

Bulletin

of the Sea Fisheries Institute

3(151) 2000

CONTENTS

Scientific papers

LEONARD EJSYMONT and KENNETH SHERMAN Poland and United States' Cooperation in Fisheries Ecology: A Multidecadal Retrospective	3
MORGAN S. BUSBY, ANN C. MATARESE, DEBORAH M. BLOOD and MALGORZATA KONIECZNA Advancements in Ichthyoplankton Taxonomy in the Northeastern Pacific Ocean and Bering Sea: Research Conducted by the Alaska Fisheries Science Center 1965-1999	11
ARTHUR W. KENDALL, JR. Status of Recruitment Studies of Northeast Pacific Fishes	21
ALLYN B. POWELL, DONALD E. HOSS, MALGORZATA KONIECZNA and LEONARD EJSYMONT Summary of Ichthyoplankton Research by the NOAA Beaufort Laboratory in Florida Bay, Everglades National Park, Florida, USA	43
JOANNE LYCZKOWSKI-SHULTZ, MALGORZATA KONIECZNA and WILLIAM J. RICHARDS Occurrence of the Larvae of Beryciform Fishes in the Gulf of Mexico	55
JACK W. JOSSI and JOSEPH KANE An Atlas of Seasonal Mean Abundances of the Common Zooplankton of the United States Northeast Continental Shelf Ecosystem	67
KENNETH SHERMAN Marine Ecosystem Management of the Baltic and Other Regions	89
BENJAMIN H. SHERMAN Marine Disease, Morbidity and Mortality, Toward a Baltic Sea Ecological Disturbance Information System	101
PIOTR MARGOŃSKI Impact of Hydrological and Meteorological Conditions on the Spatial Distribution of Larval and Juvenile Smelt (<i>Osmerus eperlanus</i>) in the Vistula Lagoon (Southern Baltic Sea)	119

INSTRUCTIONS FOR AUTHORS

GENERAL INFORMATION

The Bulletin of the Sea Fisheries Institute is a scientific journal which accepts papers from all over the world. Foreign authors are requested to submit their papers in English, the research staff of the SFI in Polish and authors not associated with the SFI in Polish and English.

Papers submitted to the Bulletin are classified according to the following three categories: 1) scientific papers, 2) short communications, 3) varia.

The Editorial Staff will accept a paper and assign it to one of the above categories. Papers accepted for publication in the *Bulletin* may not be published elsewhere. Publication in the *Bulletin* is free of charge.

TYPESCRIPT FORM

Papers should be submitted in two copies of single-sided, double-spaced typescript on A4 paper and a diskette containing all the material in the article must be included. Words to be set in italic type, i.e. Latin names of species and genera, as well as symbols for the values of variables, should be underlined with a wavy line (~~~~~). No other underlining should be used.

In the papers from categories 1 and 2, the following order is required:

1. **Title:** brief (up to 100 characters).
2. **First and last name of the author and the name of the affiliated institution.**
3. An **abstract** must precede every scientific paper, research report and other paper; length – one typewritten page at the most.
4. **Key words:** a few terms which enable a given paper to be found among computer files.
5. **Text.** The length of the typescript of papers from category 1 should not exceed 40 pages, and papers from category 2 – 15 pages. In papers from categories 1 and 2, the traditional division is used: 1) introduction, 2) materials and methods, 3) results, 4) discussion, 5) references. The results of measurements should be given in metric system units and their abbreviations should comply with the International System of Unit (SI).
6. **Acknowledgments** should be limited to the necessary minimum (the initials and the last name of the person they are addressed to, without listing scientific titles or names of institutions).
7. **References** should be put in alphabetical order, with the year of publication directly after the author's name and should list solely the papers referred to in the text. (e.g. Smith 1990). Titles of journals – in full form. Titles of papers – in the original language. The exception is titles in Russian which are in a non-Latin alphabet, such as Cyrillic, which should be translated into either English or Polish.

8. **Footnotes** should be marked with Arabic numerals in superscript (...¹), and numbered in succession throughout the text, except for tables; footnote content should be on separate sheets of paper.

9. **Tables** should supplement, not duplicate, data contained in the text or figures. Tables should be numbered and each one should be on a separate sheet of paper. All tables must have titles; all references to them should be placed within the text. Each column in a table is supplied with a heading, explaining the content of the column. Footnotes in tables should be marked with letters in italics, in superscript (e. g. Years^a), and their explanation should be placed under the table.

10. **Figures.** Successive numeration with a reference to each number in the text should be used. Captions must be on a separate sheet of paper. Abbreviations, terms and symbols used in figures must correspond to those used in the text. After scaling, each figure, placed on a separate sheet of paper and marked with a successive number and the author's name, must fit into a column of the *Bulletin*; this should be taken into account by using the appropriate thickness of lines and size of legends in the figures. Only computer generated figures are acceptable. Both a printout and a diskette are required. Papers can be illustrated with photographs in black and white or color. The total content of drawings and photographs must not exceed 30% of the paper.

SAVING TEXT ONTO DISKETTE

Files should be saved on diskette in a format which can be opened by our editorial office. The preferred format is Word for Windows. Please save computer generated figures on diskette in the format which they were created.

REVIEWS

Upon receiving a review, the authors is obliged to revise the paper and to explain in writing which of the reviewer's suggestions he or she has taken into account, and what he or she disagrees with and why.

PROOF-READING

A ten day limit is given for proofreading. At this stage no changes in text content are allowed and only technical corrections will be accepted.

PRESENTATION COPIES

Each author published in categories 1, 2 and 3 receives one copy of the *Bulletin*; the authors of the papers from category 1 additionally receive ten offprints of their paper, and from category 2 – five.

Editorial Office Address:
**Center for Scientific Information and Publishing
Sea Fisheries Institute
Kollątaja 1, 81-332 Gdynia, Poland**

WSKAZÓWKI DLA AUTORÓW

INFORMACJE OGÓLNE

The Bulletin of the Sea Fisheries Institute jest czasopi-
smem naukowym, przyjmującym prace z całego świata.
Autorzy obcojęzyczni proszeni są o składanie prac w ję-
zyku angielskim, pracownicy MIR – języku polskim, a
pozostali autorzy – w języku polskim i angielskim.

Prace złożone klasyfikowane są według trzech kate-
gorii: 1) artykuły naukowe, 2) noty, 3) varia.

O przyjęciu pracy i zakwalifikowaniu jej do określo-
nej kategorii decyduje Zespół Redakcyjny. Prace przy-
jęte do druku nie mogą być publikowane w innym cza-
sopiśmie. Publikacja jest bezpłatna.

FORMA MASZYNOPISU

Prace należy składać w 2 egzemplarzach maszynopisu
pisanego jednostronnie, formatu A4, z podwójnym od-
stępem (konieczna jest dyskietka z całością materiału).
Słowa, które powinny być złożone drukiem pochyłym
(kursywą), tzn. łacińskie nazwy gatunków i rodzajów
oraz symbole wielkości zmiennych należy podkreślić
wężykiem (~~~~~). Innych podkreśleń nie należy sto-
sować.

W pracach kategorii 1 i 2 obowiązuje następująca
kolejność:

1. Tytuł: krótki (do 100 znaków).

**2. Imię i nazwisko autora oraz nazwa i adres instytu-
cji macierzystej.**

3. Abstrakt musi poprzedzać każdy artykuł naukowy i
notę; objętość – najwyżej 1 strona maszynopisu.

4. Słowa kluczowe: kilka pojęć pozwalających na od-
szukanie danej pracy w systemach komputerowych.

5. Tekst. Objętość maszynopisu prac kategorii 1 nie
powinna przekraczać 40 stron, a kategorii 2 – 15 stron.
W pracach kategorii 1 i 2 stosuje się tradycyjny podział:
1) wstęp, 2) materiał i metoda badań, 3) wyniki badań,
4) dyskusja, 5) bibliografia. Wyniki pomiarów należy
podawać w jednostkach miar przyjętych w systemie me-
trycznym, a ich skróty – zgodnie z Międzynarodowym
Układem Jednostek Miar (SI).

6. Podziękowania należy ograniczyć do niezbędnego mi-
nimum (inicjały imienia i nazwisko osoby, do której są
adresowane, bez wymieniania tytułów naukowych i nazw
instytucji).

7. Bibliografię należy zestawiać w porządku alfabetycz-
nym, podając bezpośrednio po nazwiskach autorów rok
wydania i wymieniając tylko prace cytowane w tekście
(np. Kowalski 1990). Tytuły czasopism – w pełnym
brzmieniu. Tytuły prac – w językach oryginału (z wyjąt-
kiem tytułów w języku rosyjskim wydrukowanych alfa-
betem niełacińskim, np. cyrylicą, które należy przetłu-
maczyć na język polski lub angielski).

8. Przypisy oznacza się cyfrą arabską we frakcji górnej
(...) i numeruje kolejno w całym tekście, z wyjątkiem
tabel; treść przypisów – na osobnych stronach.

9. Tabele są dodatkowym źródłem informacji; nie nale-
ży powtarzać w nich danych występujących w tekście
lub na rysunkach. Tabele numerowane, każda na osob-
nej stronie, muszą mieć tytuł; powołanie na nie należy
umieścić w tekście. Każdą kolumnę w tabeli opatrzyć
się tzw. „główką” wyjaśniającą zawartość kolumny. Przy-
pisy w tabelach należy oznaczyć literami, kursywą, we
frakcji górnej (np. Lata^a), a ich objaśnienie umieścić pod
tabelą.

10. Ilustracje. Obowiązuje kolejna numeracja z przy-
wołaniem każdego numeru w tekście. Podpisy pod ilu-
stracjami – na osobnej kartce. Stosowane na rysunkach
skrótów, terminy i symbole muszą odpowiadać użytym w
tekście. Każdy rysunek, umieszczony na osobnej kartce
oraz opisany kolejnym numerem i nazwiskiem autora,
po wyskalowaniu musi zmieścić się w kolumnie; trzeba
to uwzględnić stosując odpowiednią grubość linii i wiel-
kość opisów na rysunkach. Redakcja przyjmuje wyłącz-
nie rysunki wykonane techniką komputerową (konieczny
wydruk i dyskietka). Prace można ilustrować foto-
grafiami (mogą być kolorowe). Łączna objętość rysun-
ków i zdjęć nie może przekraczać 30% objętości pracy.

ZAPIS TEKSTU NA DYSKIETCE

Plik powinien być zachowany na dyskietce w takim for-
macie, aby umożliwić odczytanie go w programach przez
nas stosowanych. Preferowanym formatem jest Word for
Windows. Rysunki wykonane techniką komputerową
prosimy zapisywać na dyskietce w formacie wykonania.

RECENZJE

Po otrzymaniu recenzji autor jest zobowiązany do po-
prawienia pracy i wyjaśnienia na piśmie, co uwzględnił
z sugestii recenzenta, a z czym się nie zgadza i dlaczego.

KOREKTA AUTORSKA

Na wykonanie i odesłanie korekty autorskiej przewiduje
się termin 10-dniowy. Na tym etapie nie należy dokony-
wać zmian autorskich w tekście, a jedynie poprawić uster-
ki techniczne.

EGZEMPLARZE AUTORSKIE

Każdy autor opublikowanego artykułu otrzymuje 1 eg-
zemplarz czasopisma, autorzy prac kategorii 1 otrzymu-
ją ponadto 10 nadtępek swej pracy; kategorii 2 – 5 nad-
tępek.

Adres Redakcji:

Ośrodek Informacji Naukowej i Wydawnictw
Morski Instytut Rybacki
ul. Kołłątaja 1, 81-332 Gdynia,
tel.: 058 620 17 28 (centrala).



Marine Ecosystem Management of the Baltic and Other Regions

Kenneth Sherman

Northeast Fisheries Science Center, Narragansett, RI 02882, USA

Abstract. A new paradigm is emerging that advocates an ecosystem-based approach to the assessment and management of Baltic Sea resources. The principles adopted by coastal nations under the terms of the United Nations Convention for the Law of the Sea (UNCLOS) have been interpreted as supportive of the management of living marine resources and coastal habitats from an ecosystems perspective. In addition, Chapter 17 of Agenda 21 adopted at the Earth Summit and the Global Program of Action (GPA) for the Protection of the Marine Environment from Land Based Activities both adopt an ecosystems perspective for holistic management of habitat, pollution discharges, and living marine resources. A “global common understanding” on the management of coastal and marine resources was elaborated by the Global Environment Facility (GEF) in 1998. The application of these principles is being introduced to the nine countries bordering on the Baltic Sea ecosystem with a GEF-funded project to be initiated in 2001. The strategic elements have been organized into five modules focused on the key indicators of ecosystem change important to adaptive resource management. The modules are focused on Baltic Sea productivity, fish and fisheries, pollution and ecosystem health, socioeconomic conditions, and resource governance practices. The project is centered about the activities of the five countries provided with financial assistance under the terms of the GEF grant – Estonia, Latvia, Lithuania, Poland, and Russia. These countries will be working in close collaboration with western Baltic countries, the Helsinki Commission (HELCOM), the International Council for the Exploration of the Sea (ICES), the International Baltic Sea Fisheries Commission (IBSFC), the World Wildlife Fund (WWF), the National Oceanic and Atmospheric Administration (NOAA), the Swedish International Development Administration (SIDA), and other institutions on assessment and management actions to promote ecosystem sustainability and continuing socioeconomic benefits to the people of the region.

Keywords: large marine ecosystems, productivity, fish and fisheries, ecosystem health, socioeconomics, governance, sustainability, ecosystem-based management

NEED FOR SUSTAINABLE MARINE RESOURCES

The sustainability, health, and biomass yields of marine resources can be enhanced by the implementation of a more holistic, ecologically-based strategy for assessing, monitoring, and managing coastal ecosystems than has been generally practiced during most of this century. A major milestone was reached in advancing toward such a strategy when leaders of the majority

of coastal nations of the world endorsed the declaration made at the United Nations Conference on Environment and Development (UNCED) in 1992 to: (1) prevent, reduce, and control degradation of the marine environment to maintain and improve its life support and productive capacities; (2) develop and increase the potential of marine living resources to meet human nutritional needs as well as social, economic, and development goals; and (3) promote integrated management and sustainable development of coastal areas and the marine environment.

The principles adopted by coastal nations under the terms of the United Nations Convention for the Law of the Sea (UNCLOS) have been interpreted as supportive of the management of living marine resources and coastal habitats from an ecosystems perspective (Belsky 1989). In addition, Chapter 17 of Agenda 21 adopted at the Earth Summit and the Global Program of Action (GPA) for the Protection of the Marine Environment from Land Based Activities both adopt an ecosystems perspective for holistic management of habitat, pollution discharges, and living marine resources. However, to date no single international institution has been empowered to monitor the changing ecological states of marine ecosystems and to reconcile the needs of individual nations with those of the community of nations in taking appropriate management actions (Myers 1990). In this regard, the need for a regional approach to implement resource monitoring, and management in support of marine resources development and sustainability at less than the global level has been recognized from a strategic perspective (Taylor and Groom 1989). This approach has been termed a "global common understanding" on the management of coastal and marine resources and was elaborated by the Global Environment Facility (Duda and Cruz 1998). The application of these principles based on the introduction of strategic elements organized into five modules focused on productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance is being introduced to the nine countries bordering on the Baltic Sea ecosystem with a GEF-funded project to be initiated in 2001. The eastern Baltic countries of Estonia, Latvia, Lithuania, Poland, and Russia are the principal recipients of the GEF funds. The project will be provided with scientific, technological, and management assistance by HELCOM, ICES, and IBSFC in collaboration with NOAA, SIDA, and the European Union (EU).

THE LARGE MARINE ECOSYSTEM CONCEPT

An ecological framework that is being used to assist a number of coastal nations achieve the UNCED objectives is the large marine ecosystem (LME) concept. LMEs are areas being subjected to increasing stress from growing exploitation of fish and other renewable resources, coastal zone damage, habitat losses, river basin runoff, dumping of urban wastes, and fallout from aerosol contaminants. LMEs are regions of ocean space encompassing coastal areas from river basins and estuaries on out to the seaward boundary of continental shelves and the seaward margins of coastal current systems. They are relatively large regions on the order of 200,000 km² or more, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations. The theory, measurement, and modeling relevant to monitoring the changing states of LMEs are based on the concept of ecosystems with multiple steady states, and the formation and diffusion of biogeophysical patterns associated with ecosystem change (Mangel 1991; AAAS 1993; Levin 1993).

Global Environment Facility

In 1990, two years before the Rio Summit on environment and development, the Global Environment Facility (GEF) was established as a pilot program to test new approaches and innovative ways to respond to global environmental challenges in four focal areas: (1) climate change, (2) biodiversity conservation, (3) ozone depletion, and (4) international waters. In 1994, the GEF was transformed from its pilot phase into a permanent financial mechanism. Its \$2 billion trust fund is open to universal participation (currently 161 countries) and builds upon the partnership between the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank – which are its implementing agencies.

In restructuring the GEF, participating governments sought to ensure that it fully embodied the principles that were set out in the UNCED conventions as well as Agenda 21. The GEF serves as a mechanism for international cooperation for the purpose of providing new and additional grant funding to meet costs of measures that achieve global environmental benefits. In October 1995, the GEF Council adopted an operational strategy which represents the framework for actions of the GEF in its four focal areas. According to the strategy's principles, the GEF will fund projects and programs that are country-driven and based on national priorities designed to support sustainable development.

Under the GEF Operational Strategy related to international waters, the explicitly stated goal of the project grants is “to assist countries in the ways that human activities are conducted in the different economic sectors so that the particular coastal/marine waters shared by several countries or a multi-country drainage basin can sustainably support new patterns of human activities.” Marine-related projects are focused on seriously threatened water bodies using LMEs as an organizing framework. The focus of the GEF international waters project in the Baltic Sea is on the most serious transboundary stressors on ecosystems shared by several countries. Consequently, priority is placed on country-based reforms of sectoral policies and activities responsible for the most serious transboundary environmental problems (GEF 1997). An ecosystem approach to resources development, management, and sustainability in coastal oceans has been adopted by the GEF. The GEF's International Waters focal area is assisting recipient countries around the globe in supporting incremental costs for innovative projects to improve the assessment and management of LMEs and increase the socioeconomic benefits to be derived from their resources.

MODULAR ASSESSMENT STRATEGY

Based on information obtained from 33 LME case studies, a modular strategy has been developed to provide information for the monitoring, assessment, and management of LMEs. The modules are focused on ecosystem (1) productivity, (2) fish and fisheries, (3) pollution and health, (4) socioeconomic conditions, and (5) governance protocols.

Productivity Module

Productivity can be related to the carrying capacity of an ecosystem for supporting fish resources (Pauly and Christensen 1995). Recently, scientists have reported that the maximum global

level of primary productivity for supporting the average annual world catch of fisheries has been reached, and further large-scale “unmanaged” increases in fisheries yields from marine ecosystems are likely to be at lower trophic levels in the marine food chain (Beddington 1995). Evidence of this effect appears to be corroborated by recent changes in the species composition of the fisheries catches from the East China Sea LME (Chen and Shen 1999). Measuring ecosystem productivity also can serve as a useful indication of the growing problem of coastal eutrophication (NSQSR 1993). In several LMEs, excessive nutrient loadings of coastal waters have been related to algal blooms implicated in mass mortalities of living resources, emergence of pathogens (e.g., cholera, vibrios, red tides, paralytic shellfish toxins), and explosive growth of nonindigenous species (Epstein 1993).

The ecosystem parameters measured in the productivity module are zooplankton biodiversity and information on species composition, zooplankton biomass, water column structure, photosynthetically active radiation (PAR), transparency, chlorophyll-*a*, NO₂, NO₃, and primary production. Plankton of LMEs have been measured by deploying Continuous Plankton Recorder (CPR) systems monthly across ecosystems from commercial vessels of opportunity over decadal time scales (Jossi and Goulet 1993; Planque and Taylor 1998). Advanced plankton recorders can be fitted with sensors for temperature, salinity, chlorophyll, nitrate/nitrite, petroleum, hydrocarbons, light, bioluminescence, and primary productivity (Aiken *et al.* 1999), providing the means to monitor changes in phytoplankton, zooplankton, primary productivity, species composition and dominance, and long-term changes in the physical and nutrient characteristics of the LME and in the biofeedback of plankton to the stress of environmental change.

The Fish and Fisheries Module

Changes in biodiversity among the dominant species within fish communities of LMEs have resulted from excessive exploitation (Sissenwine and Cohen 1991), naturally occurring environmental shifts in climate regime (Bakun 1993), or coastal pollution (Mee 1992). Changes in the biodiversity of a fish community can generate cascading effects up the food chain to apex predators and down the food chain to plankton components of the ecosystem (Payne *et al.* 1990). These three sources of variability in fisheries yield are operable in most LMEs. However, they can be described as primary, secondary, and tertiary driving forces in fisheries yields, contingent on the ecosystem under investigation. For example, in the Humboldt Current, Benguela Current, and California Current LMEs, the primary driving force influencing variability in fisheries yield is the influence of changes in upwelling strength (Crawford *et al.* 1989; Alheit and Bernal 1993; Bakun 1999); fishing and pollution effects are secondary and tertiary effects on fisheries yields. In continental shelf LMEs, including the Yellow Sea and Northeast United States Shelf, excessive fisheries effort has caused large-scale declines in catch and changes in the biodiversity and dominance in the fish community (Sissenwine 1986; Tang 1993). In these ecosystems, pollution and environmental perturbation are of secondary and tertiary influence. In contrast, significant coastal pollution and eutrophication have been the principal factors driving changes in fisheries yields of the Northwest Adriatic (Bombace 1993), Black Sea (Mee 1992), and near-coastal areas of the Baltic Sea (Kullenberg 1986). Overexploitation and natural environmental changes are of secondary and tertiary importance. Consideration of the driving forces of change in biomass yield based on multi-year time-series data is important when developing options for management of living marine resources for long-term sustainability.

The Fish and Fisheries module includes fisheries-independent bottom-trawl surveys and acoustic surveys for pelagic species to obtain time-series information about changes in fish biodiversity and abundance levels. Standardized sampling procedures, when deployed from small calibrated trawlers, can provide important information on diverse changes in fish species. Fish catch provides biological samples for stock assessments, stomach analyses, age, growth, fecundity, and size comparisons (ICES 1991); data for clarifying and quantifying multispecies trophic relationships; and the collection of samples for monitoring coastal pollution. Samples of trawl-caught fish can be used to monitor pathological conditions that may be associated with coastal pollution. Trawlers also can be used as platforms for obtaining samples of water, sediment, and benthos for monitoring harmful algal blooms, vectors of viral diseases, eutrophication, anoxia, and changes in benthic communities.

Pollution and Ecosystem Health Module

In several LMEs, pollution has been a principal driving force in changes of biomass yields. Assessing the changing status of pollution and health of the entire LME is scientifically challenging. Ecosystem "health" is a concept of wide interest for which a single precise scientific definition is problematical. Methods to assess the health of LMEs are being developed from recent modifications to a series of indicators and indices as described by Costanza and Mageau (1999). The overriding objective is to monitor changes in health from an ecosystem perspective as a measure of the overall performance of a complex system (Costanza 1992). The health paradigm is based on multiple-state comparisons of ecosystem resilience and stability (Pimm 1984; Holling 1986; Costanza 1992) and is an evolving concept.

Following the definition of Costanza and Mageau (1999), to be healthy and sustainable, an ecosystem must maintain its metabolic activity level and its internal structure and organization, and must resist external stress over time and space scales relevant to the ecosystem. These concepts have been discussed earlier by panels of experts at two NOAA workshops convened in 1992 (NOAA 1993). Five of the indices discussed by the participants are being considered as experimental measures of changing ecosystem states and health: (1) biodiversity; (2) stability; (3) yields; (4) productivity; and (5) resilience (Sherman and Solow 1992). Data from which to derive the experimental indices are obtained from time-series monitoring of key ecosystem parameters. The ecosystem sampling strategy is focused on parameters relating to resources at risk of overexploitation, species protected by legislative authority (marine mammals), and other key biological and physical components at the lower end of the food chain (plankton, nutrients, hydrography). The parameters of interest are described in Sherman (1994) and Sherman and Duda (1999).

Fish, benthic invertebrates, and other biological indicator species are used in the Pollution and Ecosystem Health module to measure pollution effects on the ecosystem, including the bivalve monitoring strategy of "Mussel-Watch;" the pathobiological examination of fish; and the estuarine and nearshore monitoring of contaminants and contaminant effects in the water column, substrate, and in selected groups of organisms (NOAA 1998; Wade *et al.* 1998). The routes of bioaccumulation and trophic transfer of contaminants are assessed, and critical life history stages and selected food chain organisms are examined for parameters that indicate exposure to and the effects of contaminants. Effects of impaired reproductive capacity, organ disease, and impaired growth from contaminants are measured (Myers *et al.* 1998). Assessments are made of contaminant impacts at the individual species and population levels. Implementation of protocols to assess the frequency and effect of harmful algal blooms (Smayda 1991) and emergent diseases (Epstein 1993) are included in the pollution module.

The Socioeconomic Module

This module is characterized by emphasis on practical applications of scientific findings in managing an LME and on the explicit integration of economic analysis with science-based assessments to assure that prospective management measures are cost-effective. Economists and policy analysts will need to work closely with ecologists and other scientists to identify and evaluate management options that are both scientifically credible and economically practical with regard to the use of ecosystem goods and services (Hanna 1998).

Designed to respond adaptively to enhanced scientific information, socioeconomic considerations and management approaches must be closely integrated with the science. This component of the LME approach to marine resources management, developed by the late James Broadus, former Director of the Marine Policy Center, Woods Hole Oceanographic Institution, consists of six interrelated elements:

(1) **Human forcing functions**

The natural starting point is a generalized characterization of ways in which human activities affect the natural marine system and the expected “sensitivity” of these forcing functions to various types and levels of human activity. Population dynamics, coastal development, and land use practices in the system’s drainage basin are clear examples. Work integrating the efforts of natural and social scientists should concentrate further on resolving apparent effects (such as eutrophication-associated red tide events or changing fish population structures) that are confounded by cycles or complex dynamics in the natural system itself. Progress is possible, too, in achieving better characterizations of the way in which human activities affecting ecosystems are mediated by alternate management options. Emphasis should be on isolating and quantifying those forcing activities (sewage discharge, agricultural runoff, fishing effort) likely to be expressed most prominently in effects on the natural system.

(2) **Assessing Impacts**

Another natural element in the systemic approach is to estimate and even predict the economic impacts of unmanaged degradation in a natural system and, conversely, the expected benefits of management measures. Such assessment is a form of standard benefit-cost analysis, but it requires scientific information to describe the effects of human forcing so they may be quantified in economic terms. Initial analysis should focus on the social and economic sectors likely to experience the largest impacts: fishing, aquaculture, public health, recreation, and tourism.

(3) **Feedbacks**

Collaborative effort between resource management agencies and stakeholders also should be devoted to reviewing the results of analyses used in identifying and estimating the feedbacks of economic impacts into the human forcing function. For example, extensive coastal eutrophication associated with coastal development and runoff might reduce the suitability of coastal areas for aquaculture production and increase their exposure to red tide damage, thereby putting a premium on capture fishery and increasing pressure on wild stocks. Similar feedback, both negative and positive, should be addressed and expressed in economic terms for all the major sectors.

(4) **Ecosystem Service/The Value of Biodiversity**

Special consideration should be given to improved knowledge of how the natural system generates economic values. Many valuable services provided by natural systems are not traded in markets or included in planning evaluations, so extra care must be taken to assure they are not sacrificed through ignorance. The services provided by coastal wetlands as nurseries for fisheries, natural pollution filters, and storm buffers are well-known examples particularly relevant to coastal reclamation activities now underway by NOAA and other federal and state agencies. Other examples are more subtle, including the importance of predator-prey relationships and the possibility of losing unrecognized “keystone” species in a valuable ecosystem. Experience indicates that growing economic values of aesthetic and recreational or tourism amenities are to be expected in LMEs. Various sources of economic value arising from the natural diversity of the LME should be identified and assessed in regard to existing uses and potential management innovations.

(5) **Environmental Economics**

Many of the elements described in this section comprise topics in Environmental Economics. Specialists in that field attempt to estimate the economic values (both use and non-use) associated with environmental resources and to identify conditions associated with their optimal management (to derive the greatest net benefits for society). An important element is the collaboration between scholars from developing and developed nations to transfer and adapt to the needs and techniques of Environmental Economics.

(6) **Integrated Assessment**

The ultimate objective is the integration of all the results achieved above, with scientific characterizations of the LME, into a comprehensive analytic framework (decision support environment) that will permit integrated assessment of human practices, effects, and management options in the region. Such work is at the forefront of recent research on the human dimensions of global environmental change as well as research on human interactions with natural marine systems.

Governance Module

The Governance module is evolving based on case studies now underway among ecosystems to be managed from a more holistic perspective than generally practiced in the past. In projects supported by the Global Environmental Facility (GEF) – for the Yellow Sea ecosystem, the Gulf of Guinea LME, and the Benguela LME – agreements have been reached among the environmental ministers of the countries bordering these LMEs to enter into joint resource assessment and management activities. Among other LMEs, the Great Barrier Reef ecosystem is being managed from an holistic ecosystems perspective (Kelleher 1993) along with the Northwest Australian Continental Shelf ecosystem (Sainsbury 1988) being managed by the state and federal governments of Australia. The Antarctic marine ecosystem is being managed from an ecosystem perspective under the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and its 21-nation membership (Scully 1993). Movement toward ecosystems management is emerging for the North Sea (NSQSR 1993), Barents Sea (Eikeland 1992), Black Sea (Hey and Mee 1993) and Baltic Sea. Recent reports have examined options

for improving linkages between the science-based Fish and Fisheries and Ecosystem Health modules to the Socioeconomic (Sutinen *et al.* 1998) and Governance modules (Juda 1999).

SUSTAINING COASTAL OCEANS

The degradation of our planet's water ecosystems is no surprise. Over the years, more and more information on the declining status of freshwater and marine biodiversity has become available. What is new is that the situation has declined so much in both the North and the South that continued economic and social benefits from these systems are at risk. Gradually, shared river basins, coastal areas, and large marine ecosystems have become degraded and benefits they have provided may not be sustained into the future. Gradually, national problems are growing into larger ones to the point they become regionally and globally significant.

The call has gone out through global and regional treaties to adopt new joint management regimes so that sustainability of our marine resources can be assured for future generations. Simplified approaches are necessary where information and management capacity are inadequate. An LME-Integrated Coastal Management approach now being tested in Asian coastal waters is a response to this need (Sherman 1998). In addition, the GEF Operational Strategy and its support for the 10 projects related to LMEs in the developing world, place a premium on mobilizing sound science to provide information for improved management practices.

The transboundary analysis used by the GEF can simply be framed as the productivity, fish/fisheries, and pollution/ecosystem health modules used for LMEs in North America. Likewise, the Strategic Action Programs (SAPs) of projects supported by the GEF focus on the socioeconomic and governance modules for LMEs. These modules are important. They serve to leverage country commitments for implementing necessary policy, legal, and institutional reforms so that socioeconomic benefits from environmental services of the ecosystem can be sustained for future generations. Science-based assessments have a role as the governance mechanism utilizes monitoring/assessment modules to ensure programs and policies are sustaining the marine resources.

Efforts are underway to determine the effectiveness of the simplified modules necessary to sustain LMEs, including the Baltic Sea LME. The objectives of the Baltic Project are (1) to overcome short-term sector by sector attempts to manage resources and environments that do not, at present, consider the importance of multiple interactions between resource use, human interventions, and environmental variability, and (2) to demonstrate the importance and utility of an ecosystem-based system of new and innovative methodologies for assessing the changing states of LMEs, and implementing actions that consider whole ecosystem effects and optimize socioeconomic benefits to the Baltic community of stakeholders.

The Baltic Sea LME project is being coordinated by Dr. Jan Thulin on behalf of ICES with both western Baltic countries (Sweden, Denmark, Finland, Germany) and eastern Baltic countries (Poland, Estonia, Latvia, Lithuania, and Russia). One of the unique features of the project is the effort to link the Baltic LME component with a parallel effort supported by the GEF and World Bank to assess and mitigate the effects of agricultural non-point source runoff of nutrients on the growing problem of near-coastal eutrophication, coincident harmful algal blooms, and changes in biodiversity of the fish community.

With the post-UNCED recognition of global environmental degradation, it is time for renewed regional efforts to address the sustainability and development of marine resources and ecosystems. It is now incumbent on industrial nations, international finance institutions, and the UN system to take leadership in forming new partnerships among governments, business interests, academia, and the public to resolve international transboundary resource sustainability problems. Their responsibility does not end there. They will be called on to provide additional funding and technology to catalyze the participation of developing nations in sustaining transboundary marine resources as part of a commitment to sustainable development by the global community of nations.

REFERENCES

- AAAS (American Association for the Advancement of Science). 1993. *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington, DC. 376 p.
- Aiken, J., R. Pollard, R. Williams, G. Griffiths, and I. Bellan. 1999. Measurements of the upper ocean structure using towed profiling systems. *In*: K. Sherman and Q. Tang, eds. *Large Marine Ecosystems of the Pacific Rim: Assessment, Sustainability, and Management*. Blackwell Science, Inc. Malden, MA. 346-362.
- Alheit, J. and P. Bernal. 1993. Effects of physical and biological changes on the biomass yield of the Humboldt Current ecosystem. *In*: K. Sherman, L.M. Alexander, and B.D. Gold, eds. *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington DC. 53-68.
- Bakun, A. 1993. The California Current, Benguela Current and Southwestern Atlantic Shelf ecosystems: a comparative approach to identifying factors regulating biomass yields. *In*: K. Sherman, L.M. Alexander, and B.D. Gold, eds. *Large Marine Ecosystems: Stress, Mitigation and Sustainability*. AAAS Press, Washington DC. 199-221.
- Bakun, A. 1999. A dynamical scenario for simultaneous regime-scale marine population shifts in widely separated LMEs of the Pacific. *In*: K. Sherman and Q. Tang, eds. *Large Marine Ecosystems of the Pacific Rim: Assessment, Sustainability, and Management*. Blackwell Science, Inc. Malden, MA. 2-26.
- Beddington, J.R. 1995. The primary requirements. *Nature* 374:213-214.
- Belsky, M.H. 1989. The ecosystem model mandate for a comprehensive United States ocean policy and law of the sea. *San Diego L. Rev.* 26(3): 417-495.
- Bombace, G. 1993. Ecological and fishing features of the Adriatic Sea. *In*: K. Sherman, L.M. Alexander, and B.D. Gold, eds. *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington DC. 119-136.
- Chen, Y. and X. Shen. 1999. Changes in the Biomass of the East China Sea Ecosystem. *In*: K. Sherman and Q. Tang, eds. *Large Marine Ecosystems of the Pacific Rim: Assessment, Sustainability, and Management*. Blackwell Science, Inc. Malden, MA. 221-239.
- Costanza, R. 1992. Toward an operational definition of ecosystem health. *In*: R. Costanza, B.G. Norton, and B.D. Haskell, eds. *Ecosystem Health: New Goals for Environmental Management*. Island Press, Washington DC. 239-256.
- Costanza, R. and M. Mageau. 1999. What is a healthy ecosystem? *In*: H. Kumpf, K. Steidinger, and K. Sherman, eds. *The Gulf of Mexico Large Marine Ecosystem: Assessment, Sustainability, and Management*. Blackwell Science, Inc. Malden, MA. 385-415.
- Crawford, R.J.M., L.V. Shannon, and P.A. Shelton. 1989. Characteristics and management of the Benguela as a large marine ecosystem. *In*: K. Sherman and L.M. Alexander, eds. *Biomass Yields and Geography of Large Marine Ecosystems*. AAAS Selected Symposium 111. Westview Press, Inc. Boulder CO. 169-219.

- Duda, A.M. and M.C.J. Cruz. 1998. Partnerships to sustain international waters. Report in Valuing the Global Environment: Actions & Investments for a 21st Century. Washington DC: Global Environment Facility [ISBN No. 1-884122-28-0].
- Eikeland, P.O. 1992. Multispecies Management of the Barents Sea Large Marine Ecosystem: A Framework for Discussing Future Challenges. The Fridtjof Nansen Institute, Polhogda, Postboks 326, Fridtjof Nansens vei 17, N-1324 Lysaker, Norway.
- Epstein, P.R. 1993. Algal blooms and public health. *World Resource Review*. 5(2): 190-206.
- GEF (Global Environment Facility). 1997. GEF Operational Programs. Global Environment Facility, Washington DC.
- Hanna, S.S. 1998. Institutions for marine ecosystems: economic incentives and fishery management. *Ecological Applications* 8(1): 170-174.
- Hey, E. and L.D. Mee. 1993. Black Sea. The ministerial declaration: an important step. *Environmental Pollution Law*, 2315: 215-217, 235-236.
- Holling, C.S. 1986. The resilience of terrestrial ecosystems: local surprise and global change. *In*: W.C. Clark and R.E. Munn, eds. *Sustainable Development of the Biosphere*. Cambridge University Press, London. 292-317.
- ICES (International Council for the Exploration of the Sea). 1991. Report of the Multispecies Assessment Working Group. ICES C.M. 1991/Assess 7.
- Jossi, J.W. and J.R. Goulet Jr. 1993. Zooplankton trends: U.S. north-east shelf ecosystem and adjacent regions differ from north-east Atlantic and North Sea. *ICES Journal of Marine Science*. 50: 303-313.
- Juda, L. 1999. Considerations in developing a functional approach to the governance of large marine ecosystems. *Ocean Development and International Law* Vol. 30(2), 89-125.
- Kelleher, G. 1993. Sustainable development of the Great Barrier Reef as a large marine ecosystem. *In*: K. Sherman, L.M. Alexander, and B.D. Gold, eds. *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington DC. 272-279.
- Kullenberg, G. 1986. Long-term changes in the Baltic Ecosystem. *In*: K. Sherman and L.M. Alexander, eds. *Variability and Management of Large Marine Ecosystems*. AAAS Selected Symp. 99. Westview Press, Inc., Boulder. 19-32.
- Levin, S.A. 1993. Approaches to forecasting biomass yields in large marine ecosystems. *In*: K. Sherman, L.M. Alexander, and B.D. Gold, eds. *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington DC. 36-39.
- Mangel, M. 1991. Empirical and theoretical aspects of fisheries yield models for large marine ecosystems. *In*: K. Sherman, L.M. Alexander, and B.D. Gold, eds. *Food Chains, Yields, Models, and Management of Large Marine Ecosystems*. Westview Press. Boulder, CO. 243-261.
- Mee, L. 1992. The Black Sea in crisis: a need for concerted international action. *Ambio*. 21(4): 1278-1286.
- Myers, M.S., L.L. Johnson, O.P. Olson, C.M. Stehr, B.H. Horness, T.K. Collier and B.B. McCain. 1998. Toxicopathic hepatic lesions as biomarkers of chemical contaminant exposure and effects in bottomfish species from the Northeast and Pacific coasts. *Mar. Poll. Bull.* 37(1,2): 92-113.
- Myers, N. 1990. Working towards one world. Book review. *Nature* 344(6266): 499-500.
- NOAA (National Oceanic and Atmospheric Administration). 1993. Emerging Theoretical Basis for Monitoring the Changing States (Health) of Large Marine Ecosystems. Summary Report of Two Workshops: 23 April 1992, National Marine Fisheries Service, Narragansett, Rhode Island, and 11-12 July 1992, Cornell University, Ithaca, New York. NOAA Technical Memorandum NMFS-F/NEC-100. Northeast Fisheries Science Center, Woods Hole MA.
- NOAA. 1998. National Status and Trends Program for Marine Environmental Quality. NS&T Program, NOAA. Silver Spring, MD. 32p.
- NSQSR (North Sea Quality Status Report). 1993. Oslo and Paris Commissions. London. Olsen and Olsen, Fredensborg, Denmark. 132+vi pp.
- Pauly, D. and V. Christensen. 1995. Primary production required to sustain global fisheries. *Nature*. Vol. 374: 255-257.

- Payne, P.M., D.N. Wiley, S.B. Young, S. Pittmann, P.J. Clapham, and J.W. Jossi. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. *Fisheries Bulletin of the U.S.* 88: 687-696.
- Pimm, S.L. 1984. The complexity and stability of ecosystems. *Nature* 307: 321-326.
- Planque, B. and A.H. Taylor. 1998. Long-term changes in zooplankton and the climate of the North Atlantic. *ICES Journal of Marine Science* 55(4): 644-654.
- Sainsbury, K.J. 1988. The ecological basis of multispecies fisheries, and management of a demersal fishery in tropical Australia. *In: J.A. Gulland, ed. Fish Population Dynamics*, 2nd edition. John Wiley and Sons, New York. 349-382.
- Scully, R.T. 1993. Convention on the conservation of Antarctic marine living resources. *In: K. Sherman, L.M. Alexander, and B.D. Gold, eds. Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press Washington DC. 242-251.
- Sherman, K. 1994. Sustainability, biomass yields, and health of coastal ecosystems: An ecological perspective. *Marine Ecology Progress Series* 112:277-301.
- Sherman, K. 1998. Large marine ecosystems: Assessment and management from drainage basin to ocean. *In: Proceedings: Stockholm Water Symposium, August 10-15, 1997. With Rivers to the Sea: Interaction of Land Activities, Fresh Water and Enclosed Coastal Seas*. Stockholm, Sweden: International Water Institute, SIWI SE-106 36. 151-166.
- Sherman, K. and A.R. Solow. 1992. The Changing States and Health of a Large Marine Ecosystem. *In: ICES annual report 1992. CM/L38 Session V*. Copenhagen, Denmark.
- Sissenwine, M.P. 1986. Perturbation of a predator-controlled continental shelf ecosystem. *In: K. Sherman and L.M. Alexander, eds. Variability and Management of Large Marine Ecosystems*. AAAS Selected Symp. 99. Westview Press, Inc., Boulder. 55-85.
- Sissenwine, M.P. and E.B. Cohen. 1991. Resource productivity and fisheries management of the northeast shelf ecosystem. *In: K. Sherman, L.M. Alexander, and B.D. Gold, eds. Food Chains, Yields, Models, and Management of Large Marine Ecosystems*. Westview Press, Inc. Boulder. 107-123.
- Smayda, T. 1991. Global epidemic of noxious phytoplankton blooms and food chain consequences in large ecosystems. *In: K. Sherman, L.M. Alexander and B.D. Gold, eds. Food Chains, Yields, Models and Management of Large Marine Ecosystems*. Westview Press, Inc., Boulder. 275-308.
- Sutinen, J. and 15 coauthors. 1998. A framework for monitoring and assessing socioeconomics and governance of large marine ecosystems. NOAA/NMFS. Northeast Fisheries Science Center, Woods Hole MA.
- Tang, Q. 1993. Effects of long-term physical and biological perturbations on the contemporary biomass yields of the Yellow Sea Ecosystem. *In: K. Sherman, L.M. Alexander, and B.D. Gold, eds. Large Marine Ecosystems: Stress, Mitigation, and Sustainability*. AAAS Press, Washington DC. 79-93.
- Taylor, P. and A.J.R. Groom, eds. 1989. *Global issues in the United Nations framework*. MacMillan, London.
- Wade, T.L., J.L. Sericano, P.R. Gardinali, G. Wolff, and L. Chambers. 1998. NOAA's mussel watch project: Current use of organic compounds in bivalves. *Mar. Poll. Bull.* 37(1,2):20-26.

The Bulletin of the Sea Fisheries Institute *was first issued in 1970.*
Since 1992, three issues of the Bulletin have been published annually.
Papers concerned with fishery-related sciences, i. e., fishery biology,
ichthyology, physical and biological oceanography, sea-food technology and processing,
fishing gear technology and marine environment conservation issues
will be considered for publication in the Bulletin.
Prior to publication, articles are reviewed by recognized authorities in the field.

The Bulletin of the Sea Fisheries Institute *is indexed and abstracted in ASFA and FSTA.*

EDITORIAL STAFF

Editor in Chief – Tomasz B. Linkowski (Director)
Guest Editor – Kenneth Sherman
(Northeast Fisheries Science Center, Narragansett, RI, USA)
Senior Publication Officer – Elżbieta Stawska
Translators and Proof-readers – Jennifer & Tymon Zieliński
Technical Editor – Lucyna Jachimowska

SCIENTIFIC ADVISERS

E. Aro – Finnish Game and Fisheries Research Institute, Helsinki, FINLAND
P. Gasjukov – AtlantNIRO, Kaliningrad, RUSSIA
L. Hernroth – Institute of Marine Research, Lysekil, SWEDEN
E. Ojaveer – Estonian Marine Institute, Tallinn, ESTONIA
A. I. L. Payne – CEFAS, Lowestoft Laboratory, Lowestoft, UK
T. Penczak – University of Łódź, Łódź, POLAND
J. Piechura – Institute of Oceanology PAN, Sopot, POLAND
M. Protasowicki – Agricultural Academy of Szczecin, Szczecin, POLAND
K. Sherman – Northeast Fisheries Science Center, Narragansett Laboratory, Narragansett, RI, USA
J. Świniarski – Agricultural Academy of Szczecin, Szczecin, POLAND
W. Załachowski – Agricultural Academy of Szczecin, Szczecin, POLAND

EDITORIAL OFFICE ADDRESS

Sea Fisheries Institute. Scientific Information and Publishing Center
Kołłątaja 1, 81-332 Gdynia, POLAND
<http://www.mir.gdynia.pl>
e-mail: bulletin@mir.gdynia.pl

THIS JOURNAL IS SUPPORTED FINANCIALLY
by
THE STATE COMMITTEE FOR SCIENTIFIC RESEARCH, POLAND