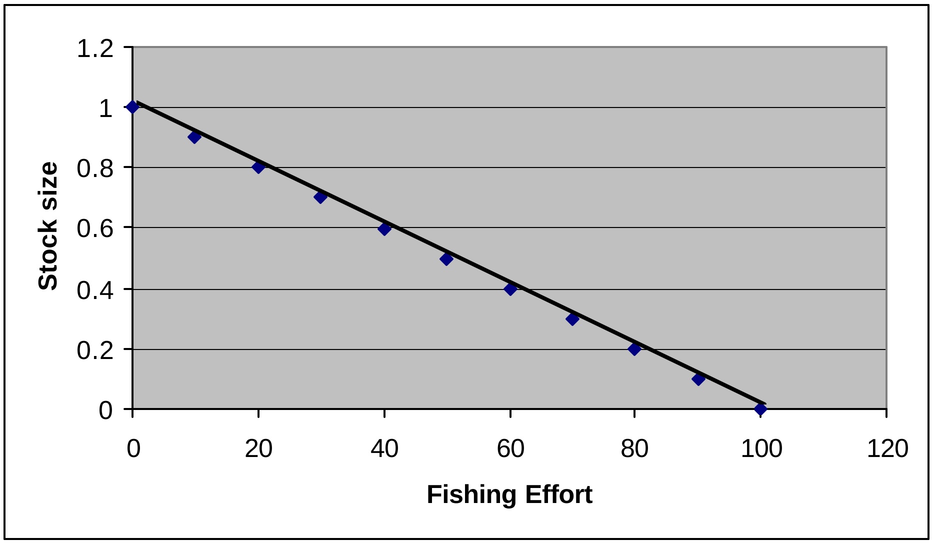
$G = S(1-S)$ [general: $G(S) = aS(1-S/k)$]



Source: Hannesson 1993.

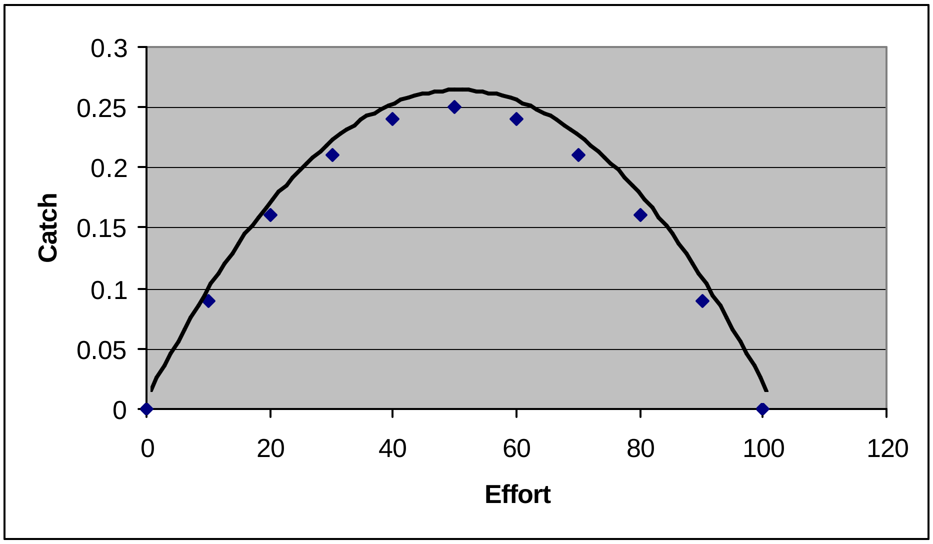
Once a stock is being exploited by man, the stock size is being reduced because, in addition to natural mortality, the stock is subject to fishing mortality. This relationship is shown in Figure A.III.2.

Figure A.III.2 Decline in stock size with increasing fishing effort



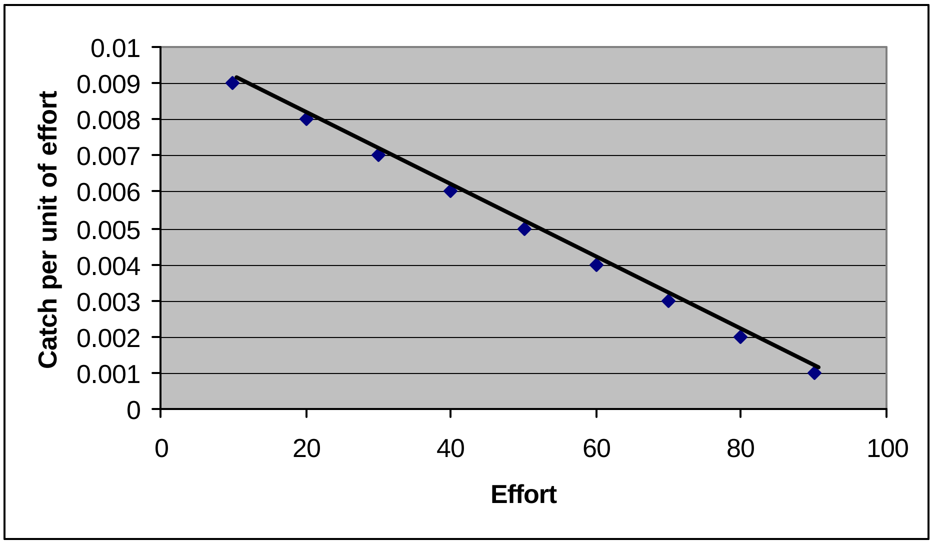
By combining the negative relationship between stock size and fishing effort on the one hand, and the relationship between net natural growth and stock on the other hand, the typical parabolic catch or yield curve is obtained (see Figure A.III.3). The underlying assumptions of this catch-effort relationship are that (i) fishing effort always removes a constant proportion of the stock and (ii) the catch is always equal to the surplus growth. (Hannesson 1993).

Figure A.III.3 The Schaefer Catch-Effort Curve



From the relationship shown in , it follows that the efficiency of effort diminishes as the level of exploitation increases. This is demonstrated by the so-called catch rate curve shown in Figure A.III.4 which depicts the catch per unit of effort (cpue) as a function of effort.

Figure A.III.4 The catch rate curve



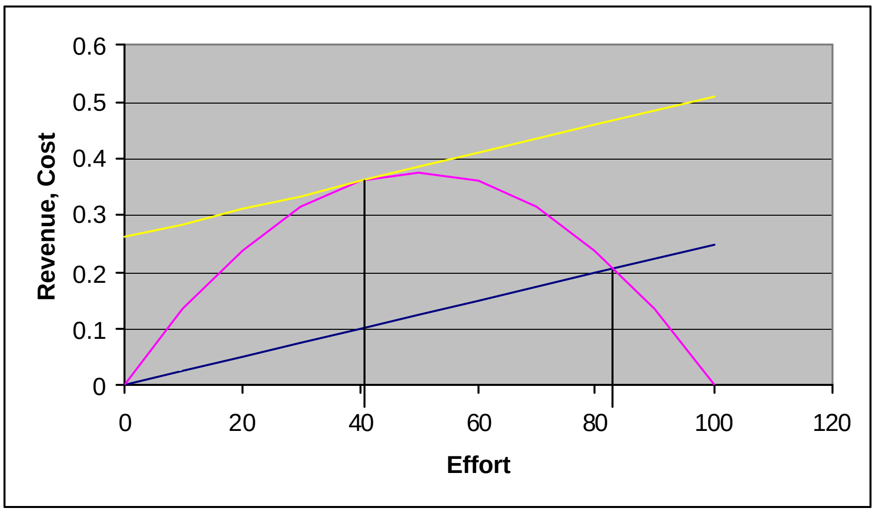
The functional relationship between catch per unit of effort and effort forms the basis for estimating the abundance of a fish stock and the maximum catch which can be removed from the stock on a sustainable basis (MSY). The estimate is derived from regression analysis of time series data of cpue and effort. The strength of the Schaefer model lies in its mathematical simplicity and the relatively small data requirements.

The Schaefer model was first expanded to include economic considerations by Scott Gordon (1954). His research resulted in two important conclusions: first, he demonstrated that a fishery which exploits a fish stock at the maximum sustainable yield is, save for exceptional circumstances, foregoing net benefits to the national economy; second, he demonstrated that an unregulated fishery with free access to anyone who wishes to exploit the fish stock will tend towards a level of exploitation were the entire resource rent is lost.

Before discussing the mechanisms which account for Gordon's conclusions, it is desirable to briefly explain the term 'resource rent'. That natural resources have the potential to create resource rent (or surplus profit) is perhaps best demonstrated in the case of mining. Suppose that with a mineral content of one per cent the cost of exploiting a body of ore equals the value of the metal extracted. This would be the economic break-even point given existing technology and metal prices. Under these circumstances a miner exploiting a body of ore with a mineral content of five per cent will be making large profits as the value of the metal extracted will be five times the cost of recovery. This profit is not the result of any particular expertise on the part of the miner, but due to the intrinsic worth of the resource itself, i.e. the resource rent (Meany 1987).

Figure A.III.5 shows graphically the resource rent to be obtained in the exploitation of a fish stock. For this purpose, Schaefer's catch-effort curve as shown in Figure A.III.3 has been converted into a value-effort curve by multiplying the catch with the average unit price. The straight line in Figure A.III.5 depicts the costs of fishing which are assumed to increase proportionately with effort. Resource rent is maximized where the distance between the cost curve and the value curve reaches its maximum (the tangent of the cost curve with the revenue curve), i.e. where marginal revenue is equal to marginal cost.

Figure A.III.5 The Gordon-Schaefer bio-economic model



From Figure A.III.5 it becomes immediately obvious that the effort that maximizes sustainable yield (MSY) would only then correspond with the effort that maximizes resource rent if the cost of fishing were zero. Once fishing incurs costs, as it usually does, the economically desirable effort is always smaller than the effort at MSY.

The second, and most important conclusion, of Gordon's theory is that an open-access fishery has a strong tendency to expand fishing effort up to point where the total value of the catch is equal to total costs of fishing and resource rent is zero (i.e. the intersection of the cost curve with the revenue curve). This point is also referred to as bio-economic equilibrium. This result arises from two mechanisms: first, if revenues are higher than fishing costs, surplus profits would be earned that would attract additional capital and labour into the fishery. Second, if revenues are lower than costs, at least some firms would lose money and would therefore leave the fishery. Implicit to this result is the fact that, as an individual fisherman increases fishing effort, he imposes a cost on other fishermen in terms of reduced value of catch per unit of effort, which is external to his own economic calculus. If the fishery was operated by one fisherman only, this external cost would not arise, and the sole owner would adjust fishing effort in such a way that the cost of the last unit of effort would just be equal to the value of the catch produced by that unit. If he were to add an additional unit of effort, the value of the catch produced by that unit would be less than its cost and thus his profit would be reduced.

The problems created by external costs are well known in fisheries and often one of the major causes for conflicts between different sectors of the fishing industry. Prime examples are the conflicts between industrial and small-scale fisheries exploiting the same fishing grounds or fish stocks. As industrial fishing effort increases, say for example, purse seining for small pelagic species such as sardines, the catches of the same species by artisanal fishermen using, for example, beach-seines may drop thus shifting wealth from the small-scale to the industrial sector. Bio-economic modelling can help in predicting such effects and assist in finding appropriate measures for minimizing conflicts in fisheries.

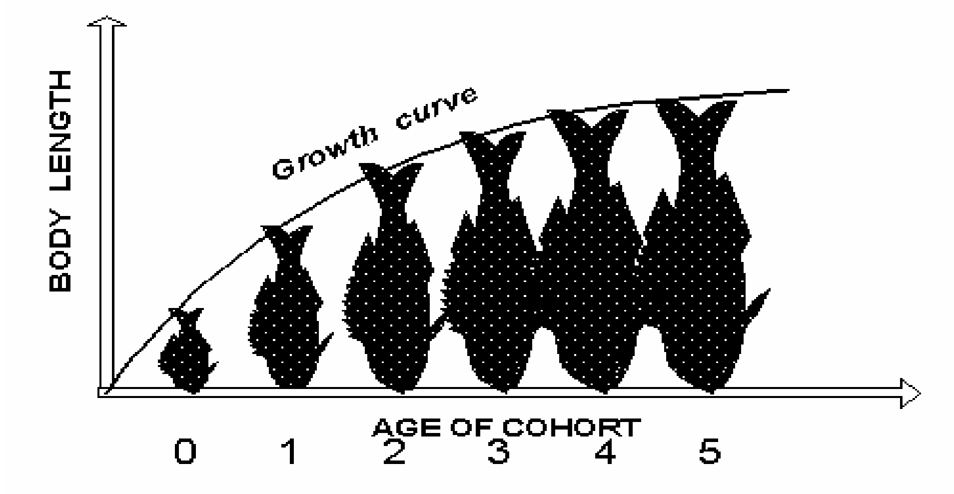
Bio-economic models based on age class

The simple Gordon-Schaefer bio-economic model has a number of limitations that reduce its usefulness for purposes of fisheries development planning and management. It is, essentially, a single species and single gear model and does not, therefore, allow the modelling of more common fisheries situations, especially in tropical and sub-tropical countries, that are characterized by several fishing fleets applying a large variety of fishing gears and exploiting simultaneously several fish stocks.

Another limitation of the Gordon-Schaefer model is that it neglects the age-class structure of the fish population and, related to this, it neglects that fishes of different sizes (and ages) may fetch different prices in the market. For example, in the case of shrimp fisheries, where the prices of larger size categories are up to three times higher than the prices of smaller size classes.

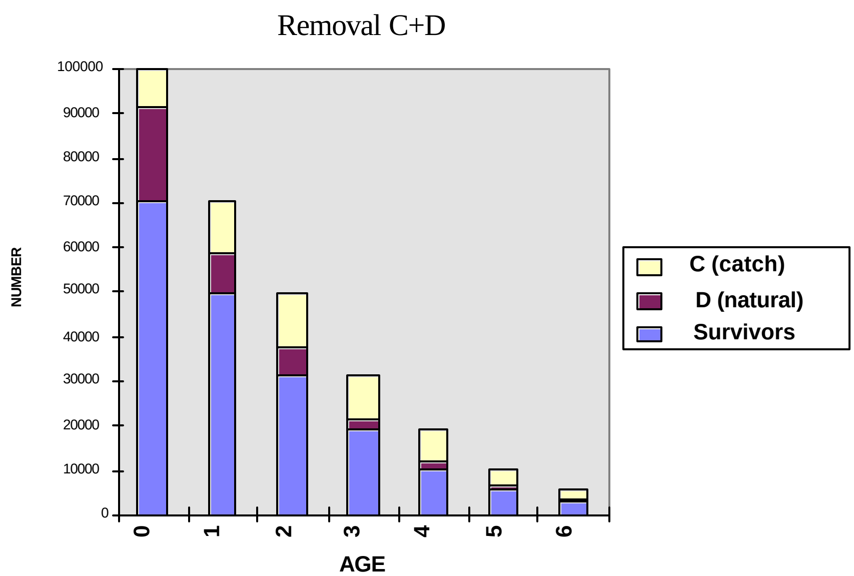
The models designed to deal with age-specific biological characteristics are the so-called dynamic pool or yield per recruit models. Most widely applied are the models by Thompson and Bell (1934) and Beverton and Holt (1957). The principal feature of such models is to follow the entire life cycle of the individual fish (or cohort) from the time it is recruited (or "born") until it dies either due to natural causes or due to being fished. Computerization has greatly facilitated the application of these models (e.g. Sparre and Willmann 1993). Figure A.III.6 illustrates the growth of the animal during its life in terms of body length (or weight) while Figure A.III.7 shows how the numbers of individual fishes decline with increasing age because the fishes die naturally or are being caught.

Figure A.III.6 Body length as a function of age



Source: Courtesy Mr. Per Sparre.

Figure A.III.7 Dynamics of a cohort



Source: Courtesy Mr Per Sparre.

The age- (or cohort-) structured representation of the fish population has the advantage that two biological processes can be clearly distinct that are of great importance in the optimum management of fisheries. These processes are (i) recruitment overfishing and (ii) growth overfishing. Recruitment overfishing occurs when the numbers of fish of reproductive age have become too small to produce a sufficiently large number of larvae or juvenile fish for sustaining the fish stock. As a consequence, the entire population may collapse.

Growth overfishing is conceptually quite different. Consider a small fish which, if unharvested, would grow bigger. It can be fished early on in its life at a small size or later on at a bigger size. Growth overfishing is given when the fish is being captured too young for maximizing its contribution to the catch in weight or in value. The optimum age of the fish to be caught is dependent, of course, on the rate at which it is growing and on the probability of its dying due to natural causes. In the case of many fish species, the growth rate and the natural mortality are positively correlated; that is, a fast growing species is usually subject to a higher natural mortality than a slow growing species. As a consequence, the optimum age at first capture varies considerably between, for example, fast growing shrimp species depicting a high natural mortality and slow growing species. The latter includes fishes such as snappers or groupers.

For the fisheries manager there are a number of possible measures to influence the age or size at which the fish is being caught. Chief among these measures are: (i) the closure of areas where fish spend their early life stage including nursery areas; (ii) the closure of the season in a year when mostly young fish are being caught; (iii) the provision of minimum mesh size regulations and (iv) the establishment of minimum sizes at which particular species can be marketed locally or exported. A fifth measure, and in many instances the most desirable one for improved economic performance of the fishery, is to reduce fishing effort and thereby giving the fish more time to grow to a larger size before capture. Bio-economic analysis based on yield per recruit models can determine the optimum timing of a closed season or the optimum mesh size or the optimum area to be closed for fishing. It can also help in deciding on whether a reduction of fishing effort would be more advantageous than these biological management measures.

ANNEX IV: FORMULAS TO CALCULATE THE INEFFICIENCY COSTS IN THE FISHERIES ACCOUNTS FOR ICELAND

Let $\tilde{H}_t$ be the optimal catch in period t given by the optimal catch rule

$$\tilde{H}_t = aH_{t-1} + (1-a)\,lS_t. \qquad (1)$$

In this study l =0.23 and a =0.5. S_t is the size of the stock by the beginning of period t as it is estimated at the time and H_{t-1} is the catch in period $(t-1)$. The optimal rent is the sum of the profit from fishing the optimal catch and the change in the value of the stock:

$$R_t^{opt} = p_t(\tilde{H}_t) + V_t(\tilde{S}_{t+1}) - V_t(S_t), \qquad (2)$$

where p_t is the profit function in period t, V_t is the function giving the value of the stock based on prices and costs in period t and $\tilde{S}_{t+1}$ is the size of the stock at the start of period $(t+1)$ if the catch in period t is $\tilde{H}_t$.

As the value of the stock is given by discounted future profits

$$V_t(S_t) = p_t(\tilde{H}_t) + \frac{1}{1+i}V_t(\tilde{S}_{t+1}), \qquad (3)$$

where i is the rate of interest. Equations (2) and (3) give that

$$R_t^{opt} = \frac{i}{1+i}V_t(\tilde{S}_{t+1}) = i\left[V_t(S_t) - p_t(\tilde{H}_t)\right].$$

The actual rent from fishing is the sum of the actual profit and the change in the value of the stock

$$R_t^{act} = p_t(H_t) + V_t(S_{t+1}) - V_t(S_t) = p_t(H_t) - Cost_t^d,$$

where S_{t+1} is the forecasted size of the stock at the start of period $(t+1)$ if the catch in period t is H_t and $Cost_t^d$ is the cost of depletion in period t.

The difference between the optimal and the actual income measures the inefficiency cost of sub-optimal (usually excessive) catches.

$$Cost_t^{ie} = \left(R_t^{opt} - R_t^{act}\right) = i\left[V_t(S_t) - p_t(\tilde{H}_t)\right] - p_t(H_t) + Cost_t^d.$$

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GLOSSARY[16]

Aquaculture: The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. (*FAO On-line glossary*). See *produced assets*.

Artisanal fishery: Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20 m. trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. Sometimes referred to as small-scale fisheries. (*FAO On-line glossary*)

Assets: See *Economic assets* and *Environmental assets*.

Bioeconomic modeling: A set of mathematically expressed functional relationships between biological characteristics of the resource base, (e.g. a fishery resource), and the economic (and sometimes social) characteristics of its use by Man. As an abstraction from reality, the validity of a bio-economic model depends on the explicit or implicit assumptions about the biological and human processes it represents. (*FAO On-line glossary*)

Biomass: Or Standing stock. The total weight of a group (or stock) of living organisms (e.g. fish, plancton) or of some defined fraction of it (e.g. spawners), in an area, at a particular time. (*FAO On-line glossary*)

Buy-back: Financial mechanism of a fishery management scheme, usually supported and often subsidised by governments, in which governments or any other relevant party (e.g. fishermen associations) buy vessels and fishing licenses from producers in order to reduce fishing effort and capacity. (*FAO On-line glossary*)

By-catch: Part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying. (*FAO On-line glossary*)

Capital stock – gross: Gross capital stock is the value of all fixed assets still in use when a balance sheet is drawn up, at the actual or estimated current purchasers' prices for new assets of the same type, irrespective of the age of the assets. (*SNA On-line glossary*)

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16 The following references were used for the terms in this glossary:
FAO On-line glossary: http://www.fao.org/fi/glossary
SNA On-line glossary: http://unstats.un.org/unsd/sna1993/glossary.asp
Operational Manual glossary: UN and UNEP, 2000
SEEA-2003: UN *et al*., 2003

Capital stock – net: The sum of the written-down values of all the fixed assets still in use when a balance sheet is drawn up is described as the net capital stock. (*SNA On-line glossary*)

Capture fisheries: The sum (or range) of all activities to harvest a given fish resource. It may refer to the location (e.g. Morocco, Georges Bank), the target resource (e.g. hake), the technology used (e.g. trawl or beach seine), the social characteristics (e.g. artisanal, industrial), the purpose (e.g., commercial, subsistence, or recreational) as well as the season (e.g. winter). (*FAO On-line glossary*)

Carrying Capacity: Represents the point of balance between reproduction potential and environmental resistance, that is the maximum population of a species that a specific ecosystem can support indefinitely without deterioration of the character and quality of the resource. The level of use, at a given level of management, which a natural or man-made resource can sustain itself over long period of time. For example, the maximum level of recreational use, in terms of numbers of people and types of activity that can be accommodated before the ecological value of the area declines. (*FAO On-line glossary*)

Catch: The total number (or weight) of fish caught by fishing operations. Catch should include all fish killed by the act of fishing, not just those landed. (*FAO On-line glossary*). In environmental accounting the catch caught by resident operators constitutes production in the SUT regardless of where it is caught. Catches from national waters, regardless of the nationality of the operator, are recorded as catch in the asset accounts.

Catch per unit of effort (CPUE): The quantity of fish caught (in number or in weight) with one standard unit of fishing effort; e.g. number of fish taken per 1000 hooks per day or weight of fish, in tons, taken per hour of trawling. CPUE is often considered an index of fish biomass (or abundance). Sometimes referred to as catch rate. CPUE may be used as a measure of economic efficiency of fishing as well as an index of fish abundance.). Also called: catch per effort, fishing success, availability. (*FAO On-line glossary*)

Compensation of employees: Total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the latter during the accounting period. (*SNA On-line glossary*)

Consumption of fixed capital: Consumption of fixed capital represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage. (*SNA On-line glossary*)

Critical capital: Natural capital that is essential for human survival and is irreplaceable. (SEEA-2003)

Cultivated assets: See *Aquaculture* and *Produced assets*.

Damage Cost: It is a valuation method to assess degradation. The estimation of damage costs involves econometric techniques or surveys on stated preferences to determine willingness to pay. (SEEA-2003, Chapter 9)

Degradation of environmental resources: Deterioration in environmental quality from ambient concentrations of pollutants and other activities and processes such as improper land use and natural disasters. (*Operational Manual glossary*)

Demersal fish: Living in close relation with the bottom and depending on it. Example: cod, grouper and lobster are demersal resources. The term "demersal fish" usually refers to the living mode of the adult. (*FAO On-line glossary*)

Depletion: See *Economic depletion* and *Physical depletion*.

Discard: To release or return fish to the sea, dead or alive, whether or not such fish are brought fully on board a fishing vessel. (*FAO On-line glossary*)

Discount rate: The rate at which to discount future income in the net present value method of valuing natural resource assets. The discount rate expresses the degree to which an economic agent prefers income today rather than in the future. This time preference will vary depending on the agent in question. In general, individuals and businesses have higher rates (private discount rate) of time preference than Governments (social discount rate). In addition to time preference, discount rates can also reflect the risks associated with the future returns expected from an investment. (*Operational Manual glossary*)

Economic efficiency: A measure of how well economic inputs (capital, labour, etc.) are combined to produce a given output. Economic efficiency is maximized when inputs are combined so as to produce the required output at minimum cost. (*FAO On-line glossary*)

Economic assets: Economic assets are entities over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time. (*SNA On-line glossary*). They include those natural resources which are currently exploitable or likely to be so, for economic purposes, even if no explicit ownership or control is currently exerted over these resources (e.g. fish in the oceans or commercially exploitable timber in tropical forests). (*Operational Manual glossary*). See also *Aquaculture, Produced assets* and *Non-produced assets*.

Economic depletion: The reduction in value of wild fish stocks and other non-cultivated biological resources as a result of the physical removal and using up of the assets. (Adapted from the *Operational Manual glossary*)

Ecosystem: A spatio-temporal system of the biosphere, including its living components (plants, animals, micro-organisms) and the non-living components of their environment, with their relationships, as determined by past and present environmental forcing functions and interactions amongst biota. (*FAO On-line glossary*)

Enterprises: Institutional units in their capacity as producers. (1993 SNA, paragraph 5.1)

Environmental assets: Entities that provide sink, service and resource functions and use and non-use benefits. (Seea-2003 Chapter 7)

Environmental Externalities: Economic concept of uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism. As a consequence of negative externalities, private costs of production tend to be lower than "social" costs. It is the aim of polluter/user pay principle to prompt households and enterprises to internalize externalities in their plans and budgets. (*National Research Council, 1999*)

Environmental Protection Activity: Any activity to maintain or restore the quality of environmental media (air, water, land) through preventing the emission of pollutants or reducing the presence of polluting substances in environmental media. (*Operational Manual glossary*)

Establishment: An establishment is an enterprise, or part of an enterprise, that is situated in a single location and in which only a single (non-ancillary) productive activity is carried out or in which the principal productive activity accounts for most of the value added. (*SNA On-line glossary*)

Exclusive economic zone (EEZ): The area adjacent to a coastal state which encompasses all waters between: (a) the seaward boundary of that state, (b) a line on which each point is 200 nautical miles (370.40 km) from the baseline from which the territorial sea of the coastal state is measured (except when other international boundaries need to be accommodated), and (c) the maritime boundaries agreed between that state and the neighbouring states. (*FAO On-line glossary*)

Fish stock: The living resources in the community or population. Use of the term fish stock usually implies that the particular population is more or less isolated from other stocks of the same species and hence self-sustaining. In a particular fishery, the fish stock may be one or several species of fish. In environmental accounting the fish stock of a country includes all stocks which occur within the country's EEZ and the part of the shared fish stock allocated to the country on the basis of international agreements. (Adapted from the *FAO On-line glossary*). See *Straddling fish stocks*.

Fishery: Generally, a fishery is an activity leading to harvesting of fish. It may involve capture of wild fish or raising of fish through aquaculture. (*FAO On-line glossary*)

Fishery resource: See *Fish stock*.

Fishing effort: The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time e.g. hours trawled per day, number of hooks set per day or number of hauls of a beach seine per day. When two or more kinds of gear are used, the respective efforts must be adjusted to some standard type before being added. (*FAO On-line glossary*)

Fixed assets: Fixed assets are tangible or intangible assets produced as outputs from processes of production that are themselves used repeatedly or continuously in other processes of production for more than one year. (*SNA On-line glossary*)

Flag: Refers to the State under the responsibility of which a boat is legally registered. (*FAO On-line glossary*)

Flag of convenience: The term pertains to cases when a boat is registered in a different State than that of ownership, for whatever reasons of convenience. (*FAO On-line glossary*)

Gross Domestic Product (GDP) at market prices – output based: Sum of the gross values added of all resident producers at producers' prices, plus taxes less subsides on imports, plus all non-deductible VAT (or similar taxes). (*SNA On-line glossary*)

Harvesting capacity: The capacity of the fishing fleet to harvest fish, usually expressed in terms of some measure of vessel size, such as gross tonnage, hold capacity, horsepower. (*FAO On-line glossary*)

High grading: The discarding of a portion of a vessel's legal catch that could have been sold to have a higher or larger grade of fish that bring higher prices. It may occur in quota and non-quota fisheries. (*FAO On-line glossary*)

High seas resources: Resources distributed exclusively in the high seas, i.e. in waters beyond the areas of national jurisdiction (which can be 200 miles or less) excluding species fixed on the continental shelf which remain under the sovereign rights of the coastal States. (*FAO On-line glossary*)

Individual Quota: A quota (possibly a percentage) of a total allowable catch (TAC) assigned to an individual, a vessel or a company. If an individual quota is transferable, it is referred to as an Individual Transferable Quota (ITQ). (*FAO On-line glossary*)

Individual transferable share quota (ITSQ): A management tool used to allocate a fixed share of the *quota* to individual fishermen or companies. ITSQs are usually granted as a form of long-term fishing rights and are tradable (transferable). (*Operational Manual glossary*)

Individual transferable quota (ITQ): A type of quota (a part of a Total Allowable Catch) allocated to individual fishermen or vessel owners and which can be sold to others. (*FAO On-line glossary*)

Industry: An industry consists of a group of establishments engaged on the same, or similar, kinds of activity. (*SNA On-line glossary*)

Institutional unit: Economic entity that is capable, in its own right, of owning assets, incurring liabilities and engaging in economic activities and in transactions with other entities. (*SNA On-line glossary*)

Internal satellite accounts: A rearrangement of the existing SNA transactions: no new flows are added but those which are there may be presented and aggregated differently and in some case separated out from existing records by a process of deconsolidation. (SEEA-2003, paragraph 2.11)

Integrated Coastal Area Management (ICAM): The dynamic process by which actions are taken for the use, development and protection of coastal resources and areas to achieve national goals established in co-operation with user groups and regional and local authorities. (*FAO On-line glossary*)

Intermediate consumption: It consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. (*SNA On-line glossary*)

Landings: Weight of what is landed at a landing site. It may be different from the catch (which includes the discards). (*FAO On-line glossary*)

License: Also known as permits. A license or permit is a document giving the producer the right to operate in a fishery according to the terms established by the regulating authority. (*FAO On-line glossary*)

Long-line: Fishing gear in which short lines carrying hooks are attached to a longer main line at regular intervals. Long-lines are laid on the bottom or suspended horizontally at a predetermined depth with the help of surface floats. The main lines can be as long as 150 km and have several thousand hooks (e.g. in tuna fisheries). (*FAO On-line glossary*)

Maintenance costing: Method of measuring imputed costs of environmental *degradation* caused by economic agents. The value of the maintenance costs depends on the cost of the technology chosen to avoid or reduce the impact of emissions or to restore the environment. It is defined as the cost of using the natural environment, that would have been incurred if the environment had been used during the accounting period in such a way as not to have affected its future use. (SEEA-2003, Chapter 9)

Mariculture: Marine fish farming (aquaculture). Raising of marine animals and plants in the ocean. For the purpose of FAO statistics, mariculture refers to cultivation of the end product in sea water even though earlier stages in the life cycle of the concerned aquatic organisms may be cultured in brackish water or freshwater. (*FAO On-line glossary*)

Material flow accounts: They measure the material "throughput" through the economy by providing information on the material input from the environment into the economy, the transformation and use of that input in economic processes (extraction, conversion, manufacturing, consumption) and its return to the natural environment as residuals (wastes). (*Operational Manual glossary*)

Maximum Economic Yield (MEY): When relating total revenues from fishing to total fishing effort in a surplus production model, the value of the largest positive difference between total revenues and total costs of fishing (including the coast of labour and capital) with all inputs valued at their opportunity costs. (*FAO On-line glossary*)

Maximum sustainable yield (MSY): The highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing (average) environmental conditions without affecting significantly the reproduction process. When relating total revenues from fishing to total fishing effort in a surplus production model, MEY is attained at a level of fishing effort where marginal costs of fishing are equal to marginal fishing revenues. At this level of fishing effort, the difference between total revenues and total costs of fishing, including the cost of labour and capital with all inputs valued at their opportunity costs, is maximized. (Adapted from *FAO On-line glossary*)

Monetary depletion: See *Economic depletion*.

Mixed income: Surplus or deficit accruing from production by unincorporated enterprises owned by households. (*SNA On-line glossary*)

National income: At the level of the total economy, national income is the total value of the primary incomes receivable within the economy less the total of the primary incomes payable by resident units. (*SNA On-line glossary*)

Natural capital: See *Environmental asset*.

Natural mortality: Deaths of fish from all causes except fishing (e.g. Ageing, predation, cannibalism, disease and perhaps increasingly pollution). (*FAO On-line glossary*)

Net present value: Present value of an investment, found by discounting all current and future streams of income by an appropriate rate of interest. *(Operational Manual glossary*)

Nominal catch: Sum of catches that are landed (expressed as live weight equivalent). Nominal catches do not include unreported discards. (*FAO On-line glossary*)

Non-produced assets: Non-produced assets are non-financial assets that come into existence other than through processes of production. (*SNA On-line glossary*)

Private discount rate: See *Discount rate.*

Operating surplus: It measures the surplus or deficit accruing from production before taking account of any interest, rent or similar charges payable on financial or tangible non-produced assets borrowed or rented by the enterprise, or any interest, rent or similar receipts receivable on financial or tangible non-produced assets owned by the enterprise; (note: for unincorporated enterprises owned by households, this component is called "mixed income"). (*SNA On-line glossary*)

Pelagic fish: Fish that spend most of their life swimming in the water column with little contact with or dependency on the bottom. Usually refers to the adult stage of a species. (*FAO On-line glossary*)

Physical depletion: Level of harvesting which is greater than net natural growth during the accounting period provided that the remaining stock size (closing stock) is below that one which can produce the *maximum sustainable yield* in future accounting periods. In other words, as long as the remaining (closing) stock does not drop below the size that can produce the MSY, no physical depletion should be accounted for in SEEAF.

Produced assets: Non-financial assets that have come into existence as outputs from processes that fall within the production boundary. (*SNA On-line glossary*)

Produced capital: See *Produced assets.*

Property right: A legal right or interest in respect to a specific property. A type of resource ownership by an individual (individual right) or a group (communal right). (*FAO On-line glossary*)

Purse seine: Nets characterised by the use of a purse line at the bottom of the net. The purse line enables the net to be closed like a purse and thus retain all the fish caught. The purse seines, which may be very large, are operated by one or two boats. The most usual case is a purse seine operated by a single boat, with or without an auxiliary skiff. (*FAO On-line glossary*)

Quota: Share of the Total Allowable Catch (TAC) allocated to an operating unit such as a country, a vessel, a company or an individual fisherman (individual quota). Quotas may or may not be transferable, inheritable, and tradable. While generally used to allocate TAC, quotas could be used also to allocate fishing effort or biomass. (*FAO On-line glossary*)

Ranching: Commercial raising of animals, mainly for human consumption, under extensive production systems, within controlled boundaries and paddocks (e.g. in agriculture), or in open space (oceans, lakes) where they grow using natural food supplies. In Fisheries, animals may be released by national authorities and re-captured by fishermen as wild animals, either when they return to the release site (e.g. salmon) or elsewhere (sea breams, flatfish). (*FAO On-line glossary*)

Recreational fishery: Harvesting fish for personal use, fun, and challenge (e.g. as opposed to profit or research). Recreational fishing does not include sale, barter or trade of all or part of the catch. (*FAO On-line glossary*)

Recruitment: The number of fish added to the exploitable stock, in the fishing area, each year, through a process of growth (i.e. the fish grows to a size where it becomes catchable) or migration (i.e. the fish moves into the fishing area). (*FAO On-line glossary*)

Resident: An institutional unit is resident in a country when it has a centre of economic interest in the economic territory of that country. (*SNA On-line glossary)*

Resource management: Integrated process of information gathering, analysis, planning, decision-making, allocation of resources and formulation and enforcement of regulations by which the management authorities control the present and future behaviour of interested parties, in order to ensure the continued productivity of the resources. (*Operational Manual glossary*)

Resource rent: Net return realized from the sale of a natural resource under particular conditions of long-term market equilibrium. It is defined as the revenue received minus all marginal costs of resource exploitation, exploration, and development, including a normal return to fixed capital employed. (*National Research Council, 1999*)

Satellite accounts: Elaboration and extension of the SNA. They provide a framework to accommodate elements which are included in the central accounts, explicitly or implicitly, plus complementary elements (either monetary or in physical quantities) and possibly alternative concepts and presentations. (*SNA On-line glossary*)

Social accounting matrix (SAM): It is a means of presenting the SNA accounts in a matrix which elaborates the linkages between a supply and use table and institutional sector accounts. (*SNA On-line glossary*)

Social discount rate: See *Discount rate.*

Small-scale fishery: See *Artisanal fishery*.

Spawning stock: (a) Mature part of a stock responsible for the reproduction; (b) Strictly speaking, the part of an overall stock having reached sexual maturity and able to spawn. Often conventionally defined as the number or biomass of all individuals beyond "age at first maturity" or "size at first maturity" i.e. beyond the age or size class in which 50% of the individuals are mature. (*FAO On-line glossary*)

Standing stock: See *Biomass*.

Straddling fish stock: Stock which occurs both within the EEZ and in an area beyond and adjacent to EEZ. (*FAO On-line glossary*). See *Fish stocks.*

Strong sustainability: It requires that natural capital stock be maintained intact independent of other form of capital. (SEEA-2003, paragraph 1.32)

Subsistence fishery: Fishery where the fish caught are shared and consumed directly by the families and kin of the fishers rather than being bought by middle-(wo)men and sold at the next larger market. (*FAO On-line glossary*)

Supply and use tables: They are in the form of matrices that record how supplies of different kinds of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate or final uses, including exports. (*SNA On-line glossary*)

Surplus growth: Growth greater than natural mortality. (from text in chapter III).

Sustainability: See S*trong sustainability* and *Weak sustainability.*

Sustainable catch: Number (weight) of fish in a stock that can be taken by fishing without reducing the stock biomass from year to year, assuming that environmental conditions remain the same. Different levels of sustainable catch exist for different stock sizes. Maximum sustainable catch is defined in reference to the size and composition of a stock that make the natural growth of the stock equal to this maximum. (*Operational Manual glossary*)

Sustainable yield: Amount of biomass or the number of units that can be harvested currently in a fishery without compromising the ability of the population/ecosystem to regenerate itself. (*FAO On-line glossary*)

Taxes on income: Taxes on income consist of taxes on incomes, profits and capital gains; they are assessed on the actual or presumed incomes of individuals, households, Non-profit Institutions or corporations. (*SNA On-line glossary*)

Taxes on production: Taxes on production consist of taxes payable on goods and services when they are produced, delivered, sold, transferred or otherwise disposed of by their producers plus other taxes on production, consisting mainly of taxes on the ownership or use of land, buildings or other assets used in production or on the labour employed, or compensation of employees paid. (*SNA On-line glossary*)

Trawl: Cone or funnel-shaped net that is towed through the water by one or more vessels. (*FAO On-line glossary*)

Total allowable catch: Total catch allowed to be taken from a resource in a specified period (usually a year), as defined in the management plan. The TAC may be allocated to the stakeholders in the form of quotas as specific quantities or proportions. (*FAO On-line glossary*)

Vessel decommissioning: See *Buy-back*.

Virtual Population Analysis (VPA): Algorithm for computing historical fishing mortality rates and stock sizes by age, based on data on catches, natural mortality, and certain assumptions about mortality for the last year and last age group. A VPA essentially reconstructs the history of each cohort, assuming that the observed catches are known without error. (*FAO On-line glossary*)

Wealth: Total of produced, natural, human and social capital. Environmental accounting focuses on the measurements of natural capital. (SEEA-2003, paragraphs 1.21-1.22)

Weak sustainability: It requires that natural resource stocks may be depleted, and environmental system degraded, but only if depletion/degradation is offset by equivalent or greater increases in other form of capital. (SEEA-2003, paragraph 1.30). See *Critical capital*.