LONGSTANDING POLISH-AMERICAN RESEARCH
OCEANS AND ATMOSPHERE

EDITED BY: MARIANNA PASTUSZAK, EMIL KUZEBSKI

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Oceans and atmosphere

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INTRODUCTION

Kenneth Sherman (in the picture below)

The joint U.S.-Polish research and assessments on marine fisheries and marine ecosystems, has encompassed an important period of transition from the general practice of single species assessments prior to 1970, to a more enlightened and effective ecosystem-based approach to fisheries science as practiced from the 1980s to the present.

On the U.S. side, changes in the broadening of the fisheries science can be attributed to the establishment of the National Oceanic and Atmospheric Administration (NOAA) in 1970 by Executive Order of President Nixon, bringing together the Weather Service, Fishery Service, and Hydrographic services in a single U.S. Government Agency designated as NOAA. During this transition period, I was detailed from 1970-1972 to the Washington D.C. Headquarters of the National Marine Fisheries Service Planning Group to develop a national strategy for the assessment and management of the nation's marine fisheries resources.

We produced, in cooperation with engineers from the Space Engineering Community, plans for implementing a national strategy for assessing fisheries, plankton, and oceanographic effects on fisheries population sustainability through a national program of surveys of trawl fisheries, pelagic fisheries, and plankton and oceanographic surveys that were funded by NOAA as the Marine Resources Monitoring Assessment and Prediction program (MARMAP). Vessels and scientists of countries fishing along the U.S. coast participated in the joint multi-disciplinary MARMAP surveys. Including Poland, the former Soviet Union, and Germany. I participated in the joint surveys as national coordinator of the MARMAP program, while located at the NOAA-Fisheries Laboratory in Narragansett, Rhode Island from 1972 and onwards.

During the period, we entered into a series of bilateral agreements with Poland that provided the opportunity to conduct joint acoustic surveys for herrings and mackerel, long line surveys of sharks and other apex predators, fish eggs and larvae (ichthyoplankton), and zooplankton, and oceanographic conditions within the spatial domain of the U.S. Northeast Shelf large marine ecosystem, extending over 260,000 km^2 from the Gulf of Maine to Cape Hatteras. The MARMAP program served as the framework leading to the five-module ecosystem-based approach on assessments of Large Marine Ecosystems (LMEs) productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance. The LME approach was made possible through several decades of cooperative studies with the Morski Instytut Rybacki.

The approach has been applied in joint U.S. Polish studies of the Antarctic LME, the Baltic Sea LME, and the LMEs along the cost of the United States, including the Northeast Shelf, the Southeast Shelf, the Gulf of Mexico, the California Current, the Gulf of Alaska, and the East Bering Sea.

Among the lasting scientific institutions resulting from this lengthy and productive collaboration is the Polish Plankton Sorting and Identification Center in Szczecin, Poland that maintains the world's longest continuous record of ichthyoplankton and zooplankton ever assembled at the scale of Large Marine Ecosystems. This is a remarkable achievement providing critical evidence of the effects of global warming on multiple marine ecosystems.

The volume titled, ***"Longstanding Polish-American Research - Oceans and Atmosphere"***, is a lasting example of the strengths generated through the cooperation in science that overcame the political constraints of the Cold War in the 1970s, through a common scientific thread in both Poland and the United States, for seeking knowledge and its application in advancing human development.

We owe a debt of gratitude to Marianna Pastuszak and the many contributors to this volume who describe the strong links and multi-decadal collaborative efforts between Polish fisheries and marine science, and U.S. fisheries and marine science during the past 50 years.

1

**ONE HUNDRED YEARS OF FISHERIES RESEARCH BY NMFRI
FIFTY YEARS OF COOPERATION BETWEEN POLAND AND THE U.S.**

*Marianna Pastuszak, Pieter Tans, Zbigniew Karnicki,
Jonathan A. Hare, Jerzy Janusz, Emil Kuzebski*

1. ONE HUNDRED YEARS OF FISHERIES RESEARCH BY NMFRI FIFTY YEARS OF COOPERATION BETWEEN POLAND AND THE U.S.

Marianna Pastuszak, Pieter Tans, Zbigniew Karnicki,
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1.1. One hundred years of Morski Instytut Rybacki (MIR) history

Morski Instutyt Rybacki (MIR) - the Sea Fisheries Institute (SFI), renamed into National Marine Fisheries Research Institute (NMFRI) in 2011, is the oldest research institution in Poland that conducts marine fisheries research. Its history goes back to the inter-war period. Its origins are connected with the date of 18th June 1921, when the Polish authorities established the precursor of MIR - the Marine Fisheries Laboratory in Hel (Fig. 1.1).

Fig. 1.1 Marine Fisheries Laboratory in Hel (source: archives of MIR→NMFRI)

In 1931, following the decision of the Ministry of Agriculture, the Marine Fisheries Laboratory in Hel was closed. However, due to the protest of many leading scientists, one year later in 1932, the Marine Fisheries Laboratory was reestablished under the name of the Marine Station in Hel. Mieczysław Bogucki (1884-1965), a future zoology professor, was its director and organizer. The establishment of the Marine Station was an impetus for the development of the Polish marine fisheries research. Soon, its fisheries department was founded in Gdynia and managed by Borys Dixon (1873-1955). In Hel, on the other hand, there was a biology department managed by Kazimierz Demel (1889-1978). In December 1938, the Marine Station was transferred from Hel to Gdynia, a city that was developing dynamically at that time. The station's new building (current Gdynia Aquarium) was located at the end of the South Pier (Fig. 1.2).

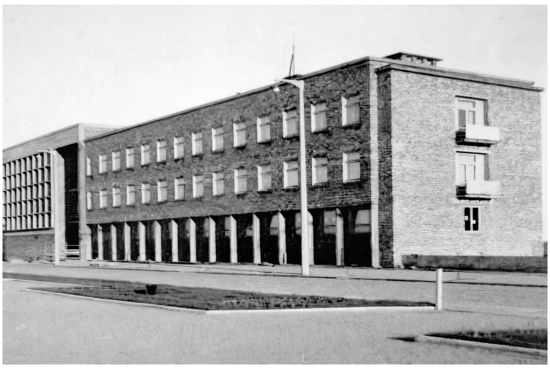

Fig. 1.2 Marine Station in Gdynia after the transfer from Hel in 1938 (source: archives of MIR→NMFRI)

The operation of the Marine Station in Gdynia and the Sea Fisheries Institute association was suspended by World War II. In 1945, the Station resumed its activities in Gdynia as the Marine Fisheries Laboratory that was a reference to the tradition of the facility that existed before 1939 in Hel. It is worth emphasizing that the new Marine Fisheries Laboratory in Gdynia hired the former employees of the Laboratory and Institute in Hel and in Gdynia before 1939. Kazimierz Demel, Mieczysław Bogucki, Walerian Cięglewicz, Zygmunt Mulicki and Władysław Mańkowski were among them.

In 1945, also the pre-war Sea Fisheries Institute association was reactivated. It was established in 1928 with important role to support the development of Polish fishing industry financially and organizationally. Prof. Michał Siedlecki (1873-1940), an eminent zoologist from the Jagiellonian University in Cracow, was the President of the aforementioned association. On 28th October 1947, the decision was taken that support of the development of fishing industry would be taken over by another government institution, and the Sea Fisheries Institute became a solely scientific institute supervised by the Ministry of Navigation. Conducting research in marine fisheries was one of the main tasks of the Institute. On 1st January 1949, the Marine Fisheries Laboratory was officially incorporated into the Sea Fisheries Institute in Gdynia. Until

1990, the expanded building at the end of the South Pier was the main headquarters of the Institute (Fig. 1.3). In 1991, the Institute was transferred to the building in Gdynia, ul. Kołłątaja 1 (Fig. 1.4). In 2000, the Sea Fisheries Institute changed its supervisor to the Ministry of Agriculture and Rural Development. Between 2015 and October 2020, it was under the supervision of the Ministry of Maritime Economy and Inland Navigation. Since November 2020, it has been again under the supervision of the Ministry of Agriculture and Rural Development. In June 2011, according to a government order, the Sea Fisheries Institute gained the status of a National Research Institute and, at the same time, joined the exclusive group of other such institutes in Poland. It changed its name into National Marine Fisheries Research Institute.

Fig. 1.3 Former, modernized and expanded, headquarters of MIR→NMFRI; currently, Gdynia Aquarium) (source: archives of MIR→NMFRI)

Fig. 1.4 Current headquarters of MIR→NMFRI (source: archives of MIR→NMFRI)

Gdynia was not the only location for the NMFRI's operations. Soon after the end of World War II, the Institute had two branches that were later transformed into departments. One of them was located in Szczecin (and existed until 1952), while the other one was in Kołobrzeg (transformed into a field unit in 1976). In 1950, the Sea

Fisheries Institute established an Ichthyological Laboratory in Trzebież, which was supervised by the Kołobrzeg Department. In 1952, it was transferred to Świnoujście, where a Department of the Institute was opened. In 1999, the Świnoujście Department was renamed into the Research Station. It has been functioning under this name until today (Fig. 1.5).

Fig. 1.5 Research Station in Świnoujście (source: archives of MIR→NMFRI)

The Plankton Sorting and Identification Center in Szczecin has a special role in MIR→NMFRI (Fig. 1.6). It was established in 1974, thanks to intergovernmental arrangements implemented by the Sea Fisheries Institute and the National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA) (see Chapter 2). Even currently it offers taxonomic identification of plankton organisms all over the world; the NOAA collaboration remains the main area of scientific cooperation and expertise.

Fig. 1.6 Plankton Sorting and Identification Center in Szczecin (source: archives of MIR→NMFRI)

The Gdynia Aquarium that was opened on 23rd June 1971 in the Institute's building (Fig. 1.3) to celebrate the 50th anniversary of the Sea Fisheries Institute, also belongs to the structures of the MIR→NMFRI. First, it was called the Oceanographic Museum and Marine Aquarium. In July 2003, it was renamed and received its current name. It is a modern zoological garden, where you can admire over 1 100 aquatic and semi aquatic animals of 200 species from all over the world. The largest attractions are the delightful colorful coral reef and unique specimens like bottom-dwelling sharks, red piranha, freshwater stingrays, the world's smallest crocodile - dwarf crocodile - as well as the world's heaviest snakes - green anacondas. Education is the most important element of the MIR→NMFRI Gdynia Aquarium's activity. Its aim is to promote knowledge in the scope of biology and ecology of the sea, as well as the environmental protection (Fig. 1.7).

Fig. 1.7 Gdynia Aquarium specimens (source: archives of MIR→NMFRI)

1.1.1. Present activity of MIR→NMFRI

The Institute is responsible for the Multiannual Program for Collection of Fisheries Data in Poland. The program is co-financed by the European Commission and the Ministry of Agriculture and Rural Development. The Ministry of Science and Higher Education is financing scientific projects within so-called “statutory activity”. In recent years, an increasing role of research that is awarded through competitive processes is observed. In the MIR→NMFRI portfolio there are numerous national and international projects financed by the European Union (EU) Framework Programs, the European Fisheries Fund, as well as the Ministry of Science and Higher Education.

International cooperation coordinated by the International Council for the Exploration of the Sea (ICES) is of crucial significance for the MIR→NMFRI’s research. The program for collection and processing of fisheries data within the European Union (EU) Data Collection Framework (DCF) is another important element of the Institute’s research activity. It is a necessary element for Poland’s implementation of the EU Common Fisheries Policy. The Director of the MIR→NMFRI is also a member of the European Fisheries and Aquaculture Research Organization (EFARO).

Developing and introducing a selective codend with meshes turned 90°, called a T90 codend, is one of the most significant practical achievements of the MIR→NMFRI in recent years. The device was introduced in 2005, with a regulation of the European Commission, as a standard selective tool to be used in the Baltic Sea fisheries (Moderhak, 1993, 1995, 1997, 1999, 2000a,b, 2005; Moderhak and Niemiro, 2005; Zaucha et al., 1999).

The Institute is also very successful in innovation and implementation activities. In 2008-2015, 14 innovative solutions were implemented at the Department of Processing Technology and Mechanization. The Department has won gold medals and awards at many domestic and international exhibitions (like POLFISH and GASTROEXPO in Gdańsk or the International Warsaw Invention Show), as well as abroad (exhibitions in Brussels, Taipei, Sevastopol or Moscow).

In December 2016, the Institute received the “HR Excellence in Research” logo awarded by the European Commission. It is a quality label awarded by the European Commission to institutions which implement the principles of creating friendly working and career development conditions, as well as transparent processes for the recruitment of researchers. Granting the logo is one of the activities of the European Commission within the framework of the Human Resources Strategy for Researchers.

Based on the results of a complex assessment of scientific as well as research and development activities of scientific units which was conducted by the Ministry of Science and Higher Education in 2017, the NMFRI received category A in the so-called heterogeneous research units group.

Exploitation of marine biological resources requires constant monitoring of the fisheries and factors (e.g. anthropogenic) that impact the state of fish stocks. Without the knowledge of the resources condition and a proper fishing management, it is easy to disturb the unstable biological balance and the possibility for the fish populations to regenerate. The National Marine Fisheries Research Institute's job is to provide the scientific bases for sustainable exploitation of fish, to provide possibilities for the resources to regenerate naturally, to provide a stable level of life to the people who live off fishing, and to maintain the natural heritage of the sea for the generations to come.

1.2. A historical view on Polish-American cooperation (oceans and atmosphere)

1.2.1. Institutions involved in Polish-American cooperation

Addressing cooperation in the field of fisheries and monitoring of greenhouse effect gases between Poland (MIR→NMFRI) and the United States, it should be emphasized that the leading institution on the U.S. side was the National Oceanic and Atmospheric Administration (NOAA) with its subordinate institutions. NOAA was established in 1970 and its task is to monitor the environment, forecast weather, as well as long-term climate and weather observations, long-term observations of changes in assessments, fish stock management, advice on the development of the U.S. coasts, safe navigation at sea. NOAA is organizationally subordinate to the U.S. Department of Commerce. NOAA's predecessors were the following government agencies: the United States Coast Survey, the United States Weather Bureau, and the United States Commission of Fish and Fisheries. NOAA works toward its mission through six major line offices, the National Environmental Satellite, Data and Information Service (NESDIS), the National Marine Fisheries Service (NMFS), the National Ocean Service (NOS), the National Weather Service (NWS), the Office of Oceanic and Atmospheric Research (OAR) and the Office of Marine & Aviation Operations (OMAO) and in addition more than a dozen staff offices, including the Office of the Federal Coordinator for Meteorology, the NOAA Central Library, the Office of Program Planning and Integration (PPI) (https://www.noaa.gov/about-our-agency).

The National Marine Fisheries Service (NMFS), also known as NOAA Fisheries, was initiated in 1871 and the current goal of the agency is research, protection, management, and restoration of commercial and recreational fisheries, protected species, and their habitat. NMFS operates twelve headquarters offices, five regional offices, six fisheries science centers, and more than 20 laboratories throughout the United States. NMFS also operates the National Oceanic and Atmospheric Administration Fisheries Office of Law Enforcement in Silver Spring, Maryland, which is the primary site of marine resource law enforcement (https://www.fisheries.noaa.gov/about-us).

In 2021, NMFRI celebrates its 100th anniversary and this anniversary coincides with the 150th anniversary of NOAA Fisheries. During the 100 years of joint existence and research activity of NMFRI and NOAA Fisheries, as many as 50 years have been spent on joint research of the oceans in terms of natural resources and their sustainable exploitation, and research of the atmosphere in terms of climate change.

NOAA's Office of Oceanic and Atmospheric Research (OAR), is the driving force behind NOAA environmental products and services that protect life and property and promote economic growth. Research, conducted in OAR laboratories and by extramural programs, focuses on enhancing our understanding of environmental phenomena such as tornadoes, hurricanes, climate variability, solar flares, changes in the ozone, air pollution transport and dispersion, El Niño/La Niña events, fisheries productivity, ocean currents, deep sea thermal vents, and coastal ecosystem health. NOAA research also develops innovative technologies and observing systems (https://research.noaa.gov/Labs-Programs/oar-programs#:~:text=Stay%20Connected,OAR%20PROGRAMS,and%20ocean%20and%20coastal%20resources).

Issues related to fisheries took on special significance for Americans in the mid-1970s, when a significant decrease in fish stocks in popular fishing areas e.g. in Georges Bank region (Northwest Atlantic), was observed. This situation was the result of intensive, not selective, and not fully controlled catches of fish not only by the USA and Canada, but also, and maybe mainly, by Russia, Japan, as well as European countries, including Poland (see Chapter 3). This situation forced the International Commission for the Northwest Atlantic Fishery (ICNAF) to introduce fisheries controls from 1972, and this involved the introduction of catch limits for individual species and the allocation of quotas among the countries concerned (see sub-chapter 1.2.2.).

Information on changes in the ecosystem, in particular changes in fish stocks in exploited fisheries, has become necessary for the proper management of resources. This type of information could only be obtained through extensive scientific research focused on estimating fish stocks and mathematical modeling of changes, taking into account changes in the natural environment.

1.2.2. Fifty years of joint Polish-American fisheries research

In the Bulletin of the Sea Fisheries Institute [No. 3-4 (113-114)] published in 1989, there are six articles devoted to Polish-American cooperation in fisheries and in titles of two of them (Karnicki, 1989; Ropelewski, 1989) there appears a 25-year period of Polish-American cooperation in the field of fisheries (see Chapters 3-6). To continue the story up to 2021, we must add that from 1974 to the present, Polish-American cooperation in the field of fishery ecology has been carried out by the fact of functioning of the Plankton Sorting and Identification Center in Szczecin, Poland (see Chapter 2). In 1992, MIR joined the U.S. scientists from the Climate Monitoring and Diagnostic Laboratory (CMDL), now Global Monitoring Laboratory (GML), NOAA, Boulder, Colorado, U.S.A. in carrying monitoring of greenhouse gases content in the air on a global scale. MIR→NMFRI was responsible for the air sampling and logistics of the "BALTIC" measuring station in the period 1992-2011. These studies have been carried out in reference to the observed climate changes, which have a great impact on the functioning of marine ecosystems (see Chapter 7). In 1972-1987, we jointly carried fisheries research in the Northwest Atlantic, the Eastern Southern Atlantic, the Southern Ocean, the Northeast Pacific (see Chapters 3-6; Fig. 1.8). If we add all these years of Polish-American cooperation, we get half a century of combined efforts to build a better world.

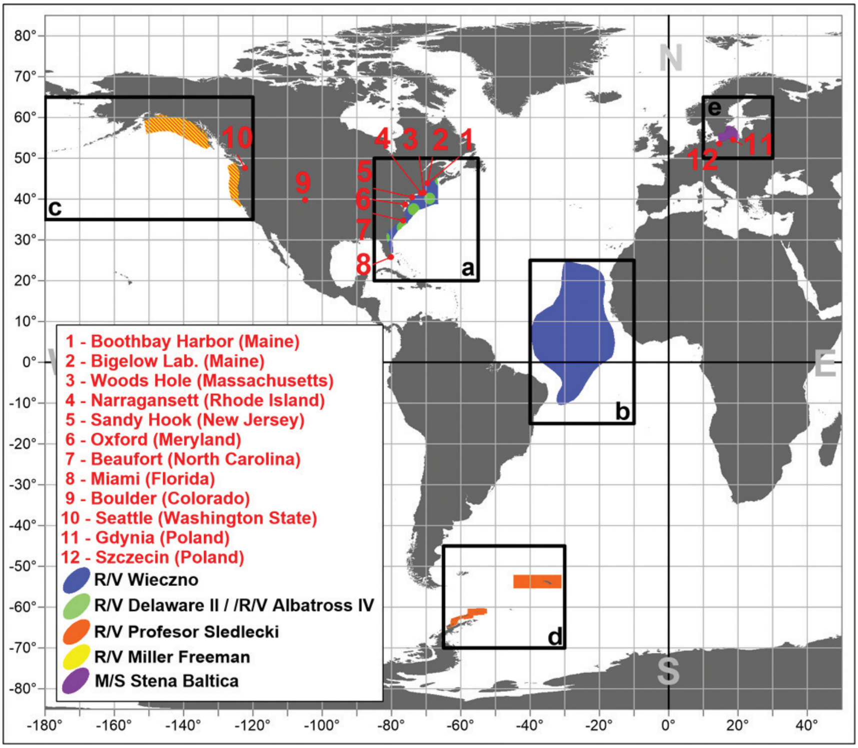

Fig. 1.8 Location of Polish-American research areas in the Northwest Atlantic, the Eastern Central Atlantic, the Northeast Pacific, the Southern Ocean, and the Baltic Sea (see Chapters that follow); list of the institutions and ships involved in joint Polish-American studies (graph prepared by T. Wodzinowski, NMFRI)

We dare to state that the hundred-year history of MIR→NMFRI is an example of the longest international cooperation. Historical facts focused on the Polish-American cooperation in the field of fisheries are contained in the review by Ropelewski (1989) and many of the facts listed there will be used in this study, which summarizes 50 years of joint research against the background of the MIR→NMFRI's 100-year history. The story presented in this monograph calls for a certain background which is presented in an elaboration by Anderson (1998), who states that a number of European nations had established fisheries in the Northwest Atlantic dating back several hundreds of years. Following the end of World War II, fishing intensified rapidly and, by the late 1940s and early 1950s, increasing numbers of large trawlers began operating on grounds off West Greenland, Labrador and Newfoundland. As a result of continued concern over declining abundance of stocks throughout the Northwest

Atlantic, the USA convened a conference of ten countries in Washington, D.C. in January 1949 which led to the establishment of the International Convention for the Northwest Atlantic Fisheries (ICNAF). The International Convention for the Northwest Atlantic Fisheries was agreed in Washington, D.C. in January 1949, it was opened for signature on February 8, 1949; it came into force on July 3, 1950 following ratification by Canada (including Newfoundland), Iceland, the United Kingdom (UK) and the USA. The stated purpose of the Convention was "the investigation, protection and conservation of the fisheries". The name of Convention was then changed into Commission and the first meeting of ICNAF was held in April 1951 in Washington, D.C. and was attended by five signatory governments (Canada, Denmark, Iceland, UK and USA); five additional countries whose ratifications were pending (France, Italy, Norway, Portugal and Spain) and two observer organizations - United Nations Food and Agriculture Organization (FAO) and the International Council for the Exploration of the Sea (ICES) - also participated. The Convention was designed to provide for the investigation, protection and conservation of the fisheries of the Northwest Atlantic in order to make possible the maintenance of a maximum sustained catch from those fisheries (Anderson, 1998). The number of Contracting Parties increased from the initial five (Canada, Denmark, Iceland, UK and USA) in 1951 to a high of 18 by 1975 – Bulgaria, Canada, Cuba, Denmark, France, German Democratic Republic (GDR), Federal Republic of Germany (FRG), Iceland, Italy, Japan, Norway, Poland, Portugal, Romania, Spain, the Union of Soviet Socialist Republics (USSR), the United Kingdom (UK), and the USA - before decreasing to only 12 (Bulgaria, Canada, Cuba, German Democratic Republic (GDR), Iceland, Japan, Norway, Poland, Portugal, Romania, Spain and the USSR) by the time ICNAF officially dissolved on December 31, 1979 (Anderson, 1998).

As members of ICNAF, Polish and the U.S. scientists and fishery managers worked together to bring into force the first multispecies ecosystem approach to fisheries management (Peterson, 1989). This author further states that in 1974, with adoption of the two-tiered quota system, we succeeded in propelling our scientists into forefront of studies on multispecies relationships. These studies were necessary to achieve common ground leading to agreements by ICNAF member countries on overall annual fisheries biomass yields as the first tier of management and the individual total allowable catch limits (TAC's) of the second management tier. It was clear that if we are to improve predictions of abundance trends and hence improve management practices, we need to learn more about multispecies interactions among the pelagic and demersal fish stock as well as improve our understanding of how reproductive success and other interrelationships are shaped by natural and human perturbations within the regional ecosystems supporting the fish stocks. This new approach in fish stocks management and new strategies for reducing incidental catches of marine mammals in the pelagic fisheries for mackerel in the Northeast Atlantic were jointly developed by Dr. J. Horbowy, MIR→NMFRI and Dr. Smith, NOAA, Northeast Fisheries Center (NEFC) (Peterson, 1989).

Cooperation with the U.S. covered also some other areas e.g. fish processing, quality control and its implementation on board fishing vessels and onshore (Karnicki, 1989). The author further states that scientists and experts from NEFC, Fish Technology Laboratory in Gloucester and NMFS in Washington began to cooperate with MIR→NMFRI in 1969 with the aim of standardizing inspection methods and finding a common language when evaluating quality of fish and fisheries products. Food and Agricultural Organization/World Health Organization (FAO/WHO) Codex Alimentarius Committee on Fish and Fisheries products helped to establish close working ties and friendship between the U.S. and Polish participants and resulted in exchange visits of scientists from Gdynia and Gloucester (J. Slavin, J. Brooker, R. Learson, F. King).

Cooperation in quality control was carried out parallel with development of Polish-U.S. industrial cooperation in fisheries. It is worth mentioning here that in the early 1970s the U.S. became the main market for Polish fishery products, chiefly fillets. Joint effort of scientists and the industry led to establishment of highest world quality standards and introduction of boneless fillets onto the U.S. market. It was a milestone in the development of marketing of fish products in the U.S., particularly Polish products (Karnicki, 1989).

Analysis of historical facts allowed Ropelewski (1989) to state that the need for a new phase of scientific cooperation between Poland and the U.S. appeared after 1960, when Polish deep-sea fishing vessels began operations and started to make increasing catches in the Northwest Atlantic, and MIR→NMFRI started to study the natural resources of this region on R/V WIECZNO (see Chapter 3). In 1962, Poland ratified the ICNAF document, and that fact marked the start point for joint meetings of Polish and American representatives connected with the fishery sector. One of the platforms for such meetings was ICES, after the U.S. had joined this organization.

Ropelewski (1989) points out that the year 1962 was probably the first year in which Polish vessels, owned by the ODRA Deep Sea Fishing Company, fishing for herring in Northwest Atlantic, called at Boston harbor. An increasing effort of international fleet, including the Polish fishing vessels in the Northwest Atlantic (see Chapter 3), must have been observed with interest but also concern by the U.S. administration and this supposition finds confirmation in facts that follow. There were arranged official talks at MIR→NMFRI headquarters, and Mr. Andrew Wallance Anderson representing the U.S. fisheries administration acting as Regional Fisheries Attaché for Europe with headquarters at the U.S. Embassy in Copenhagen, was the first supervisor. He proposed that MIR→NMFRI prepares an extensive technical and economic analysis of exploitation of Polish deep-sea commercial fishing vessels; that was meant to be sent to the Bureau of Commercial Fisheries (BCF), U.S. Department of Interior. The relevant document was signed on June 25, 1964, and within three years such an analysis for four types of Polish fishing trawlers (B-15, B-18, B-20, and B-23) was submitted to the U.S. partner. The implementation of the agreement was supervised by American representatives, namely A.W. Anderson and then A. M. Sandberg and it ran smoothly. Equally good contacts were maintained with other representatives of BCF, who visited MIR→NMFRI in connection with the implementation of the venture. Among those Americans there were people holding important posts in the U.S. fisheries administration and science, e.g. D.L. Alverson, base director of Exploratory Fishing and Gear Research in Seattle, Wash., or C. Butler, chief of Division of Industrial Research, BCF, V. Norton, an economist from BCF (Ropelewski, 1989).

According to Ropelewski (1989), first Polish-American official talks concerning cooperation in fisheries were initiated in Warsaw in May 1969. They were held in connection with the ICNAF 19th session. In June 1969, the first agreement between the subjected authorities of Poland and the U.S. was signed in Warsaw. The agreement concerned the cooperation in the fisheries and conditions for Polish fishing operations in the Northwest Atlantic, in the zone of the U.S. interest. This document opened also a new chapter in scientific cooperation carried out by relevant fisheries research centers in both countries. An additional impulse for such cooperation was generated at the ICNAF meeting at the beginning of the 1970s; it turned out then that there was a significant difference between the Polish and American fish stocks assessment estimates in Georges Bank region. **In order to explain these differences, joint oceanographic and ichthyological studies were undertaken in fall 1972 and that is how R/V WIECZNO got involved in the joint Polish-American fisheries research which was continued for 16 years (1972-1987) (see Chapter 3).**

Events from the turn of 1972/73 were of great importance for the development of Polish-American cooperation in fisheries. The visit of Dr. K. Siudziński and Dr. B. Lubieniecki (Department of Oceanography, MIR→NMFRI) at the Northeast Fisheries Center (NEFC) in Woods Hole at the turn of 1972/73, and talks with NEFC directors (R. Edwards, K. Sherman) regarding the expansion of cooperation, laid the foundations for establishing in Poland of plankton study center, working for and financed by the

U.S. With great scientific contribution of Kenneth Sherman (NMFS, Narragansett), a preliminary draft of the scope of activities, organizational forms and financing principles of such a center in Poland were worked out. **In 1974, the Plankton Sorting and Identification Center was established** and has been successfully working till today (Ropelewski, 1989; see Chapter 2). The visit of two above mentioned Polish scientists in the U.S. scientific institution was followed by a visit of the first official American delegation at MIR→NMFRI. It consisted of director R. Edwards, Dr. M. Grosslein, Dr. R. Hennemuth (Woods Hole) and Dr. J. Suomala from Massachusetts Institute of Technology (MIT), cooperating with NEFC in the field of hydroacoustics. The talks were focused on the scope of cooperation between NEFC and MIR→NMFRI and the conclusions reached were to serve as a basis for the expected Polish-U.S. bilateral agreement on cooperation in fisheries (Ropelewski, 1989). In the years that followed, the cooperation was widened not only with NEFC but also with other centers in the U.S. This was facilitated by good relations between the governments of Poland and the U.S. On May 25, 1973 the U.S. delegation came to Warsaw, headed by Ambassador Donald L. Mc Kernan, special adviser to the President of the U.S. on Forestry, Wildlife and Fisheries, in order to hold talks at our Ministry of Shipping and sign another agreement on cooperation in the fisheries in the Northwest Atlantic. Director of the NEFC, Woods Hole, R. Edwards was a part of delegation. The relevant document was signed and came into force in 1973. It widened the research carried out by both sides on the state of stocks which were the object of joint interest, exchange of scientists, and statistical data on catches, meetings between Polish and the U.S. scientists, and their participation in cruises of research vessels of both parties (Ropelewski, 1989).

On May 29, 1975, another Polish-U.S. agreement on cooperation in the fisheries in the **Northwest Atlantic** was signed in Washington D.C., and on the following day the next agreement widened the scope of cooperation to cover the **Northeast Pacific**, where Polish fishing vessels began to appear since fall 1973 (Ropelewski, 1989; Fig. 1.8; see Chapters 3-5). The first meeting between Polish and the U.S. scientists focused on fish stocks studies in Northeast Pacific took place on board the fishing vessel ANDROMEDA (Chapter 5). The U.S. partner was represented by NEFC scientists from Seattle, Wash. - T. Dark, H.D. Larkins and J. Pruter, while the Polish side - by four scientists J. Barthelke, E. Jackowski, J. Romer, C. Żukowski. Following these talks, in 1977 Polish R/V PROFESOR SIEDLECKI carried out research program with 18 scientists from Northwest Fisheries Center (NWFC) in Seattle on board the ship. The vessel called three times at Seattle and one time in Kodiak, Alaska (Chapter 5). In the years that followed cooperation was limited to discussing the results of studies and Dr. J. Janusz from MIR→NMFRI participated in this project.

In 1981-1985, MIR→NMFRI implemented the Government Program, whose goal was to determine the fishing possibilities of large pelagic fish (sharks, tunas and tuna-like) in the **Eastern Central Atlantic** using the longline system (Fig. 1.8; Chapter 4). The results of research on these fisheries were to provide information on the location and seasonality of fish aggregation in relation to hydrological conditions. It should be mentioned here that by 1981 R/V WIECZNO had already had great experience in longline fishing of apex predators. The apex predators study in the Northwest Atlantic was initiated on board R/V WIECZNO in 1976, and the program was led by very experienced scientists from the NMFS, Narragansett e.g. J. Casey, C. Stillwell, N. Kohler (see Chapter 3). Longline fishing in the Northwest Atlantic in 1976-1980 was conducted using American longlines. Preparing for possible industrial fishing in the rich in natural resources of the Central Eastern Atlantic, in 1981 MIR→NMFRI bought and installed Japanese longline equipment (Ropelewski, 2001). Japanese longline system was then used in common Polish-American studies carried out in the Northwestern Atlantic till 1987. Polish deep-sea fishing companies were interested in longline catches, and the MIR→NMFRI research in the Eastern Central Atlantic was to answer the question of the efficiency and potential profitability of such a large-scale undertaking. Our American partners from the NMFS, Narragansett, and specialists in longline fishing knew about this project and officially turned to MIR→NMFRI to use the possibilities and continue the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP). It is a collaborative effort between recreational anglers, the commercial fishing industry, and NMFS to study the life history of Atlantic Sharks (https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html). Tags and deck logs were provided by NMFS, Narragansett prior to Polish longline fishing program in the abovementioned region. The Americans did not physically participate in these studies, but we can of course state that it was a continuation of Polish-American cooperation in the Atlantic waters, in this case, in the Eastern Central Atlantic (Kurowicki, 1987; Ropelewski, 2001; see Chapter 4).

The Antarctic waters of the Atlantic (Southern Ocean) (Fig. 1.8; Chapter 6), was the next area of Polish-American cooperation which was initiated on 10 Sep. 1986 by signing an agreement on that subject. The American side was represented by Dr. K. Sherman, personally interested in planned Antarctic Marine Living Resources Program, carried out in the first joint cruise of R/V PROFESOR SIEDLECKI which took place at the turn of 1986/1987. The first American to take part in the cruise of R/V PROFESOR SIEDLECKI to the Antarctic was N.A. Svedensen from Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). He participated in sea trials of a prototype krill peeler constructed by his firm (Ropelewski, 1989). Our joint studies brought us together in the scientific efforts to support the conservation objectives of the established CCAMLR. The CCAMLR was the first International Commission to support ecosystem approach to the conservation and management of living resources. CCAMLR mandates a management regime committed to applying measures to ensure that harvesting of Antarctic species, such as finfish and krill, is conducted in a manner that considers ecological relationship among dependent and related species.

These projects, covered by bilateral Polish-U.S. agreements, survived the difficult period of strained political relations between the two countries. Besides, many Polish scientists received fellowships in U.S. scientific centers, while the MIR→NMFRI and laboratories on research vessels could acquire modern equipment (see Chapter 3). It is also worth emphasizing the fact that as a result of this cooperation and scientific achievements, the Polish deep-sea fisheries could obtain free catch quotas in the U.S. Exclusive Economic Zone (EEZ) (Popiel, 1989).

In April 1998, MIR→NMFRI in cooperation with the North Atlantic Treaty Organization (NATO), namely the NATO Committee for the Challenges of Modern Society, organized a conference on modeling eutrophication processes in bays and sea lagoons. In addition to experts from the NATO member states, Polish representatives of the Ministry of Transport and Maritime Economy, the Ministry of Environmental Protection, Natural Resources and Forestry, the Institute of Meteorology and Water Management, the Maritime Institute, the University of Gdańsk and the Maritime Colleges participated in it. It was the first international conference at MIR→NMFRI headquarters organized in cooperation with NATO structures (Ropelewski, 2001).

Over the years of joint cooperation Polish scientists spent some time in various U.S. fishery research centers e.g. in Woods Hole, Narragansett, Gloucester, Boothbay Harbor, Milford, Sandy Hook, Oxford, Miami, Saint Petersburg, Ocean Springs, La Jolla, Seattle, Leetown, Manoa. Pursuant to a bilateral agreement concluded between NMFS, Woods Hole and MIR→NMFRI, in each R/V WIECZNO cruise to the Northwest Atlantic region, MIR→NMFRI scientists were entitled to go ashore for one of the three parts of the cruise. In those days it gave us Poles access to specialist literature, as well as direct contacts with eminent scientists from Woods Hole and Narragansett (see Chapter 3). MIR→NMFRI had numerous guests from numerous fisheries and biological centers in the U.S., many of them worked on board Polish research vessels and fishery vessels (see Chapters 3-6). In the 1970s, MIR→NMFRI was visited by D. Fluharty from the School of Natural Resources, Univ. of Michigan who came to Poland to collect materials for his doctoral dissertation.

1.2.3. A new K. Sherman's concept in marine research - Large Marine Ecosystems (LME's)

The scale of the occurrence of anthropopressure in the natural environment of man over the past decades imposes the need for a holistic view in all environmental research. By definition, a holistic approach to ecosystem management means an approach to the environment that fully recognizes the wide range of interactions within the ecosystem, including human activities, and thus excludes from the sphere of interest the study of only detached individual issues, species, or ecosystem functions without combining all together. A holistic view requires the researcher to fully understand the fact that all phenomena form holistic systems that are subject to specific regularities that cannot be fully understood on the basis of knowledge of regularities governing only selected components. The whole cannot be reduced to the sum of its ingredients. The functioning of the ecosystem is a whole series of physical, chemical and biological processes that exhibit non-linear interaction. Modern research requires a holistic approach in determining not only the causes of perturbations in the functioning of any ecosystem, but also in determining the current and forecasting the future consequences of these perturbations (Witek et al., 1982; Cloern, 2001; Nixon, 1995, 2009; Nixon and Fulweiler, 2009; Duarte, 2009; Duarte et al., 2009; Pastuszak and Witek, 2012a, b; Kowalkowski et al., 2012; Pastuszak, 2012a, b; Pastuszak et al., 2012a, b, 2013, 2014, 2016, 2018a,b).

A holistic approach to assessing the state of the environment has become the basis for creating a new concept in marine research, and this concept has been called Large Marine Ecosystems (LMEs) (Sherman, 2000, 2016; Sherman et al., 2009; Sherman and Hamukuaya, 2016). 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, contamination with plastic. 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. Large marine ecosystems are extensive areas of the globe, encompassing approximately 200,000 km^2, or more, within the Exclusive Economic Zones of coastal nations in which biological communities have evolved together in response to unique bathymetry, hydrography, and circulation (Frye, 1986; Sherman, 1989; Mangel, 1991; AAAS, 1993; Levin 1993; Sherman et al., 2009).

Sherman and Hamukuaya (2016) distinguish 66 LMEs on the globe and the boundaries of these LMEs are based on ecological criteria including bathymetry, hydrography, productivity, and trophic linkages. As the authors further state, it is within the spatial domains of LMEs that five modules of indicators of changing ecological states of LMEs are applied to support ecosystem based management of LMEs: (i) productivity, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socio-economics, and (v) governance. The suites of LME indicators are used to measure the changing states of LMEs in relation to a driver-pressure-state-impact-response system in support of adaptive management actions (Sherman et al., 2009). These authors refer their findings to identified LMEs, and state further that the basic effort is to better understand climate variability, to improve the long-term sustainability of marine goods and services, and to move in the direction of ecosystem-based ocean management and linked watersheds.

In one of the mails exchanged with M. Pastuszak in 2020, K. Sherman stated *"from my perspective, the 45 years of joint research (period of activity of Plankton Sorting and Identification Center in Szczecin, Poland; Fig. 1.9) work we have done on the plankton and ichthyoplankton components of the Baltic Sea, the U.S. Continental Shelf Large Marine Ecosystem, the Southeastern U.S. Continental Shelf Large Marine Ecosystem, the Gulf of Mexico Large Marine Ecosystem, the California Current Large Marine Ecosystem, the Gulf of Alaska Large Marine Ecosystem, the East Bering Sea Large Marine Ecosystem, and the Beaufort Sea Large Marine Ecosystem has been and continues as a major contribution to the ecosystems-based approach to the assessment and management of LMEs and their goods and services around the globe*".

Fig. 1.9 Celebration of 45 years of the U.S.-Poland Cooperative Research in the field of fish ecology (45 years of activity of Plankton Sorting and Identification Center, in Szczecin, Poland) at MIR→NMFRI headquarters on 6-10 May, 2019; from the left - Ms. Katey Marancik (NOAA Fisheries, Narragansett), Dr. David Richardson (NOAA Fisheries, Narragansett), Dr. Alison Deary (NOAA Fisheries, Seattle), Dr. Jon Hare (NOAA Fisheries, Woods Hole), Dr. Kenneth Sherman (NOAA Fisheries, Science and Technology), Dr. Piotr Margoński (NMFRI, Gdynia), Mr. Glenn Zapfe (NOAA, Fisheries, Pascagoula), Dr. David Kimmel (NOAA, Fisheries, Seattle), Ms. Wanda Kalandyk (NMFRI, Szczecin), Ms. Małgorzata Konieczna (NMFRI, Szczecin), Mr. Paweł Kaźmierczak (NMFRI, Szczecin) (source: archives of MIR→NMFRI)

1.3. Scientific degrees, titles, and awards

The **Professor Kazimierz Demel Medal** is awarded by the MIR→NMFRI for extraordinary scientific and organizational achievements in research and promotion of biological, environmental and fisheries knowledge of the sea. It is awarded to Polish and foreign persons as well as institutions and associations, based on applications, which can be submitted to the Committee at any time. The Medal is a circle 90 mm in diameter. It is made of silvered bronze. It was made at the Mint of Poland in Warsaw in 1991, according to a design by Józef Jezierski, an artist (Fig. 1.10).

Fig. 1.10 The obverse and the reverse of the Professor Kazimierz Demel Medal (source: archives of MIR→NMFRI)

The Medal Committee is composed of the past winners of the medal (people only) as well as the Chairman of the Scientific Council and the Director of the MIR→NMFRI. The Medals Awarded by the Committee are ceremonially handed in by the Director of the MIR→NMFRI. Among 42 Medal Laureates there are three from the U.S., namely **Dr. Kenneth Sherman (1997)**, **h.c. Witold Klawe (1998)**, and recently **Dr. Jonathan A. Hare (2019)** (Figs. 1.11, 1.12).

Fig. 1.11 Dr. Kenneth Sherman, the Laureate of the Professor Kazimierz Demel Medal in 1997 (source: archives of MIR→NMFRI)

Fig. 1.12 Dr. Jonathan A. Hare, the Laureate of the Professor Kazimierz Demel Medal in 2019 (source: archives of MIR→NMFRI)

In 1978, **Kenneth Sherman** (NMFS, Narragansett) defended his doctoral dissertation before the MIR→NMFRI's Scientific Council and received his degree. In 1989, he was conferred a title "**Doctor Honoris Causa**" from the Agricultural Academy in Szczecin, Faculty of Marine Fisheries (Figs. 1.13, 1.14).

Fig. 1.13 Dr. Kenneth Sherman, director of NMFS, Narragansett, receives a title *Doctor Honoris Causa* from the Agricultural Academy in Szczecin; congratulations from Dr. Leonard Ejsymont - manager of the Plankton Sorting and Identification Center (source: archives of MIR→NMFRI)

Fig. 1.14 Kenneth Sherman, director of NMFS, Narragansett in company of Zbigniew Karnicki, former director of MIR→NMFRI - after the ceremony of conferring a title "*Doctor Honoris Causa*" from the Agricultural Academy in Szczecin, Faculty of Marine Fisheries in 1989 (source: archives of MIR→NMFRI)

In mid-June 1993, Gdynia and Szczecin celebrated the twentieth anniversary of the Plankton Sorting and Identification Center, the MIR→NMFRI Branch in Szczecin (see Chapter 2). At the solemn meeting of the Institute's Scientific Council with the participation of representatives of the U.S. institutes cooperating with MIR→NMFRI, director of the Narragansett Laboratory **Dr. K. Sherman** was awarded the **Commander of the Order of Merit of the Republic of Poland.** On 29 June 1999, Aleksander Kwaśniewski, President of the Republic of Poland, awarded Orders of Merit to the following U.S. scientists for their outstanding contribution to the success of the U.S.-Polish joint cooperative studies of marine fisheries: **Commander's Cross with Star of the Order of Merit of the Republic of Poland to Dr. Kenneth Sherman, Officer's Cross of the Order of Merit of the Republic of Poland to Dr. Arthur Kendall, and Knight's Cross of the Order of Merit of the Republic of Poland to Dr. Donald Hoss** (Fig. 1.15). They were decorated on behalf of the President by Mr. Gołębiewski, Deputy Governor of Pomerania Province. On July 5 and 6, 1999, MIR→NMFRI celebrated the 25th anniversary of the establishment of the Plankton Sorting and Identification Center (see Chapter 2). On that occasion, an international symposium was organized with the participation of numerous specialists from the United States and the Baltic States, where problems related to the study of large marine ecosystems were discussed.

Fig. 1.15 From the left - Mr. Gołębiewski, Deputy Governor of Pomerania Province, with Drs. Sherman, Kendall, and Hoss on 29 June 1999 after presenting Orders of Merit awards to them on behalf of Aleksander Kwaśniewski, President of Poland, in recognition for their outstanding contribution to the success to the U.S.- Polish joint cooperative studies of marine fisheries (source: archives of MIR→NMFRI)

Upon request of the MIR→NMFRI, supported by the Ministry of Transport, Shipping and Communications and the Minister of Foreign Affairs, the Polish State Council passed a resolution of Sept. 14, 1988 conferring the **Gold Insignia of the Order of Merit of the Polish People's Republic** on our friend and collaborator, **Dr.**

Witold Klawe, a senior scientist, a member -American Tropical Tuna Commission in La Jolla, Ca. (Fig. 1.16). In 1970s W. Klawe visited MIR, giving a series of lectures on tuna fishery. W. Klawe cooperated also with Poznań University (Department of Geographic and Geologic Sciences), the Agricultural Academy in Szczecin (Department of Sea Fishery and Food Technology), the Fruit-Growing Institute, and the Institute of Soil Science and Plant Cultivation (Ganowiak, 1989).

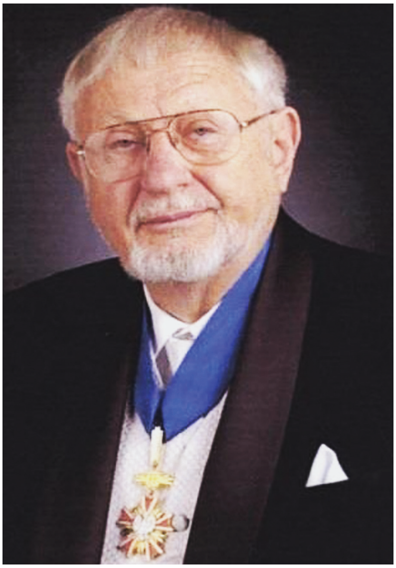

Fig. 1.16 Dr. Witold Klawe, Inter-American Tropical Tuna Commission (IATTC), La Jolla, Ca. (source: private archives of W. Pelczarski)

The **Polish air monitoring station** (see Chapter 7) has been recognized by Americans as one of the best organized stations in the world. In 2003, the U.S. Department of Commerce awarded Polish project coordinator Dr. Marianna Pastuszak (MIR→NMFRI), the STENA BALTICA ferry captains: Krzysztof Romowicz, Andrzej Kędziora, Darek Grzybek, Marek Czapiewski, and officers: Włodzimierz Jarzyński, Andrzej Kalicki, Piotr Kamiński, Janusz Maślanka, Mieczysław Miakinko, Daniel Skrzypek, Konrad Soćko, Robert Żuk the prize ***Environmental Hero Award*** in recognition of outstanding contributions to environmental protection on the globe. It was the first prize of this type granted to Poles. The ceremony took place in the U.S. Embassy in Warsaw in June 2003 (Figs. 1.17-1.22). The American Embassy in Warsaw was chosen to conduct this ceremony not only because it is a diplomatic headquarters in Poland, but also because it was an extremely important link in the entire project of monitoring greenhouse gases emissions in the Baltic region. Thanks to the kindness of the Embassy, it was possible to send in transit the air sampling bottles to MIR→NMFRI and then bottles with air samples back to the Climate Monitoring and Diagnostics Laboratory of the National Oceanic and Atmospheric Administration in Boulder, Colorado, U.S. It would not be possible to initiate this project without the assistance and constant help of many people in the Embassy, particularly Mrs. Ewa Kurhanowicz. The ceremony at the Embassy was preceded by speeches by the Ambassador (Fig. 1.17), Dr. T. Conway (Fig. 1.18) and Dr. M. Pastuszak (Fig. 1.19) (see Appendix I). All the speeches emphasized the need for international research focused on climate change, its causes and consequences (see Chapter 7). Dr. Conway stressed that quantifying and understanding carbon emissions and sinks is crucial for governments and society in general to make informed decisions on energy policy and climate change.

Fig. 1.17 Speech of the U.S. Ambassador in Poland, Mr. Christopher Hill - the award ceremony at the U.S. Embassy in Warsaw in June 2003 (source: private archives of M. Pastuszak)

Fig. 1.18 Speech of Dr. Thomas Conway, representative of CMDL Group from Boulder, Colorado, USA - the award ceremony at the U.S. Embassy in Warsaw in June 2003 (source: private archives of M. Pastuszak; full text of the speech - see Appendix I)

Fig. 1.19 Speech of Dr. Marianna Pastuszak - Polish coordinator of air sampling at the BALTIC Station - the award ceremony at the U.S. Embassy in Warsaw in June 2003 (source: private archives of M. Pastuszak; full text of the speech - see Appendix I)

Fig. 1.20 Dr. T. Conway representative of CMDL Group from Boulder, Colorado and Dr. M. Pastuszak, coordinator of air sampling at the Baltic station from MIR→NMFRI, Gdynia - the award ceremony at the U.S. Embassy in Warsaw in 2003 (source: private archives of M. Pastuszak)

Fig. 1.21 The rewarded heroes and Mr. Ambassador C. Hill, standing next to MIR director Dr. D. Dutkiewicz (on the left), and Dr. T. Conway (standing second from the right) - the award ceremony at the U.S. Embassy in Warsaw in 2003 (source: private archives of M. Pastuszak)

Fig. 1.22 The rewarded heroes, Mrs. Ewa Kurhanowicz - the employee of the U.S. Embassy in Warsaw (in black dress), Dr. D. Dutkiewicz (fourth from the left), director of the MIR→NMFRI - the award ceremony at the U.S. Embassy in Warsaw in 2003 (source: private archives of M. Pastuszak)

In June 2003, Dr. M. Pastuszak received a letter (see the text below) signed by Dr. John Boreman, Acting Science and Research Director, in Woods Hole. He congratulated her on receiving the Environmental Hero Award. It is worth mentioning that between the year 2003 and 1987 (the last R/V WIECZNO cruise to the Northwest

Atlantic within the U.S. - Poland cooperation) many years passed, but scientists from Poland and their past as well as current achievements are still highly valued and followed by the American partners in science.

Both Poles and our American partners are aware of climate change, its causes and consequences, and the need for scientific research in this matter. It is the duty of science to show the threats of changes in the functioning of not only terrestrial but also marine ecosystems, as a consequence of climate change. Chapters 3-6 of this monograph focus on historical research and important administrative decisions regarding protection of natural marine resources, while the most comprehensive Chapter 7 is devoted to climate change and the resulting threats the world is facing now and will be facing in the coming decades. The seriousness of the situation requires often costly actions throughout the world, which in turn must be based on sound scientific research. Chapter 7 shows some examples of how climate change affects the functioning of Large Marine Ecosystems.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole Laboratory
166 Water Street
Woods Hole, MA 02543

June 30, 2003

Dr. Marianna Pastuszak
Sea Fisheries Institute
ul. Kollatoja 1
Pl-81-332 Gdynia, Poland

Dear Marianna,

We are delighted that Under Secretary Lautenbacher extended his personal thanks to you on behalf of NOAA for your contributions to global climate change air monitoring studies.

We should like to add our congratulations. Designating you as an Environmental Hero for your organization and oversight of air quality sampling over the Baltic Sea from the STENA BALTICA ferry lines, is an extension of our thanks for nearly 30 years of joint scientific studies between the Sea Fisheries Institute of Poland and the National Marine Fisheries Service. During this time, you have consistently demonstrated scientific creativity, effusive energy, and commitment to excellence in the reporting of your results. Your early studies of nutrient flux on Georges Bank, and your research on the relationships between highly migratory fish species and oceanographic processes conducted in the 1970's and 1980's, stand as important contributions to studies of the U.S. Northeast Shelf ecosystem.

You have our thanks for being a good shipmate, excellent scientist, and good friend to your many colleagues at the Northeast Fisheries Science Center. We look forward to continued and valued cooperation with you and MIR.

Sincerely,

John Boreman, Ph.D.
Acting Science and Research Director

c: K. Sherman

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2

POLISH-AMERICAN COOPERATION IN FISHERIES ECOLOGY - PLANKTON SORTING AND IDENTIFICATION CENTER

Paweł Kaźmierczak, Jonathan A. Hare, Wanda Kalandyk, Marianna Pastuszak, Emil Kuzebski

2. POLISH-AMERICAN COOPERATION IN FISHERIES ECOLOGY - PLANKTON SORTING AND IDENTIFICATION CENTER

Paweł Kaźmierczak, Jonathan A. Hare, Wanda Kalandyk, Marianna Pastuszak, Emil Kuzebski

2.1. Declining biomass of fish stocks - impetus for Polish-American cooperation in fisheries ecology

Excessive fishing effort was responsible for an unprecedented decline in the biomass of demersal and pelagic fish stocks off the northeast coast of the United States in the mid-1970s; the biomass of cod, haddock, and flounder was approximately 50 percent lower than during the previous decade (see Chapter 3). In recognition of the declining condition of the fish stocks of the U.S. northeast shelf, National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) encouraged cooperative research and assessment studies between the Northeast Fisheries Science Center (NEFSC), Woods Hole (Fig. 2.1) and fisheries research organizations of several other countries fishing intensively in the region, including Poland and the Sea Fisheries Institute (SFI→NMFRI) of Gdynia, Poland. Joint studies of the U.S. and Poland were directed toward recruitment studies of herring, mackerel, cod, and haddock with a focus on defining the spatial and temporal variability in annual spawning patterns. Studies were also conducted on sharks along the entire shelf-slope region of the northeast U.S. coast (see Chapter 3). Special attention was given in the study to the influence of oceanographic features on the seasonal and annual movements of the more abundant species. Apart from the Northwest Atlantic Ocean, Polish-American fisheries studies were carried out in other regions on the globe e.g. in the Eastern Central Atlantic (see Chapter 4), the Northwest Pacific (see Chapter 5), and Atlantic Antarctic (Southern Ocean) (see Chapter 6).

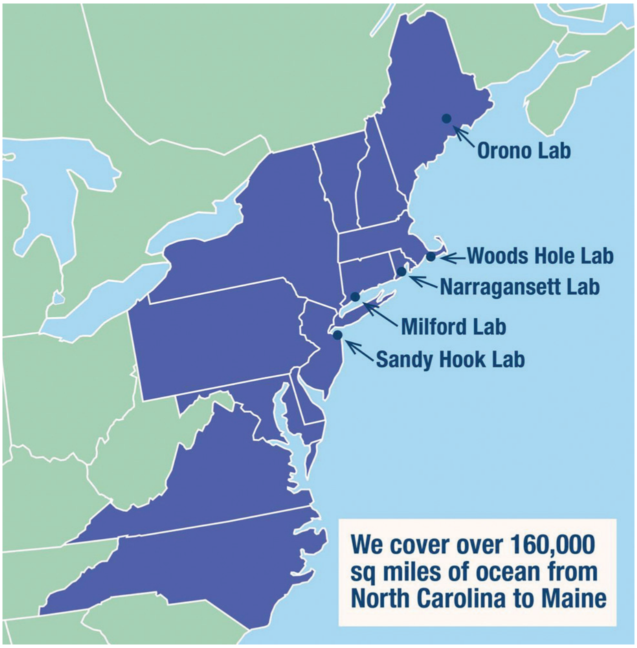

Fig. 2.1 Eastern coast of the U.S.; locations of Northeast Fisheries Science Center (NEFSC) laboratories along the eastern U.S. coast (source: https://nefsc.noaa.gov/aboutus.html)

In the early 1970s, there was a growing concern among nations harvesting fishery resources in the Northwest Atlantic Ocean. Fishing pressure exerted by several nations on the stocks of fish resident in this area, combined with environmental factors, threatened to severely depress the abundance of very valuable species (see Chapters 1, 3). Also, there was general recognition that the dynamics of these fisheries were little understood. Pursuant to a recommendation of the International Commission for the Northwest Atlantic Fisheries (Anderson, 1998), the management authority for the Northwest Atlantic, several nations expanded their fishery assessment survey operations in a joint investigation of the biological and oceanographic factors controlling survival of fish larvae (Ejsymont and Sherman, 2000, 2013) (see Chapters 1 and 3).

Obtaining the relevant information on a particular stock of fish involves a concentrated study of the growth and mortality of the early stages of the year classes and concurrent observation of related environmental factors. Such a study requires a high frequency of sampling over a considerable area throughout the each year of the investigation. Considerable ship time with adequate laboratory support was essential to ensure adequate sampling results (Ejsymont and Sherman, 2000, 2013). These conditions were already met in the early 1970s, when, among other research vessels, R/V WIECZNO owned by MIR→NMFRI, was included in extensive international fisheries research, covering also the collection of ichthyoplankton, zooplankton, and phytoplankton samples (see Chapter 3). Thus, a research base at sea already existed;

the large amount of collected biological samples gave rise to plans for a processing Center, well equipped and with properly trained staff. The proposed Plankton Sorting and Identification Center in Szczecin, Poland was developed to meet these conditions. The fact is that the first samples of plankton from the Atlantic Ocean, intended for processing at the Center, were from R/V WIECZNO and R/V ALBATROSS IV (Ejsymont and Sherman, 2000, 2013) (see Chapter 3).

2.2. Plankton Sorting and Identification Center - historical overview of joint Polish-American project

The historical overview is presented by Ejsymont and Sherman (2000, 2013) and we will follow the facts which have been gathered and published by these authors. Occasional research cooperation in fisheries between Poland and the United States was carried out before World War II, but joint coordinated study in fisheries ecology began with the visit to Woods Hole and Narragansett by the Polish scientists Dr. Kazimierz Siudziński and Dr. Bogdan Lubieniecki in 1972/73 to discuss potential fisheries ecology projects. In July 1974, Dr. Kenneth Sherman, the U.S. Project Officer, and Dr. Robert Edwards, the Director of NOAA/NMFS Northeast Fisheries Center, met Wojciech Polaczek, Director of the Polish Central Fisheries Board in Szczecin, to discuss the principles of scientific exchange between the two countries and reach agreement on the elements of a bilateral program. As one of the activities in a joint program of research in fisheries ecology focused on the productivity, growth, survival, and recruitment of the important pelagic and demersal species of the Northeast Atlantic Shelf ecosystem, a **Plankton Sorting and Identification Center was established by MIR→NMFRI in 1974** (Fig. 2.2). The Center is located on the campus of the Agricultural Academy Faculty of Marine Fisheries in Szczecin, Poland (Fig. 2.3).

Fig. 2.2 December 1974: Wojciech Polaczek, Director Central Fisheries Board of Poland and Dr. Robert Edwards, Director Northeast Fisheries Center of Woods Hole, Mass. cut through the ribbon during Center's opening ceremony; in the second row - Dr. Ryszard Maj, Director of MIR→NMFRI (source: archives of MIR→NMFRI)

Fig. 2.3 Plankton Sorting and Identification Center of the MIR→NMRFI (headquarters in Szczecin) (source: archives of MIR→NMFRI)

2.2.1. Scientific exchange and training in plankton taxonomy

The 100th anniversary of MIR→NMFRI obliges us to show the effort of many people, both from Poland and the USA, which translates into building the prestige of scientific institutions in Poland and the USA. From the perspective of a hundred years of activity at MIR→NMFRI, we know perfectly well that the international exchange of scientific thought, based primarily on direct interpersonal contacts, is a great value. These interpersonal contacts, related to activity of the Center, have been collected in archival material published by Ejsymont and Sherman (2000, 2013), and hereafter we extensively use these sources of information and present the names of the people who created the Center from scratch. Preparing staff for work in the Center required their training, which in turn required specific biological material as well as trainers and trainees. It is important to emphasize this huge exchange of research staff, because it is people that made this endeavor successful, with their commitment, motivation, constant desire to acquire knowledge, reliability at work, and desire to build the prestige of their scientific institution. The first visitors from the Center to the U.S. under the agreement were Dr. Idzi Drzycimski and Dr. Leonard Ejsymont who visited the NEFC Narragansett (RI) and Woods Hole (MA) Laboratories in **September 1974** for training in plankton taxonomy and orientation in laboratory procedures. From the U.S. side, David Kramer of the SWFC La Jolla (CA) visited the Center in **October 1974**, whereas Robert Marak of NEFC Narragansett visited the Center in **December 1974** to provide training in plankton sorting methods. R. Edwards and J. Suomala of NEFC Woods Hole (MA), and the U.S. consul from Poznań participated in the opening ceremonies of the Plankton Sorting and Identification Center in Szczecin in December 1974 (Ejsymont and Sherman, 2000, 2013) (see Chapter 1). The Center initially supported joint U.S.-Polish larval herring surveys with systematic sorting and identification of samples from the northeast Atlantic shelf. Key staff appointments to the Center were made in **April and August 1974**. Since that time, U.S. scientists have visited the Center to provide training in sorting and identification methodology; Polish scientists have visited the U.S. to attend ichthyoplankton and zooplankton workshops in taxonomy and laboratory procedures. The Center was initially staffed with five sorters, thirteen sorter-identifiers and two administrative assistants. The sorting staff was trained at the Agricultural Academy Faculty of Marine Fisheries in Szczecin, Poland. Thirteen of the scientific staff held M.S. degrees and five B.S. degrees in fisheries science and engineering. The operational plan included staffing for sorting up to 5 000 samples annually. Prof. Idzi Drzycimski from the Agricultural Academy, the current West Pomeranian University of Technology in Szczecin, was the first head of the Center in 1974-1975, then the position was taken over by Dr. Leonard Ejsymont (Fig. 2.4) and he remained at this post till 2010 (Ropelewski, 2001; Ejsymont and Sherman, 2000, 2013). In 2010-2020, the Center was managed by Wanda Kalandyk (Center Manager and Manager of the Zooplankton Ecology Section), and in 2021, the Center management was taken over by Paweł Kaźmierczak (Fig. 2.5A, B).

Fig. 2.4 Dr. Leonard Ejsymont: head of Plankton Sorting and Identification Center of the MIR→NMRFI in 1975-2010 (source: archives of MIR→NMRFI)

Fig. 2.5 (A) From the left - Barbara Kłopotowska (Manager of the Zooplankton Ecology Section), Paweł Kaźmierczak (Acting Center Manager), and Małgorzata Adamus (Manager of the Fish Taxonomy Section) in Plankton Sorting and Identification Center, MIR→NMFRI, Szczecin, 2021 (source: archives of MIR→NMFRI);
(B) Hanna Skólska, Manager of Plankton Sorting Section in MIR→NMFRI, Gdynia, 2011 (source: archives of MIR→NMFRI)

Following an initial training period, systematic sorting was initiated in April 1975. The bilateral exchange of scientific personnel for training has been a regular practice since 1975. E. Kliś, E. Mackus, L. Ejsymont, and B. Wolf participated in the MARMAP (Marine Resources Monitoring, Assessment, and Prediction) ichthyoplankton taxonomy training course conducted by Dr. E. Ahlstrom at the Southwest Fisheries Center (SWFC) in La Jolla (CA). R. Kaczanowicz, B. Kaczmaruk, E. Mackus, and E. Kliś visited the NEFC MARMAP Field Group facility in Narragansett (RI) for training in fish taxonomy; Reymond Maurer, Dr. Elbert Ahlstrom, Dr. Robert Marak, and Dr. Kenneth Sherman visited the Center to provide training in zooplankton and ichthyoplankton sorting and identification. During the first six months of operation, the Center processed approximately 1500 ichthyoplankton samples and separated and identified some 200 000 fish larvae and zooplankton constituents. The principal sorting effort in 1976 was directed to larval herring samples collected during joint survey operations on the U.S. northeast shelf as part of a cooperative study of herring recruitment for the International Commission for the Northwest Atlantic Fisheries (ICNAF) (Anderson, 1998; Ejsymont and Sherman, 2000, 2013) (see Chapters 1 and 3).

The principal sorting effort in 1976 was directed to larval herring samples collected during joint survey operations on the U.S. northeast shelf as part of a cooperative study of herring recruitment for the International Commission for the Northwest Atlantic Fisheries (ICNAF) (Anderson, 1998; Ejsymont and Sherman, 2000, 2013) (see Chapters 1 and 3). John Green, Edward Cohen, R. Maurer, and R. Marak, participated in the aliquoting experiment conducted at the Center **in March 1976** on the efficiency of aliquoting plankton samples. **In June 1976,** the Center was a host to environmental scientists from the ICNAF (International Commission for the Northwest Atlantic) Environmental Subcommittee Working Group representing: Poland, the U.S.A., the Federal Republic of Germany (FRG), and Canada. Dr. Lars Hernroth, a Swedish planktologist from the Institute of Marine Research Fisheries Board of Sweden, visited the Center **in June 1976** to become acquainted with the Center's operations. Other visitors to the Center included a group of German marine scientists, led by Prof. Gotthilf Hempel, from the Institut für Meereskunde, Kiel, who arrived **in August 1976** on the R/V ALKOR.

Dr. George Grice, a UNESCO observer, visited the Center **in 1977**. He presented the work of other UNESCO Sorting Centers in Cochin, Singapore, and Mexico City. **In June 1977**, seven U.S. scientists visited Szczecin, participating in the Advisory Committee Annual Meeting and a Workshop on Georges Bank Larval Herring Studies. The Workshop was held on June 20-23, 1977 in Szczecin. Participants included scientists from the SFI Rostock (GDR), the University of Kiel and the Fishery Sciences Institute, Hamburg (FRG); the MIR→NMFRI Gdynia (Poland), AtlantNIRO, Kaliningrad (USSR), and the MARMAP Field Group, Narragansett, the (Northeast Fisheries Center), NEFC Sandy Hook, and Woods Hole Laboratories (U.S.A.). Gunnar Joakimsson, a scientist from the University of Kiel, spent two months in residence at the Center **from May through July 1977** working on the FRG ichthyoplankton samples. **In September 1977**, biologists from the Center: H. Nowak, M. Płocka, W. Kalandyk and B. Kaczmaruk spent two weeks at the NEFC facility in Narragansett to participate in a workshop on zooplankton taxonomy, ecology, and data processing. **In November 1977**, Dr. L. Ejsymont visited the SWFC in La Jolla (CA), the NEFC in Narragansett and the Woods Hole Laboratories to participate with his U.S. colleagues in cooperative scientific research on the problems of NW Atlantic fisheries.

In August 1978, four biologists from the Center: J. Różak, H. Fidelus-Ferlas, B. Kosiorowska, and E. Mazuchowska visited the NEFC Sandy Hook and Narragansett Laboratories for one-month training in fish egg and larvae identification. During the same year, U.S. scientists: Richard Hennemuth, K. Sherman, R. Marak, John Pearce, Robert Learson, Wallace Smith, and H. C. Boyar visited the Center to advise on MARMAP operations.

W. Smith visited the Center **in May 1979** for two weeks to provide guidance in the identification of *gadoid* and *anguillid* larvae. Four biologists from the Center: M. Baranowski, M. Konieczna, R. Lipska, and E. Meller spent the month of **August 1979** in NEFC Sandy Hook and Narragansett Laboratories studying fish egg identifications. Length frequency analyses were made comparing efficiencies in the use of an electronic counting and sizing system. **In October 1979,** Dr. R. Edwards, K. Sherman, R. Marak (NEFC), and Eileen Maturi (State Department) visited the Center following an ICES meeting in Warsaw; Sharon McLean, from the NEFC Oxford (MD) Laboratory visited **in October 1979** to work on zooplankton pathology; Doris Finan, a fishery biologist from the NEFC Sandy Hook, spent a 6-week period in **October and November 1979** working with the Ichthyoplankton Group of the Center.

Wallace Smith of NEFC Sandy Hook Laboratory visited the Center **in February 1980** to review operations and provide instruction in ichthyoplankton systematics and ecology. M. Adamus and E. Mackus-Baranowska, biologists from the Center, visited the Sandy Hook Laboratory **in August 1980**. Both worked exclusively on fish egg identifications under the guidance of Peter Berrien. During the 6th Advisory Committee Meeting held at the NEFC in Narragansett from **19 to 23 May 1980**, interest was expressed by the Northwest and Alaska Fisheries Center Seattle (WA) and the Southeast Fisheries Center Miami (FL) in having samples sorted for ichthyoplankton.

This initiative was undertaken and was followed by a bilateral exchange of scientists: Dr. Arthur Kendall of the NWAFC Seattle (WA) and Dr. Reuben Lasker of the SWFC La Jolla (CA), and Thomas Potthoff of the SEFC Miami (FL) visited the Szczecin Center **in October 1980**. Polish scientists: L. Ejsymont and B. Kosiorowska visited Northwest and Alaska Fisheries Center (NWAFC) **in November 1980** to work with American colleagues on fish larvae identification. In this way, all the American fisheries research centers: the Northeast Fisheries Center (NEFC), the Southeast Fisheries Center (SEFC), the Northwest and Alaska Fisheries Center (NWAFC), and the Southwest Fisheries Center (SWFC) became involved in coordinated scientific cooperation in fisheries ecology between the MIR→NMFRI in Gdynia and NOAA's National Marine Fisheries Service (NMFS).

In 1981, a three person Pathobiology Group was formed at the Center to conduct research on the parasites of two economically important fish species: Atlantic mackerel, *Scomber scombrus* from the Georges Bank area, and the European eel, *Anguilla anguilla*, from the Odra River estuary.

In 1982, U.S. scientists: Dr. K. Sherman, Dr. R. Edwards, R. Hennemuth and Helen Mustafa visited Warsaw for a meeting with the staff of MIR→NMFRI. From the Polish side: Dr. L. Ejsymont and H. Fidelus-Ferlas visited SEFC Miami (FL) to attend a course of study on the systematics of fish eggs and larvae from the Gulf of Mexico and the Caribbean under the guidance of Dr. William Richards.

In 1983, A. Kodrzycka-Kogut and W. Drozgowski, spent one month in the NWAFC Seattle (WA) attending a course of study on the systematics of fish eggs and larvae of the Gulf of Alaska and coastal waters off Oregon and Washington.

In 1984, U.S. scientists: Jean Dunn of the NWAFC in Seattle and T. Potthoff of the SEFC in Miami spent one month period in residence at the Center providing instruction on the systematics of fish eggs and larvae and completing predator-prey studies.

In December 1985, D. Sujak and M. Kałuża visited the NWAFC in Seattle to attend a course of study on the systematics of fish eggs and larvae from the Gulf of Alaska and East Bering Sea.

In May 1986, Kenneth Stuck, a biologist from the Gulf Coast Research Laboratory, Biloxi (MS) visited the Center to provide instruction in decapods sorting protocol.

In September 1987, W. Kalandyk visited the Gulf Coast Research Laboratory, Biloxi (MS) to learn the taxonomy of zooplankton from the Gulf of Mexico under the supervision of K. Stuck. At the same time, M. Konieczna (Manager of the Fish Taxonomy Section in 1987-2020), visited marine laboratories cooperating in the

Southeast Area Monitoring and Assessment Program (SEAMAP), including the Archival Center in St. Petersburg (FL), the Southeast Fisheries Center (SEFC) in Miami (FL), Louisiana State University, the State Laboratory of Charleston (SC), and the NMFS Laboratory in Beaufort (NC) to exchange information and receive training in ichthyoplankton systematics. **In 1987,** I. Ruminkiewicz was provided with training in the identification of Antarctic ichthyoplankton, zooplankton and micronecton at the NEFC Narragansett Laboratory. Additionally, P. Jędra worked with U.S. colleagues on fish larvae systematics at Sandy Hook Laboratory. **In October 1987,** P. Berrien of Sandy Hook Laboratory spent a two-week period in Szczecin instructing staff on the protocols for BIOMAC sample processing, including the staging of mackerel eggs (see Chapter 3).

In 1988, 400 Antarctic samples collected from R/V PROFESOR SIEDLECKI were successfully sorted and identified by the staff of the Center. **In 1988,** Beverly Vinter of the NWAFC in Seattle spent a month at the Center instructing staff on the protocol for ichthyoplankton sample processing; Dr. Joanne Lyczkowski-Shultz of the SEFC in Pascagoula (MS) visited the Center for one month to work with Polish colleagues on sciaenid and carangid larvae.

In 1989, Rene Eppi of the NOAA in Washington D.C. visited the Center and the Polish Fisheries Board to present a status report on the Maria Skłodowska-Curie Joint Fund II proposal between MIR→NMFRI and NMFS. During the same year, Dr. W. Richards from the SEFC in Miami, and Dr. A. Kendall from the NWAFC in Seattle, and Suam Kim of Korea visited Szczecin to observe the Center's operation. Two biologists from the Center, M. Płocka and S. Bartosiewicz visited the NWAFC in Seattle (WA) **in July 1989** to consult with Dr. A. Kendall, Dr. Ann Matarese, B. Vinter, Deborah Blood and Deborah Siefert on taxonomic issues in zooplankton and ichthyoplankton.

In 1990, a new Branch of the Plankton Sorting Center with the addition of five new positions was established at the MIR→NMFRI, Gdynia. The Branch specializes in presorting fish eggs and larvae and processing Continuous Plankton Recorder (CPR) silks. **In 1990,** the Pacific Biological Station of the Canadian Fisheries and Oceans Department in Nanaimo, B.C. expressed interest in having samples sorted for zooplankton and ichthyoplankton. This initiated the successful cooperation between the Center and Mr. William Shaw of PBS Nanaimo **from 1991 to 1996**.

In November 1992, Morgan Busby and Deborah Siefert from AFSC Seattle came to the Center in Szczecin and Gdynia to provide training in NE Pacific fauna: Morgan Busby instructed the fish taxonomy staff in ichthyoplankton identification and D. Siefert worked with zooplankton staff on development and implementation of the protocol for processing and identifying zooplankton samples.

In October 1993, training was provided to three scientists from the Center, L. Ejsymont, W. Kalandyk and K. Maśko, in collaboration with a plankton specialist, Andrew Warner of Plymouth (UK), in the methods for sorting and identifying plankton from fine mesh netting of the Continuous Plankton Recorder (CPR) system. The need for continuing time-series assessments of the changing state of marine ecosystems in relation to the sustainability of fisheries yields was discussed. W. Kalandyk and K. Maśko visited the NWAFC Laboratory in Seattle **in October 1993** for additional training in Pacific zooplankton taxonomy and new methodologies.

In 1994, the first "SKAGEX" zooplankton samples from the North Sea, Kattegat and Skagerrak were processed, on a noninterference basis, for the Royal Swedish Academy of Science Kristineberg Marine Research Station.

In 1995, the Center accepted the request from the SWFSC to process ichthyoplankton samples from the California Current ecosystem. The samples were collected throughout the 3-year period of 1995-1997 as part of a project to estimate the spawning biomass of *Sebastes* spp. and forwarded to the Center from the SWFSC Tiburon Laboratory.

In October 1996, Dr. Patricia Tester of National Ocean Service (NOS) Beaufort visited Center in Szczecin and Gdynia facilities to give a training course on Continuous Plankton Recorder (CPR) sample processing.

In October 1997, the Beaufort Laboratory of SEFSC was pleased to host M. Konieczna and Grażyna Buczek from the Center Ichthyoplankton Taxonomy Group. While at the Beaufort Laboratory, the two Polish scientists worked with Dr. J. Lyczkowski-Shultz from Pascagoula Laboratory and with Drs. Allyn Powell and Jonathan Hare from the Beaufort Laboratory. Many taxonomic problems were solved and other problems were identified.

In 1998, Lisa Britt, W. Rugen, and D. Blood from AFSC in Seattle made a visit to the Center, both in Szczecin and Gdynia. Lisa Britt and W. Rugen delivered and provided training for the Center data entry system. Deborah Blood provided training in the identification of Northeast Pacific fish eggs.

To commemorate the 25th year of the Joint Studies in Fisheries Ecology between the United States and Poland, a Symposium was held at the Sea Fisheries Institute in Gdynia on **5 and 6 July 1999**. Two themes emerged from the discussion during the symposium: (1) need for continuing time-series assessments of the changing states of marine ecosystems in relation to the sustainability of fisheries yields, and (2) the importance of studies of zooplankton and larval fish in assessments of biodiversity changes in large marine ecosystems around the world including the Gulf of Mexico, the eastern Bering Sea, Gulf of Alaska and the U.S. Northeastern Shelf and the Baltic Sea.

In June 2000, W. Kalandyk and M. Konieczna visited Seattle at the AFSC for a week following the 26th Advisory Committee meeting to work with Drs. A. Kendall, A. Matarese, and Jeffrey Napp on taxonomic issues in zoo- and ichthyoplankton.

In August 2001, Dr. Dariusz Fey of MIR→NMFRI, Gdynia visited National Ocean Science (NOS) Beaufort Laboratory following the Larval Fish Conference (Early Life History - ELH section of the American Fisheries Society - AFS) to learn otolith work conducted at Beaufort. Larval king mackerel (*Scomberomorus cavalla*) age and growth studies were begun by Dr. D. Fey of MIR→NMFRI and Dr. J. Lyczkowski-Shultz of NMFS Pascagoula Laboratory.

In 2002, Dr. D. Fey received a one-year post-doc National Research Council Research Associateship (USA) to work at the NOAA Beaufort Laboratory with Dr. J. Hare on the effect of larval growth rate on cohort survival in Atlantic menhaden (*Brevoortia tyrannus*). In the next years, as a result of the continued cooperation between Dr. D. Fey and Dr. J. Hare, several scientific papers were published in the field of larval fish ecology and otolith microstructure analysis (Fey et al., 2005; Fey and Hare, 2005, 2008; Hernandez et. al., 2009; Fey and Hare, 2012).

During 30 years (1974 to 2004) of continuous cooperation, over 50 scientists from the Center have visited the U.S. NMFS Centers and other collaborators (federal, state, academic, private, and international) for advanced scientific and technical training in plankton identification and laboratory procedures. Out of this number, 20 biologists from the Center visited NEFSC Narragansett and Sandy Hook; 5 biologists, SEFSC Beaufort (NC), Biloxi (MS), Miami and St. Petersburg (FL); 5 biologists, SWFSC La Jolla (CA), and 13 biologists, AFSC Seattle (WA) Laboratories. From the U.S. side 49 scientists have visited the Center to attend annual Advisory Committee meetings, to provide training in sorting methodologies and identification of plankton, observe operations, and provide advice on fisheries assessment research (Ejsymont and Sherman, 2013).

Very intensive scientific exchange and training in plankton taxonomy, which took place from the 1970s till the beginning of the 2000s, made it possible to prepare Polish staff not only for taxonomic determinations at the highest international level, but this group of employees could train their successors at work. For this reason, starting from the mid-2000s, supplementary training in taxonomic determinations was only conducted during Advisory Committee

meetings listed in Appendix II. All the names of Americans and Poles participating in these meetings are presented in Appendix II.

Currently, the Center provides research and technical services of enumerating plankton samples according to the methodology recommended by partners. The facility offers services connected with taxonomic identification of various plankton samples as well as defining their size and biological structure. The laboratories and institutes of the U.S. National Marine Fisheries Service (NMFS) are the main partners of the Center. The Center's capacity allows conducting analyses also for Canadian and European partners as well as for the Departments of the MIR→NMFRI. Over 46 years of its operation, the Center built a trained and qualified team. The skills, together with the quality of the services result in a full portfolio of long-lasting projects. These long-term projects provide essential data regarding the structure and function of ecosystems and provided data to investigate the impact of changing climate on marine ecosystems.

Several NOAA-NMFS projects are utilizing the Center's expertise, including fisheries ecology programs in Gulf of Alaska, eastern Bering Sea, Gulf of Mexico, Southeast U.S. Shelf, and Northeast U.S. Shelf Large Marine Ecosystems (Sherman, 1989, 2000, 2016; Sherman and Hamukuaya, 2016). In collaboration with the National Science Foundation and the National Ocean Service Coastal Ocean Program, the NMFS Fisheries Science Centers have conducted studies focused on global climate change (see Chapter 7) and coastal ocean processes that include (i) the South Atlantic Bight Recruitment Experiment (SABRE) focused on menhaden recruitment in the Southeast Shelf and Georges Bank, (ii) Global Ocean Ecosystems Dynamics (GLOBEC), a study of ocean dynamics, (iii) and the growth and survival of Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) eggs and larvae, and (iv) the population dynamics of their principal zooplankton prey (*Calanus finmarchicus*) and (*Pseudocalanus* spp.). Activities in the Pacific include the Southeast Bering Sea Carrying Capacity (SEBSCC) program with a focus on examining the ecosystem of the Bering Sea, the role of walleye pollock (*Theragra chalcogramma*) in the food web, and a study of effects of El Niño on the Gulf of Alaska ecosystem (see Chapter 5). Other projects for which samples were processed by the Center include the ecosystem survey efforts to monitor the changing states and health of coastal ecosystems underway by the NEFSC (Ejsymont and Sherman, 2000, 2013).

2.2.2. Organizational structure of Plankton Sorting and Identification Center

The Plankton Sorting and Identification Center consists of three sections:

1. Plankton Sorting Section: A team which specializes in sorting samples and identifying CPR samples,
2. Fish Taxonomy Section: A team which specializes in taxonomic identification of fish species and classifying fish eggs by development stage,
3. Zooplankton Ecology Section: A team which specializes in marine invertebrate taxonomy.

2.2.3. The range of plankton sorting and identification offer

The laboratory analyses encompass:

1. species composition of ichthyoplankton, zooplankton, and phytoplankton,
2. measuring the invertebrate and fish larvae,
3. plankton identification in ballast water,
4. classifying eggs by development stages,
5. determining the abundance of zooplankton dominants,
6. determining the food composition of fish larvae (Figs. 2.6, 2.7).

Fig. 2.6 Fish egg development stages (left) and fish larvae (right) (source: archives of MIR→NMRFI)

Fig. 2.7 Larvae of goosefish (*Lophius Americanus*) (left) and Pacific halibut (*Hippoglossus Stenolepis*) (right) (source: archives of MIR→NMRFI)

2.2.4. Center's performance – computerization and biological analyses

In June 1994, Mirosław Ciupiński visited the Alaska Fisheries Science Center (AFSC) Seattle Laboratory where he became acquainted with entering results of ichthyo- and zooplankton analyses into the computer database. His visit was a milestone in Polish-American joint cooperative studies as discussion with Drs. A. Kendall and Bernard Megrey along with William Rugen and Jane Small concerning use of computers in the operation of the Center was initiated. Following Dr. A. Kendall's suggestion, the computerization of the Center was implemented through the effort of M. Ciupiński at the Center and specialists at AFSC (Ejsymont and Sherman, 2013; Fig. 2.8). In June of 1995, two complete 486-class PC computer systems were purchased. The systems consisted of high-powered CPU's and color monitors, external storage dual Bernoulli disks (880MB capacity), printers, and uninterruptible power supplies. These systems were configured and software was installed at the AFSC for testing. The computer systems were then delivered and installed at Plankton Sorting and Identification Center in September 1995. Development of the database design, table definition, relational schema, data entry forms, and database application scripts that permit the facility to enter, edit and validate data, including all programming, debugging and testing were completed by the end of August 1996 (Ejsymont and Sherman, 2013). In March 1997, Dr. B. Megrey (AFSC) delivered and installed a Pentium-class PC computer system to the Center along with a beta version of data base. The Center maintained two complete operational systems. W. Rugen (AFSC) conducted a follow-up training visit where he provided instruction to the database administrator on how to use the application software. Also, Dr. Richard Brodeur made brief visits to the Center, both in Szczecin and Gdynia, to discuss the streamlining of protocols for predatory zooplankton processing. These efforts by MIR→NMFRI and

AFSC were replicated with the NEFSC and SEFSC greatly facilitating the transfer of data developed by the joint studies.

Fig. 2.8 Databases operator, Mirosław Ciupiński at Plankton Sorting and Identification Center, MIR→NMFRI, Szczecin, 2021 (source: archives of MIR→NMFRI)

The Center provides employment to 21 people, especially the graduates of the previous Agricultural Academy and the current West Pomeranian University of Technology in Szczecin. The Center is a unique facility which provides this kind of aquatic ecosystem research in various geographic regions (ichthyoplankton and zooplankton) in such a wide taxonomic and quantitative range.

The basic laboratory range of analyses can be extended based on scientific needs. The Plankton Sorting and Identification Center analyses approximately 6 000 samples a year within the basic American project, and 200-400 samples a year within the projects conducted by the European Union (EU) countries: Denmark, Sweden, Germany, the Netherlands, Spain, and outside the EU: Norway, the United Kingdom.

The solid work of the Center is valued by scientists all over the world, which is confirmed by projects realized every year and performed on time. From 1974 to 2020, Poland and the United States implemented a Joint Fisheries Ecology Program. The Joint Fisheries Ecology Program supports the identification and quantification of ichthyoplankton and zooplankton samples collected from Atlantic and Pacific Large Marine Ecosystems (LMEs) (see Chapter 3). The samples are taxonomically separated, enumerated, and measured by the scientific staff of the MIR→NMFRI Laboratories in Szczecin and Gdynia, Poland.

The operational plan included staffing for the identification and quantification of up to 7 000 samples annually. During the 46 years of continuous collaborative effort, the scientific staff of MIR→NMFRI has made significant contributions to the biodiversity, demography, and taxonomic studies of ichthyoplankton and zooplankton within six of the world's LMEs. The staff has identified 23 million fish eggs and larvae, and 42 million zooplankters. The information from 290 000 plankton samples constitutes an unprecedented database of plankton biomass, measured as displacement volume, and species biodiversity of the zooplankton and ichthyoplankton communities supporting the fisheries of the U.S. Northeast Shelf, Southeast Shelf, Gulf of Mexico, Gulf of Alaska, and East Bering Sea LMEs. The data gathered through the combined efforts of the staff of the NOAA-Fisheries Centers and MIR→NMFRI scientists and technicians has led to improved ecosystem-based assessment and management practices for initiating the recovery of depleted fish populations in LMEs off the U.S. coasts. Ichthyoplankton taxonomic and biodiversity data are used in estimating the size of the spawning biomass of important fishery resources and the species composition, abundance and distribution of their zooplankton prey. The database has supported analyses leading to the publication of the important research and assessment reports that benefit marine fisheries research, assessment and management. The combined efforts of the scientists and technicians, along with the willing assistance of the captains and crews of research vessels from both countries have contributed to an improved ecosystem-based approach to fisheries science (Ejsymont and Sherman, 2000, 2013) (see Chapter 3).

The data base developed during the years of joint study represents the most complete sampling coverage of the Continental Shelf off the U.S. northeast coast. The data provided are essential to a better understanding of the stock-recruitment relationship and spawning stock biomass of important fish species desired by the U.S. fishermen (haddock, cod, flounder, mackerel, herring, hake, tunas, and others). It is important to keep this body of knowledge intact, and to extend it over the next several years. Loss of continuity in the operations of the Plankton Sorting and Identification Center would seriously jeopardize the U.S. fish and fisheries research effort. The Magnuson–Stevens Fishery Conservation and Management Act (MSFCMA) calls for research efforts to provide *"...best scientific information possible..."* for the effective management and conservation of the fish resources within the management zone (https://www.fisheries.noaa.gov/topic/laws-policies). The work of MIR→NMFRI and the partnership with National Marine Fisheries Service supports these research efforts.

2.2.5. Center's international cooperation

The Plankton Sorting and Identification Center in Szczecin has cooperated with numerous institutions worldwide (Fig. 2.9; see the list below):

- NOAA-NMFS, John J. Howard Marine Sciences Laboratory, Highlands (NJ),
- NOAA-NMFS, Southeast Fisheries Science Center, Division of Coastal and Estuarine Ecology, Beaufort Laboratory (NC),
- NOAA - NEFSC, Northeast Fisheries Science Center,
- NOAA - AFSC, Alaska Fisheries Science Center,
- NOAA - NWFSC, Northwest Fisheries Science Center,
- NOAA - SEFSC, Southeast Fisheries Science Center,
- Florida Dept. of Natural Resources, Bureau of Marine Research (SEAMAP Archiving Center), St. Petersburg (FL),
- Florida Dept. of Environmental Protection, Florida Marine Research Institute – Division of Marine Resources, St. Petersburg (FL),
- NOAA-NMFS, National Marine Fisheries, Miami Laboratory (FL),
- NOAA-NMFS, Southwest Fisheries Center, Tiburon Laboratory (Ca).
- Gulf States Marine Fisheries Commission (represented by the fishery representatives from the USA: Alabama, Florida, Louisiana, Mississippi, Texas),
- Center of Marine Ecology and Climate Impact, Greenland Institute of Natural Resources, Greenland,
- Coastal and Marine Ecosystem Unit Scottish Natural Heritage,
- Dauphin Island Sea Laboratory (DISL), Dauphin Island (AL),
- IMARES Institute, Wageningen University and Research Center, Ijmuiden, The Netherlands,
- Institute of Hydrobiology and Fishery Science, University of Hamburg, Germany,
- Institute of Marine Research Center for Development Cooperation in Fisheries, Norway,
- Institute of Marine Research in Lyseklil, Sweden,
- Instituto Milenio de Oceanografía, Universidad de Concepción, Barrio Universitario SN, Edificio Departamento Oceanografía, Concepción, Chile,
- Johann Heinrich von Thünen Institute, Institute of Baltic Sea Fisheries, Germany,
- King Abdullah University of Science and Technology, Red Sea Research Center, Saudi Arabia,
- Kristineberg Marine Biological Station of Royal Swedish Academy of Sciences,
- Kuwait Institute for Scientific Research, Kuwait,

- Leibnitz Institute of Marine Science, Kiel, Germany,
- Linnaeus University, Centre Ecology and Evolution in Microbial model Systems, Sweden,
- Marine Monitoring AB, Lysekil, Sweden,
- National Environmental Research Laboratory, Department of Marine Ecology in Aarhus University, Roskilde, Denmark,
- National Institute of Aquatic Resources, Technical University of Denmark, Denmark,
- Natural Environment Research Council, British Antarctic Survey, Cambridge, United Kingdom,
- Pacific Biological Station, Nanaimo B.C., Canada,
- Roskilde University, Department of Life Sciences & Chemistry, Denmark,
- School of Biological Science, University of Aberdeen, Scotland, United Kingdom,
- Swedish Meteorological and Hydrological Institute, Oceanographic Unit, Sweden,
- University of Gothenburg, Department of Marine Ecology, Goteborg, Sweden,
- Urban Coast Institute, Monmouth University, New Jersey, USA.

The Center conducts also research in the Pomeranian Bay, the Vistula Lagoon and the Baltic Sea and these studies have been commissioned by the scientific departments of MIR→NMFRI in Gdynia.

Fig. 2.9 Orange color indicates regions from which plankton samples were gathered for sorting and identification by the Center (source: archives of MIR→NMFRI)

2.2.6. Center's Advisory Committee Meetings

In 1974-2019, Dr. Kenneth Sherman, Director of the National Marine Fisheries Service in Narragansett (RI), was the U.S. Project Officer; in 2020 the responsibility was assumed by Dr. Jonathan Hare, Science and Research Director in the Northeast Fisheries Science Center (NEFSC) (Fig. 2.1). Scientists from each country serve on the Advisory Committee for the Center. The Advisory Committee meets annually to review joint progress in advancing fisheries ecology studies, establish sorting priorities, and guide Center development (Ejsymont and Sherman, 2000, 2013) (Figs. 2.10-2.13). Both parties agreed that a permanent Advisory Committee should be formed to ensure the full operational capability of the Center. The first annual meeting of the Committee was held in Szczecin on August 26-28, 1975. In attendance were scientists from the U.S.: R. Edwards, K. Sherman and R. Marak, and from Poland: K. Siudziński, I. Drzycimski, and L. Ejsymont. During the first meeting, the Advisory Committee considered a number of subjects including organizing an ICNAF workshop on Larval Herring Surveys in Szczecin (Ejsymont and Sherman, 2000, 2013). Historical documentation of Advisory Committee Meetings can be found in publication by Ejsymont and Sherman (2013) and in Appendix II.

Fig. 2.10 The U.S.-Polish Technical Meeting with staff during Advisory Committee Meeting in 2017 (source: archives of MIR→NMFRI)

Fig. 2.11 The Advisory Committee Meeting in Gdynia, Poland, 2019 - presentation of Dr. Kenneth Sherman NMFS, Narragansett (left) and Dr. Piotr Margoński, Director of MIR→NMFRI (right) (source: archives of MIR→NMFRI)

Fig. 2.12 The Advisory Committee Meeting in Gdynia, Poland, 2019 - Dr. Jonathan Hare (NEFSC, Science and Research Director) and Dr. Piotr Margoński (NMFRI, Director) (source: archives of MIR→NMFRI)

Fig. 2.13 The Advisory Committee Meeting in Gdynia, Poland, 2019 – Dr. Kenneth Sherman (NMFS, Narragansett) receives a gift commemorating 45 years of cooperation within the framework of Plankton Sorting and Identification Center; in the picture - Wanda Kalandyk, Paweł Kaźmierczak - managers of the Center (source: archives of MIR→NMFRI)

In recognition of 46 years of continuous cooperation within the Joint Fisheries Ecology Program, we are pleased to dedicate this commemorative volume of history, personal profiles, and exceptional successes to a continuation of our longstanding U.S. and Polish partnership.

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3

POLISH - AMERICAN FISHERIES RESEARCH IN THE NORTHWEST ATLANTIC

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Nancy Kohler, Tycjan Wodzinowski

3. POLISH - AMERICAN FISHERIES RESEARCH IN THE NORTHWEST ATLANTIC

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3.1. Study area - general overview

We have decided to start each "fisheries" chapter in this monograph with a general look at the studied area in terms of fisheries and changing fish stocks as a result of human activity, particularly unsustainable fishing. The Food and Agriculture Organization of the United Nations (FAO) studies (FAO, 2011; http://www.fao.org/3/i2389e/i2389e.pdf) are excellent overview material in this matter. This general knowledge was used in this monograph; the graphs, presented in Chapters 3-6, are based on updated data available in FAO (2019).

As stated in FAO (2011) document, one of the tasks of this organization is to make agriculture, forestry and fisheries more productive and sustainable. Among numerous valuable documents prepared on a regular basis by FAO are those concerning commercial fisheries in sub-regions which were specified to facilitate FAO statistics (e.g. FAO, 2011, 2019; Figs. 3.1, 3.2). Marine fisheries are very important to the economy and well-being of coastal communities. Maintaining the long-term prosperity and sustainability of marine fisheries is not only of political and social significance but also of economic and ecological importance. Every FAO *"Review of the state of world marine fishery resources"* presents an updated assessment of the current status of the world's marine fishery resources. Its aim is to provide the FAO Committee on Fisheries, policy-makers, civil society, fishers and managers of world fishery resources with a comprehensive, objective and global review of the state of the living marine resources of the oceans. Every review is based mainly on official catch statistics and relevant stock assessment and other complementary information available (FAO, 2011). In the text that follows in this monograph we will adopt the FAO names of geographical regions and will adopt FAO global maps showing subdivisions (FAO, 2007, 2011;http://www.fao.org/tempref/FI/STAT/by_FishArea/Default.htm;http://www.fao.org/3/i2389e/i2389e.pdf).

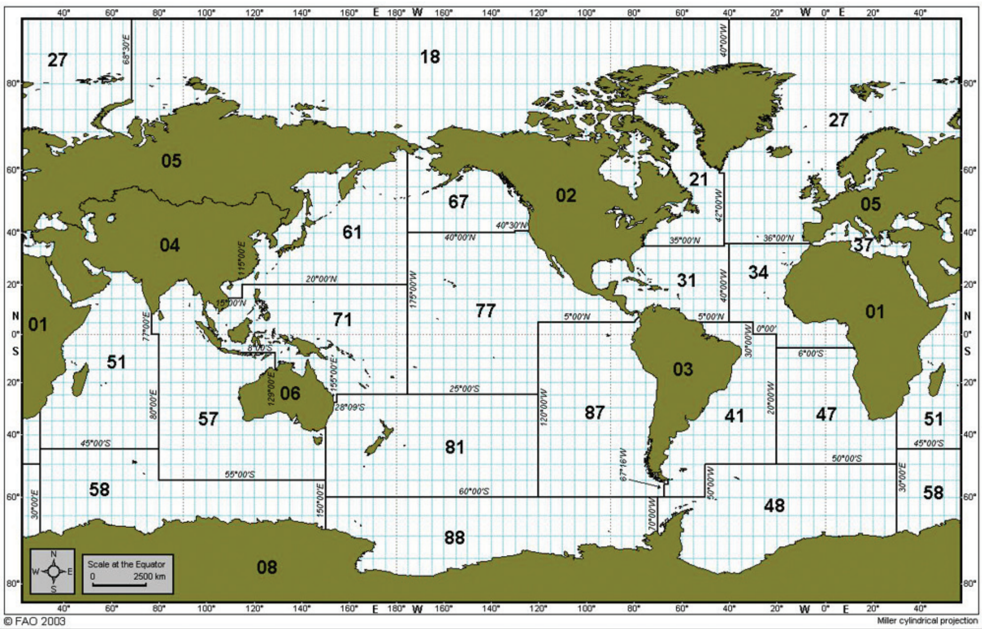


Fig. 3.1 Global map showing FAO major fishing areas (source: FAO, 2007; retrieved on 06 October 2020; http://www.fao.org/tempref/FI/STAT/by_FishArea/Default.htm; 01 - Africa-Inland Water; 02 - America-Inland Water; 03 - America, South-Inland Water; 04 - Asia-Inland Water; 05 - Europe-Inland Water; 06 - Oceania-Inland Water; 21 - Atlantic, Northwest; 27 - Atlantic, Northeast; 31 - Atlantic, Western Central; 34 - Atlantic, Eastern Central; 37 - Mediterranean and Black Sea; 41 - Atlantic, South West; 47 - Atlantic, South East; 48 - Atlantic, Antarctic; 51 - Indian Ocean, Western; 57 - Indian Ocean, Eastern; 58 - Indian Ocean, Antarctic; 61 - Pacific, Northwest; 67 - Pacific, Northeast; 71 - Pacific, Western Central; 77 - Pacific, Eastern Central; 81 - Pacific, Southwest; 87 - Pacific, Southeast; 88 - Pacific, Antarctic). This work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo)

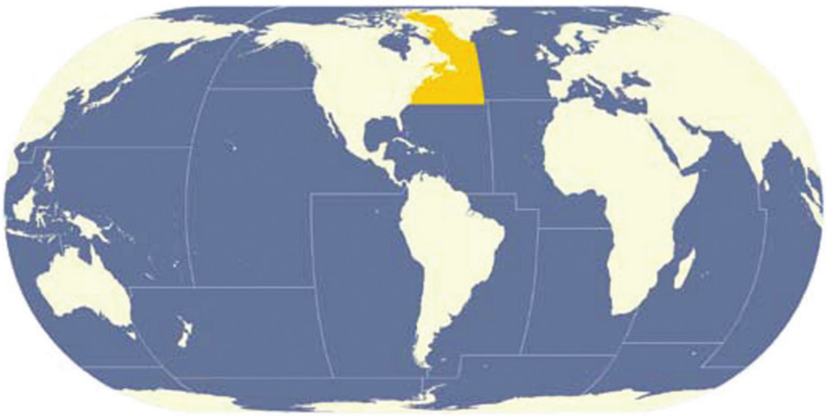


Fig. 3.2 The Northwest Atlantic (FAO Area 21) [source: FAO, 2011; retrieved on 09 March 2020; this work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo)]

The Northwest Atlantic Region (Area 21 according to FAO division) extends over 6.5 million km^2 and covers 43 degrees of latitude from Greenland to the Carolinas off the United States of America (Figs. 3.1, 3.2). It encompasses an extensive continental shelf and slope out to 1000 m that covers 1.3 million km^2. It comprises the mid-Atlantic Bight of the United States of America, Georges Bank/Gulf of Maine, the Scotian Shelf, the Gulf of St. Lawrence, the Grand Banks, the northeast Newfoundland and Labrador Shelves, Davis Strait and Baffin Bay bordering the Arctic Basin (FAO, 2011).

3.2. Fisheries in the Northwest Atlantic (FAO Area 21)

The commercial fisheries of the Northwest Atlantic, particularly those for Atlantic cod (*Gadus morhua*), have been important for five centuries. Area 21 (Figs. 3.1, 3.2) has a total surface area of 6.26 million km^2 of which 1.29 million km^2 is shelf area. The region's marine environment is dominated by the cold Labrador Current, which flows southward to the Grand Banks, and by the warm Gulf Stream, which flows north-eastwards from Cape Hatteras, seaward of the continental shelf;

it supplies relatively warm water to West Greenland. The freshwater influence from the St. Lawrence River is also important. The major fisheries resources occur on the broad continental shelves, particularly Georges Bank, the Scotian Shelf, the Gulf of St. Lawrence and the Grand Banks of Newfoundland (FAO, 2011).

According to FAO statistics (FAO, 2019) nominal catches in Area 21 doubled from 2.3 million tonnes in 1950 to peak at 4.6 million tonnes in 1968 (Fig. 3.3). Since that year catches subsequently declined from 4.4 million tonnes in 1973 to 2.8 million tonnes in 1978. They stabilized at about 2.7 million tonnes until 1984, and then increased slowly, reaching 3.3 million tonnes in 1990. Catches subsequently declined steeply to about 2 million tonnes in 1994, as a result of the groundfish collapse off eastern Canada. A slight recovery has been evident since 1998, when 1.96 million tonnes were reported. Total catch increased to 2.3 million tonnes in 2001; however, in 2017 it declined to the lowest since 1950 level of 1.7 million tonnes. Historic patterns in catch in Area 21 are primarily affected by changes in cod (decrease) and Northern prawn (*Pandalus borealis*) (increase) stocks. Cumulatively 39 million tonnes of Atlantic cod, 20 million tonnes of Atlantic herring (*Clupea harengus*), and 19 million of Atlantic menhaden (*Brevoortia tyrannus*) were caught between 1950-2017 in the area. Cod catches dominated the fisheries catches prior to the 1950s and increased in the 1960s to a peak of almost 2 million tonnes (Fig. 3.3). Almost doubling overall catches in the 1960s and 1970s began to raise serious concerns about ecological disruption across the entire Northwest Atlantic ecosystem. Catches of Atlantic herring, Atlantic redfishes (*Sebastes spp.*), silver hake (*Merluccius bilinearis*), haddock (*Melanogrammus aeglefinus*), Atlantic menhaden (*Brevoortia tyrannus*) and American sea scallop (*Placopecten magellanicus*) also increased in the 1950s and 1960s (Fig. 3.3). These were followed by increased catches of Atlantic mackerel (*Scomber scombrus*) and capelin (*Mallotus villosus*) as a result of increasing distant-water fleet effort (Fig. 3.4).

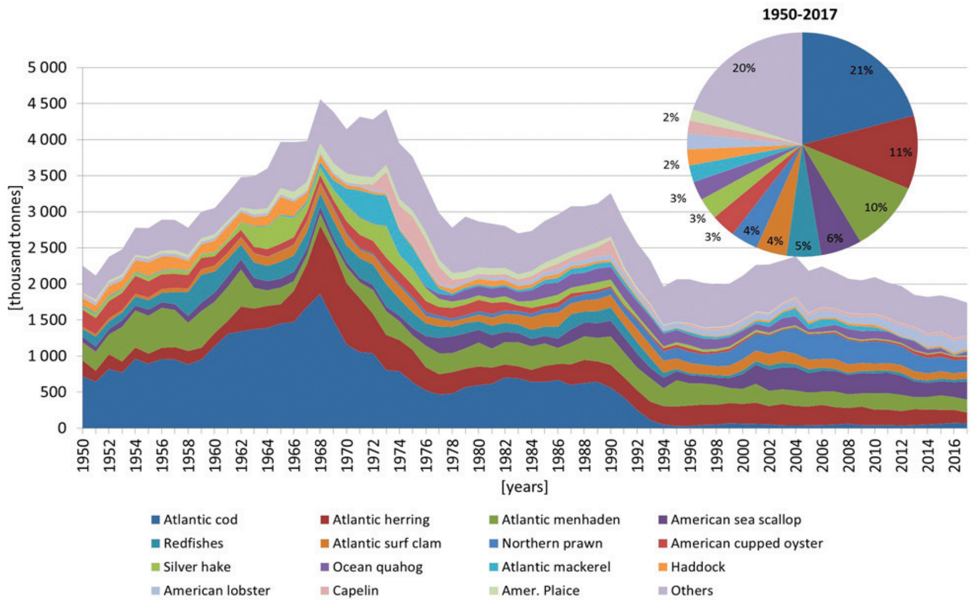


Fig. 3.3 Annual nominal catches of top 15 fish species in the Northwest Atlantic (FAO Area 21) in 1950-2017 (source of data: FAO, 2019)

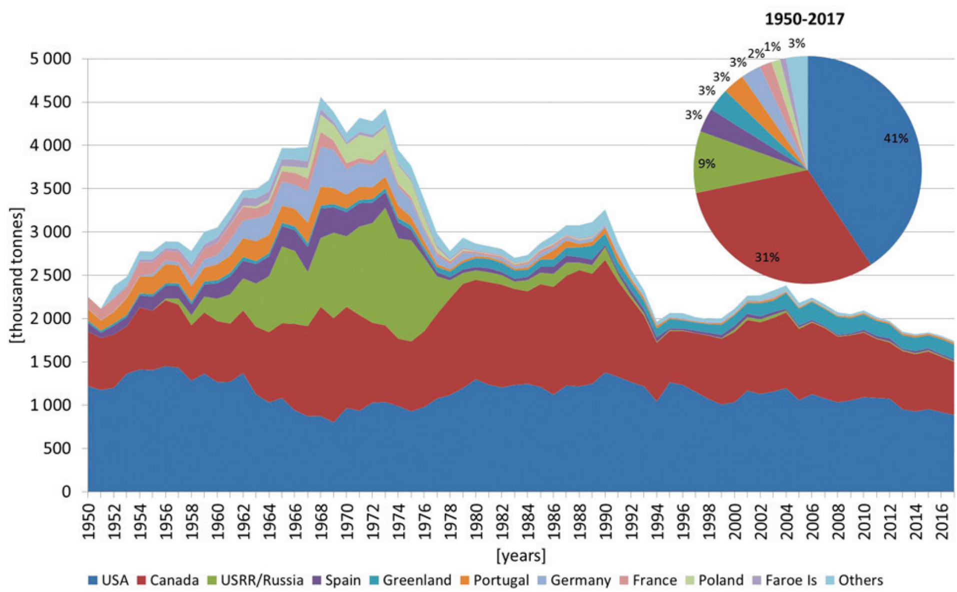


Fig. 3.4 Annual nominal fish catches in the Northwest Atlantic (FAO Area 21) in 1950-2017 by 10 countries (source of data: FAO, 2019)

It is noteworthy that the sharp increase in pressure from the deep-sea fleet of non-coastal countries has not coincided with the increase in catches by the U.S. and Canada (Fig. 3.4). At the turn of the 1960s and 1970s, the U.S. annual catches even fell slightly, while Canadian catches remained virtually unchanged. Atlantic menhaden, Atlantic surf clam (*Spisula solidissima*), American sea scallop, and American cupped oyster (*Crassostrea virginica*) accounted for over 50% of the total cumulative (1950-2017) U.S. catches in the Northwest Atlantic (Fig. 3.5). According to FAO statistics (FAO, 2019) there were six non-coastal countries exploiting Northwest Atlantic fish resources in the mid-nineties. Foreign countries fishing fleets (15 states) output exceeded for the first time the combined U.S. and Canadian catches in 1965 (Fig. 3.4). Non-coastal countries, including Poland, were then seriously affected by extension of the U.S. and Canadian Exclusive Economic Zones (EEZ) to 200 nautical miles in 1976/1977. Polish catches in the Northwest Atlantic started in 1959, peaked in 1971 (270 thousand tonnes - 53% of total Polish fisheries production) then gradually decreased as a result of declining resources and limitation imposed after 1976 by the U.S.[1)] and Canada as well as the International Commission for the Northwest Atlantic Fisheries/Northwest Atlantic Fisheries Organization (ICNAF/NAFO) (Fig. 3.6; see Chapter 1). Atlantic mackerel (*Scomber scombrus*), Atlantic herring and Atlantic cod were three main species targeted by the Polish fleet in the area (Fig. 3.6). The first two species were the subject of fisheries research conducted as part of a large research program prepared by the National Marine Fisheries Service (NMFS), Woods Hole, and Narragansett and then adopted by all countries involved in a large international research venture. Among these countries was Poland with its research potential encompassing the scientific staff aboard R/V WIECZNO (see sub-chapter 3.3.).

[1)] Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), signed on April 13, 1976.

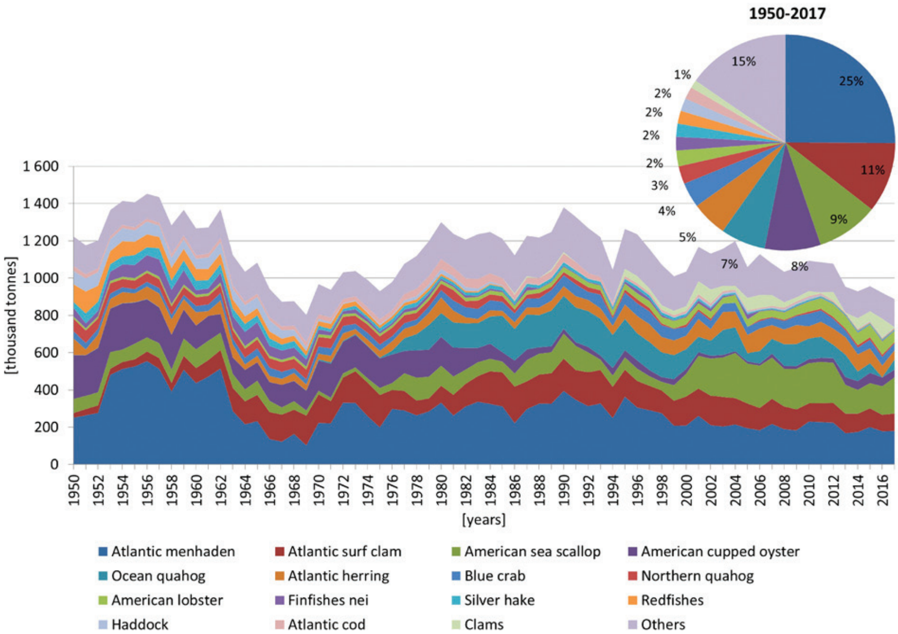


Fig. 3.5 The U.S. catches of main species in the Northwest Atlantic area (FAO Area 21) in 1950-2017 (source of data: FAO, 2019)

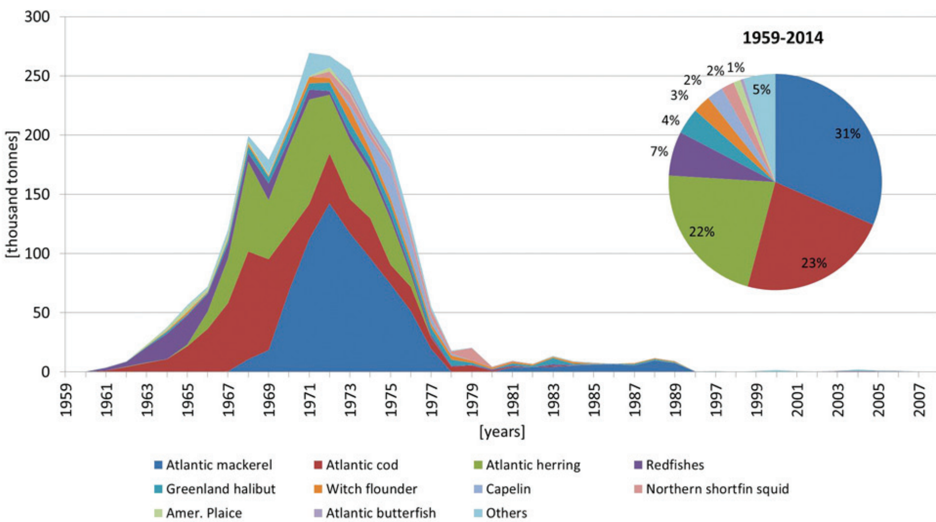


Fig. 3.6 Polish catches of main species in the Northwest Atlantic area (FAO Area 21) in 1959-2007 (source of data: FAO, 2019)

3.3. International fisheries research in the Northwest Atlantic in the 1970s and 1980s

In light of the intensive exploitation of fish stocks in the Northwest Atlantic (Figs. 3.3-3.6), mainly in the Georges Bank region, and the threat of ecological imbalance, the National Marine Fisheries Service in Woods Hole and Narragansett saw the need for extensive scientific research focused on all fish species exploited, and on basic parameters defining environmental conditions: measurements of salinity, water temperature and oxygen content in water, and in some cruises measurements of chlorophyll *a* concentration, nutrients content, primary production.

Undoubtedly, the logistic undertaking was not easy, because first of all it required a scientific holistic view of the functioning of the entire ecosystem and planning of all studies allowing receiving answers regarding the state of fish stocks, which were also important for the American consumer market. Another issue was the encouragement addressed to countries exploiting natural fish stocks in the U.S. Eastern Shelf to participate in international research. Very crucial was the recognition of technical facilities and scientific capabilities on foreign vessels planned to take part in partial cruises, which were to create one clear data set for further scientific analyzes. We are convinced that the scope of scientific research conducted on the U.S. eastern shelf and their excellent planning every year, the number of research vessels engaged, the number of scientific and technical employees involved in the research, and above all a deep understanding of the need to conduct scientific research - is unprecedented in the global scale.

The 1970s and 1980s were years without computers, mobile phones and other facilities making life easier. In our archives we found working plans of cruises planned on the U.S. eastern continental shelf from March 1977 to February 1978 (Tables 3.1, 3.2). Table 3.1 is a handwritten summary table containing all planned vessels, scope of scientific research and the number of research personnel. Tables 3.2 and 3.3 show more structured data and show that during one exemplary calendar year 16 research vessels from 8 countries were planned, including 7 from outside the USA. As many as 441 scientists, 5 309 man-days, and 4 935 research stations were planned in those cruises. The huge amount of data collected had to be systematized and on this basis working databases were built constituting the basis for further mathematical and statistical calculations. Data elaboration took place in the National Marine Fisheries Service (NMFS) Woods Hole, Narragansett, Sandy Hook (MARMAP surveys of the continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia in 1977-1983). The outcome of these elaborations can be found in: Atlas no.1. Summary of operations Published Date:1984 Series: NOAA technical memorandum NMFS-F/NEC; 33, MARMAP Surveys of the continental shelf from Cape Hatteras, North Carolina to Cape Sable, Nova Scotia (1984-1987), Atlas no.2. Annual Distribution Patterns of Fish Larvae Published Date:1987 Series: NOAA technical memorandum NMFS-F/NEC; 47, MARMAP surveys of the continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1977-1984). Atlas no.3. Summary of operations Published Date: 1989 Series: NOAA technical memorandum NMFS-F/NEC; 88.

Table 3.3 does not cover all the ships that took part in international studies of the Northwest Atlantic. Some ships may be unintentionally omitted due to a lack of information. In 1975, there were for example two cruises of R/V BELOGORSK (USSR) (Pastuszak et al., 1982). We also know (Dr. Hoss - personal communication) that R/V OREGON II, home-ported in Pascagoula, Mississippi took part in fisheries studies in the coastal waters of western Atlantic but this ship has never cooperated at sea with R/V WIECZNO in terms of carrying parallel studies or participation of American scientists from Pascagoula Laboratory onboard Polish research vessel. As the monograph focuses on Polish-American fisheries cooperation, R/V OREGON II, as well as some other American vessels, carrying studies in regions presented in this book, are not shown in pictures in subchapter 3.3.1.

Table 3.1 Vessel operations and types of research conducted by NEFC, Woods Hole, Narragansett from 1 March 1977 to 28 February 1978 (source: private archives of M. Pastuszak)

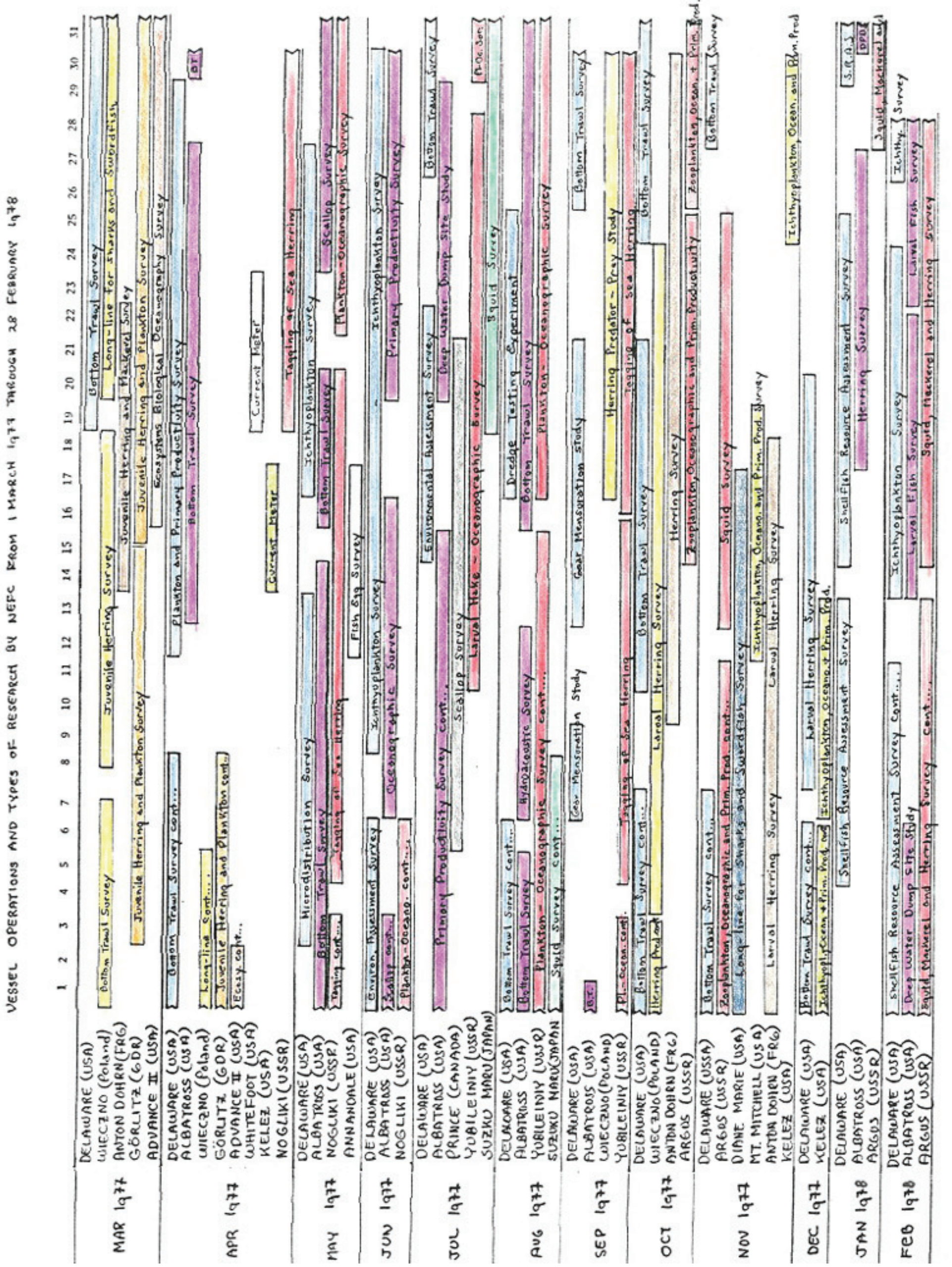


Table 3.2 Vessel operations and types of research by NEFC from 1 March 1977 to 28 February 1978 - more specific data (source: private archives of M. Pastuszak)

VESSEL OPERATIONS AND TYPES OF RESEARCH BY NEFC FROM 1 MARCH 1977 THROUGH 28 FEBRUARY 1978

VESSEL (COUNTRY)	CRUISE NUMBER	DATES OF OPERATIONS	NUMBER OF SEA DAYS	TYPE OF OPERAION	NUMBER OF SCIENTISTS	NUMBER OF MAN DAYS	NUMBER OF STATIONS
WIECZNO (Poland)	77-01	01-07 Mar	7	Bottom Trawl, Plankton & Dredge Survey	4	28	49
GORLITZ (GDR)	77-01 (I)	03-15 Mar	13	Juvenile Herring-Plankton Survey	2	26	52
WIECZNO (Poland)	77-02	08-18 Mar	11	Juvenile Herring Survey	3	33	29
KELEZ (U.S. NOAA)	77-04	14-17 Apr	4	Current Meter Recovery and Deployment	5	20	12
ANTON DOHRN (FRG)	77-01	14-22 Mar	9	Juvenile Herring & Mackerel Survey	2	18	52
GORLITZ (GDR)	77-01 (II)	15 Mar-08 Apr	25	Juvenile Herring & Plankton Survey	2	50	57
ADVANCE II (U.S. Charter)	77-01	16 Mar-02 Apr	18	Ecosystems Biological Oceanography	8	144	35
ALBATROSS IV (U.S.-NOAA)	77-02 (II)	30 Apr-14 May	15	Bottom Trawl Survey	13	195	92
DELAWARE II (U.S.-NOAA)	77-05 (I)	03-13 May	11	Microdistribution Survey	4	44	91
NOGLIKI (USSR)	77-01 (II)	05-20 May	16	Tagging of Sea Herring	5	90	6
WHITEFOOT (U.S. Charter)	77-01	19-23 Apr	5	Current Meter Recovery and Deployment	5	25	1
DELAWARE II (U.S.-NOAA)	77-03	19 Mar-08 Apr	21	Bottom Trawl Survey	9	189	147
WIECZNO (Poland)	77-03	20 Mar-05 Apr	17	Long-line Survey for Sharks & Swordfish	4	68	19
DELAWARE II (U.S.-NOAA)	77-04	12-29 Apr	18	Plankton & Primary Productivity Survey	6	128	131
ALBATROSS IV (U.S.-NOAA)	77-02 (I)	13-27 Apr	15	Bottom Trawl Survey	13	195	111
NOGLIKI (USSR)	77-01 (I)	19 Apr-03 May	15	Tagging of Sea Herring	5	75	1
ANNANDALE (U.S. Charter)	77-01	12-17 May	6	Fish Egg Survey	9	55	33
ALBATROSS IV (U.S.-NOAA)	77-02 (III)	16-20 May	5	Bottom Trawl Survey	13	45	24
DELAWARE II (U.S.-NOAA)	77-05 (II)	17-27 May	11	Ichthyoplankton Survey	6	66	89
NOGLIKI (USSR)	77-02	22 May-06 Jun	16	Plankton-Oceanographic Survey	3	48	95
ALBATROSS IV (U.S.-NOAA)	77-03	24 May-03 Jun	11	Scallop Survey	11	121	163
DELAWARE II (U.S.-NOAA)	77-06 (I)	01-06 Jun	6	Environmental Assessment Survey	4	24	48
ALBATROSS IV (U.S.-NOAA)	77-04	07-16 Jun	10	Oceanographic Survey	13	130	27
DELAWARE II (U.S.-NOAA)	77-07	09-30 Jun	22	Ichthyoplankton Survey	7	154	134
ALBATROSS IV (U.S.-NOAA)	77-05	20 Jun-15 Jul	26	Primary Productivity Survey	10	260	32
PRINCE (Canada)	77-01	06-21 Jul	16	Scallop Survey	1	16	148
YUBILEINIY (USSR)	77-01	11-28 Jul	18	Larval Hake-Oceanographic Survey	1	18	120
DELAWARE II (U.S.-NOAA)	77-08	15-22 Jul	8	Environmental Assessment Survey	8	64	106
SUZUKA MARU (Japan)	77-01	19 Jul-08 Aug	21	Squid Survey	3	63	112
ALBATROSS IV (U.S.-NOAA)	77-06	20-29 Jul	10	Deep Water Dump Site Study	6	60	180
DELAWARE II (U.S.-NOAA)	77-09	27 Jul-06 Aug	11	Bottom Trawl Survey	8	88	115
YUBILEINIY (USSR)	77-02 (I)	30 Jul-15 Aug	17	Plankton-Oceanographic Survey	3	51	107
ALBATROSS IV (U.S.-NOAA)	77-07 (I)	01-05 Aug	5	Bottom Trawl Survey	13	45	40
ALBATROSS IV (U.S.-NOAA)	77-07 (II)	07-12 Aug	6	Hydroacoustic Survey	13	78	15
ALBATROSS IV (U.S.-NOAA)	77-07 (III)	16 Aug-01 Sep	17	Bottom Trawl Survey	13	221	149
DELAWARE II (U.S.-NOAA)	77-10	17-25 Aug	9	Dredge Testing Experiment	7	63	60
YUBILEINIY (USSR)	77-02 (II)	17 Aug-03 Sep	18	Plankton-Oceanographic Survey	2	36	83
YUBILEINIY (USSR)	77-03 (I)	05-16 Sep	12	Tagging of Sea Herring	2	24	1
DELAWARE II (U.S.-NOAA)	77-11 (I)	07-09 Sep	3	Gear Mensuration Study	5	15	8
DELAWARE II (U.S.-NOAA)	77-11 (II)	13-21 Sep	9	Gear Mensuration Study	5	45	153
YUBILEINIY (USSR)	77-03 (II)	16 Sep-04 Oct	19	Tagging of Sea Herring	2	38	7
WIECZNO (Poland)	77-05	17 Sep-03 Oct	17	Herring Predator-Prey Study	2	34	38
DELAWARE II (U.S.-NOAA)	77-12 (I)	26 Sep-07 Oct	12	Bottom Trawl Survey	8	96	137
WIECZNO (Poland)	77-06	04-24 Oct	21	Larval Herring Survey	5	105	117
ANTON DOHRN (FRG)	77-02	10-30 Oct	21	Herring Survey	10	210	78
DELAWARE II (U.S.-NOAA)	77-12 (II)	11-21 Oct	11	Bottom Trawl Survey	9	99	71
ARGUS (USSR)	77-01 (I)	15-25 Oct	11	Zooplankton, Oceanographic & Primary Productivity Sur.	6	66	72
ARGUS (USSR)	77-01 (II)	25 Oct-11 Nov	18	Zooplankton, Oceanographic & Primary Productivity Sur.	7	126	72
DELAWARE II (U.S.-NOAA)	77-12 (III)	25 Oct-07 Nov	14	Bottom Trawl Survey	8	112	138
DIANE MARIE (U.S.-Charter)	77-01	01-17 Nov	17	Long-line for Sharks & Swordfish	3	51	10
ANTON DOHRN (FRG)	77-03	01-18 Nov	18	Larval Herring Survey	9	72	117
MT. MITCHELL (U.S.-NOAA)	77-11	12-19 Nov	8	Ichthyoplankton, Oceanographic & Prim. Prod. Survey	5	45	37
ARGUS (USSR)	77-02	13-25 Nov	13	Squid Survey	3	39	41
KELEZ (U.S.-NOAA)	77-11/12	25 Nov-06 Dec	12	Ichthyoplankton, Oceanographic & Prim. Prod. Survey	7	84	38
DELAWARE II (U.S.-NOAA)	77-12 (IV)	28 Nov-06 Dec	9	Bottom Trawl Survey	7	63	72
KELEZ (U.S.-NOAA)	77-12	06-13 Dec	8	Ichthyoplankton, Oceanographic & Prim. Prod. Survey	5	40	17
DELAWARE II (U.S.-NOAA)	77-13	08-20 Dec	13	Larval Herring Survey	9	117	74
DELAWARE II (U.S.-NOAA)	78-01 (I)	05-13 Jan	9	Shellfish Resource Assessment Survey	8	72	107
DELAWARE II (U.S.-NOAA)	78-01 (II)	15-25 Jan	11	Shellfish Resource Assessment Survey	8	88	123
ALBATROSS IV (U.S.-NOAA)	78-01	18-27 Jan	10	Herring Survey	13	130	90
ARGUS (USSR)	78-01 (I)	28 Jan-13 Feb	17	Squid, Mackerel & Herring Survey	4	68	34
DELAWARE II (U.S.-NOAA)	78-01 (III)	30 Jan-11 Feb	13	Shellfish Resource Assessment Survey	8	104	121
ALBATROSS IV (U.S.-NOAA)	78-0x	31 Jan-06 Feb	7	Deep Water Dump Site Study	1	7	72
ALBATROSS IV (U.S.-NOAA)	78-02 (I)	14-22 Feb	9	Larval Fish Survey	9	81	140
ALBATROSS IV (U.S.-NOAA)	78-02 (II)	23 Feb-	6 *	Larval Fish Survey	11	66 *	41
DELAWARE II (U.S.-NOAA)	78-02 (I)	14-24 Feb	11	Ichthyoplankton Survey	7	108 *	60
ARGUS (USSR)	78-01 (II)	15 Feb-	14 *	Squid, Mackerel & Herring Survey	4	56 *	64
DELAWARE II (U.S.-NOAA)	78-02 (II)	27 Feb-	2 *	Ichthyoplankton Survey	7	14 *	20
			864		441	5,309	4,935

Table 3.3 Vessels taking part in joint studies from March 1977 through 28 February 1978

Name of the ship	Country
ADVANCE II	U.S. charter
ALBATROSS IV	U.S. NOAA
ANNANDALE	U.S. charter
ANTON DOHRN	Federal Republic of Germany
ARGUS	USSR
DELAWARE II	U.S. NOAA
DIANE MARIE	U.S. charter
GORLITZ	German Democratic Republic
KELEZ	U.S. NOAA
MT. MITCHELL	U.S. NOAA
NOGLIKI	USSR
PRINCE	Canada
SUZUKA MARU	Japan
WHITEFOOT	U.S. charter
WIECZNO	Poland
YUBILEINIY	USSR

3.3.1. Polish R/V WIECZNO, American R/V ALBATROSS IV and R/V DELAWARE II - involved in joint fisheries studies

Over the years 1972-1987, R/V WIECZNO participated in 18 cruises in the Northwestern Atlantic and jointly with Americans conducted various types of fisheries studies (Fig. 3.7A; Table 3.4). In majority of cases, each cruise consisted of three legs, each leg being devoted to a different type of fisheries research. In some cruises R/V WIECZNO was accompanied by American R/V ALBATROSS IV and/or R/V DELAWARE II (Fig. 3.7 B, C).

Fig. 3.7 Polish R/V WIECZNO (A), American R/V ALBATROSS IV (B), R/V DELAWARE II (C) taking part in joint studies in Northwestern Atlantic (source: private archives of M. Pastuszak and L. Despres - with permission to use in this monograph)

Table 3.4 Research work of R/V WIECZNO conducted on the Northeast Continental Shelf of the U.S. in 1972-1987 (source: based on the cruise reports available at MIR→NMFRI)

Date	**Region of studies**	**Ichthyo-plankton MARMAP project**	**Hydro-graphy**	**Groundfish Survey Project (GSP) + control fishing**	**APEX Predators Survey**	**Other activities**
1972 Aug.-Sep.	Nantucket Shoals, Georges Bank, Gulf of Maine, Nova Scotia shelf	bongo	temperature (T), salinity (S), oxygen (O_2; XBT - Expendable Bathythermo graph			
1973 Jan.-April	Nantucket Shoals, Georges Bank, Delaware Bay	bongo neuston	T, S, O_2	GSP		phyto-plankton
1974 Aug.-Nov.	Nantucket Shoals, Georges Bank,	bongo neuston	T, S, O_2	GSP herring- main interest		phyto-plankton; hydroacoustic stock assessment
1975 Feb.-Apr.	Nantucket Shoals, Georges Bank to Hudson Canyon	bongo neuston	T, S, O_2	GSP herring, mackerel- main interest		hydroacoustic stock assessment
1976 Mar.-June	Nantucket Shoals, Georges	bongo + small bongo	T, S, O_2	GSP herring- main interest		phyto-plankton, chlorophyll *a*
1976 Sep.-Dec.	Nantucket Shoals, Georges Bank, Gulf of Maine	bongo	T, S, O_2, nutrients, (PO_4, SiO_2, NO_3+NO_2)	Control fishing, mackerel- main interest	APEX Predators – longlines. Acoustic Telemetry Experiment with pelagic fish	phyto-plankton, primary production (C_{14})
1977 Feb.-Apr.	Gulf of Maine, Georges Bank to cape Hatteras	bongo	T, surf. Salinity, O2, XBT	GSP, some control fishing; herring predator-prey study; larval herring survey	APEX Predators – longlines. Sharks and swordfish (*Xiphias gladius*)	Collection of bottom sediments, biological, hydrological samples after oil spill from a tanker
1977 Sep.-Nov.	Georges Bank, Gulf of Maine	bongo, MARMAP project	T, S, O_2, XBT	GSP	Larval herring and their food organisms; predator – prey study	

Date	**Region of studies**	**Ichthyo-plankton MARMAP project**	**Hydro-graphy**	**Groundfish Survey Project (GSP) + control fishing**	**APEX Predators Survey**	**Other activities**
1978 Feb.-May	Nantucket Shoals, Georges Bank, Flemish Cap down to Cape Hatteras and Florida	bongo, MARMAP project	T, surf. Salinity, O2, XBT	GSP, some control fishing	APEX Acoustic Telemetry Experiment with pelagic fish	Flemish Cap experiment - herring
1978 Sep.-Dec.	Gulf of Maine, Georges Bank to cape Hatteras	bongo + small bongo, MARMAP project	T, S, O_2, XBT	some control fishing	APEX Predators Acoustic Telemetry Experiment with sharks and swordfish	phyto-plankton
1979 Sep.-Dec.	Georges Bank, Cape Hatteras, Hudson Canyon	bongo + small bongo, MARMAP project	XBT		APEX Acoustic Telemetry Experiment with sharks	squid fishing with jiggers; ornithological observations
1980 Jan.-Apr.	Nantucket Shoals, Gulf of Maine, Georges Bank to Cape Hatteras	bongo + small bongo, neuston, MARMAP project	T, S, O_2, XBT	GSP, yellowtail flounder (*Limanda ferruginea*)	APEX Predators	phyto-plankton, chlorophyll, ornithological observations
1981 Oct.-Nov.	Georges Bank to Hudson Canyon and Cape Hatteras		T, S, O_2, XBT	GSP, Atlantic herring – distribution, abundance	APEX Predators; tagging	phyto-plankton
1983 Jan.-Apr.	Nantucket Shoals, Georges Bank, Cape Hatteras to Block Island		XBT	GSP, mackerel, herring – distribution, food habits, maturity, diseases; predators of these species – cod and spiny dogfish	APEX Predators	
1984 Mar.-June	Nantucket Shoals, Georges Bank, Cape Lookout, Virginia Capes		XBT	GSP, herring, mackerel	APEX Predators – sharks, tunas, swordfish	
1985 Sep.-Dec.	Cape Cod to Cape Hatteras		XBT	GSP, herring, butterfish, haddock, cod	APEX Predators	hydro-acoustic stock assessment

Date	Region of studies	Ichthyo-plankton MARMAP project	Hydro-graphy	Groundfish Survey Project (GSP) + control fishing	APEX Predators Survey	Other activities
1986 July-Oct.	Nantucket Shoals, Georges Bank, shelf of Gulf Stream between Miami, Florida and Georges Bank, ca. 300 miles east of Cape Hatteras, North Carolina	bongo MARMAP plankton tows	Surface salinity samples, XBT		APEX Predators – sharks and swordfish – **the biggest experiment in the history of cooperation**	
1987 May-Aug.	Middle Atlantic Bight, Georges Bank, Gulf of Maine	bongo + small bongo, MARMAP	Surface salinity samples, XBT	Estimate the absolute abundance of Atlantic mackerel in the western North Atlantic from Cape Hatteras to the Gulf of St. Lawrence using ichthyoplankto n survey information		BIOMAC activities on ADMIRAL ARCISZEWSKI and KULBIN (both form "GRYF" – Polish deep-sea fishing company

A very wide range of research required adequate research support - i.e. scientific teams that always consisted of Poles and Americans. It has been over three decades since the last R/V WIECZNO cruise to the Northwest Atlantic region. Since then, many people, our wonderful colleagues have gone to "eternal watch." We have decided that it is our honorable duty to commemorate everyone (Table 3.5). The exchange of correspondence with descendants allows us to state that the memory of their ancestors is still alive and that refreshing this memory in the form of not only text, but above all in the form of attached photos will be very important to them. That is why we have made an effort to review all our archives and list all participants of the cruises on the Polish research vessel, which we at MIR→NMFRI still have in our hearts. Numerous pictures can be found in Appendix III. In total, sixty one scientists and technicians from Poland and more than one hundred scientists and technicians from various research institutions, mainly subordinate to NMFS, NOAA, participated in joint research on board R/V WIECZNO over the years 1972-1987. The greater number of Americans is due to the fact that each leg of the cruise, and there were usually three legs, was manned by a different American team. To emphasize the equal treatment of Polish and American partners, a chief scientist on the Polish and American side was appointed prior to each cruise. Their decisions during the cruise were equivalent, and reaching a compromise was not a problem.

Table 3.5 Alphabetical list of scientists, technicians and students taking part in cruises on R/V WIECZNO in 1972-1987, M/T ADMIRAŁ ARCISZEWSKI and M/T KULBIN (GRYF - Deep Sea Fishing Company, Poland - marked with stars) (source: based on documents available at NMFRI)

	Polish staff		American staff	
No.	**Surname and name**	**Affiliation**	**Surname and name**	**Affiliation**
1	Bielecki Janusz	NMFRI	Almeida Frank	NMFS, Woods Hole
2	Chmielowski Henryk	NMFRI	Anderson Emory	NMFS, Woods Hole
3	Chromicz Tadeusz	NMFRI	Benz Charles	Student University Connecticut
4	Dąbrowski Henryk	NMFRI	Benz George	NMFS, Narragansett
5	Dobrosielski Andrzej	NMFRI	Berrien Peter	NMFS, Sandy Hook
6	Formela Zdzisław	NMFRI	Bisack Catherine	NMFS, Woods Hole
7	Furtak Andrzej	NMFRI	Bowman Ray	NMFS, Woods Hole
8	Grimm Stefan	NMFRI	Brazier Olivier	WHOI, Woods Hole
9			Brodeur Richard	WHOI, Woods Hole
10	Giedz Mieczysław	NMFRI	Brosius Anita	WHOI, Woods Hole
11	Grelowski Alfred	NMFRI	Burgess Georges	Florida State Museum
12	Gurbiel Ryszard	NMFRI	Burns Thurston	NMFS, Woods Hole
13	Grzywacz Ryszard	NMFRI	Burrell Galen	MBO, Manomet
14	Janusz Jerzy	NMFRI	Casey John	NMFS, Narragansett
15	Kisler Borys	NMFRI	Carey Francis	WHOI, Woods Hole
16	Knurowski Julian	NMFRI	Carem Brian	AC/BC Associates, New York
17	Komasara Piotr	NMFRI	Carter Gary	College of the Atlantic Bar Harbor, MA
18	Kosior Andrzej	NMFRI	Carter Patricia	NMFS, Woods Hole
19	Korzekwa Wiesław	NMFRI	Carey Brian	
20	Kreft Krzysztof	NMFRI	Cavin Cheryl	NMFS, Narragansett
21	Król Franciszek	NMFRI	Clifford Roger *)	NMFS, Woods Hole
22	Kuczyński Jerzy		Cohen Edward	NMFS, Woods Hole
23	Kurowicki Antoni	NMFRI	Cohen Rosalind	NMFS, Woods Hole
24	Lichterowicz Stanisław	NMFRI	Collie Jeremy	WHOI, Woods Hole
25	Linkowski Tomasz	NMFRI	Crossen James	NMFS, Woods Hole
26	Lipiński Marek	NMFRI	Despres Linda	NMFS, Woods Hole
27	Majewicz Andrzej	NMFRI	De Ruso William	MIT, Cambridge, MA
28	Markiewicz Kazimierz	NMFRI	Dorhman John	NMFS, Woods Hole
29	Masło Waldemar	NMFRI	Drew Cathleen*)	NMFS, Woods Hole
30	Morawski Maciej, Stanisław	NMFRI	Duggan James	NMFS, Sandy Hook
31	Multanowski Kazimierz	Maritime Economy Office, Warsaw	Dupuis Elizabeth	student, Woods Hole
32	Netzel Jan	NMFRI	Dwyer Deborah	NMFS, Woods Hole
33	Nowakowski Bogdan	NMFRI	Early Julie	WHOI, Woods Hole

	Polish staff		American staff	
No.	**Surname and name**	**Affiliation**	**Surname and name**	**Affiliation**
34	Ochocki Stanisław	NMFRI	Edwards A.	
35	Orłowski Andrzej	NMFRI	Fogarty Michael	NMFS, Woods Hole
36	Ostrowski Jerzy	NMFRI	Fahay Cinda	NMFS, Sandy Hook
37	Paciorkowski Andrzej	NMFRI	Farley, F. Austin*)	
38	Pactwa Romulad	NMFRI	Finan Doris*	NMFS, Sandy Hook
39	Pastuszak Marianna	NMFRI	Green John	NMFS, Narragansett
40	Piotrowski Antoni	NMFRI	Gruczka Thad	NMFS, Narragansett
41	Redlarski Andrzej	NMFRI	Hansford Dennis	NMFS, Woods Hole
42	Romański Jan	NMFRI	Halpin Robert	NMFS, Woods Hole
43	Skorupski Wojciech	NMFRI	Hess Janet*)	NMFS, Narragansett
44	Smorawski Marian	NMFRI	Hoey John	NMFS, Narragansett
45	Supeł Krzysztof	NMFRI	Hughes David	Bigelow Lab. Boothbay Harbor
46	Ślósarczyk Wiesław	NMFRI	Jackmol G.	
47	Sobczak Ryszard	NMFRI	Jansen H.	
48	Sołończyk Stanisław	NMFRI	Javeck John	NMFS, Miami , FL
49	Sompoliński Maciej	NMFRI	Johnson Ellen	NMFS, Woods Hole
50	Stróżyk Tomasz	NMFRI	Kanwisher John	WHOI, Woods Hole
51	Stolarz Włodzimierz	Maritime Economy Office, Warsaw	Kane Joseph	NMFS, Narragansett
52	Sztajnduchert Wojciech	NMFRI	Kelly Sean	NMFS, Woods Hole
53	Tkacz Zbigniew	NMFRI	King Kevin	WHOI, Wood Hole
54	Torbicki Henryk	NMFRI	Kohler Nancy	NMFS, Narragansett
55	Trypaluk Andrzej	NMFRI	Laird John	Bigelow Lab. Boothbay Harbor
56	Uciński Stanisław	NMFRI	Lavghead Patrick	NMFS, Woods Hole
57	Warzocha Jan	NMFRI	Lindgren Larry	NMFS, Narragansett
58	Wysocki Józef	NMFRI	Lintala Allen	NMFS, Narragansett
59	Wyszyński Mirosław	NMFRI	Lierheimer Lisa	NMFS, Woods Hole
60	Zwykielska Anna	NMFRI	Manfredi Judith	EPA Narragansett
61	Żukowski Czesław	NMFRI	Martorella Carmen	MIT, Cambridge, MA
62			Mason Ann	MBO Manomet
63			Massey Lawrence	SEFS, Miami, FL
64			Maurer Raymond	NMFS, Woods Hole
65			Mayo Ralph	NMFS, Woods Hole
66			Mc Bride Margarett	NNFS, Woods Hole
67			Mc Guire Jean	NMFS, Woods Hole
68			Mc Leam Sharon	NEFC, Oxford MD
69			McKenney Thomas	NMFS, Narragansett
70			McNamara Scott*)	NMFS, Woods Hole
71			Michaels William	NMFS, Woods Hole
72			Middleton Leslie	External expert in longline fishing; Penobscot Gulf Company, St. Simon Island, GA
73			Mikutowicz Maurille	Interpreter Woods Hole
74			Moore Karen	WHOI, Woods Hole
75			Morris Thomas	NMFS, Woods Hole
76			Musik John	Virginia Institute of Marine Science, Glouster Point, VA

	Polish staff		American staff	
No.	**Surname and name**	**Affiliation**	**Surname and name**	**Affiliation**
77			Murawski Steven	Student State University, Boston
78			Murphy Janet	NMFS, Woods Hole
79			Natanson Lisa	NMFS, Narragansett
80			Neill Janet*)	NMFS, Woods Hole
81			Nickerson Albert	MBO, Manomet
82			Olin Laurie	WHOI, Woods Hole
83			Overholtz William	NMFS, Woods Hole
84			Palmer Joan	NMFS, Woods Hole
85			Palmer Ira	NMFS, Woods Hole
86			Parris Norman	NMFS, Woods Hole
87			Powers Kevin	MBO, Manomet
88			Pratt Harold	NMFS, Narragansett
89			Prezioso Jerome	NMFS, Narragansett
90			Race Margaret	WHOI, Woods Hole
91			Rak Robert	NMFS, Woods Hole
92			Rosenberg Andrew	NMFS, Woods Hole
93			Rogers Corolyn	NMFS, Narragansett
94			Silverman Myron	NMFS, Sandy Hook
95			Skomal Gregory	NMFS, Narragansett
96			Smith Keith	NMFS, Woods Hole
97			Stanson H. *)	
98			Stillwell Charles	NMFS, Narragansett
99			Sullivan Loretta	NMFS, Narragansett
100			Suomala Jack	NMFS, Woods Hole
101			Townes James	NMFS, Woods Hole
102			Twitchell David	MBO, Manomet
103			Twohig Patrick	NMFS, Woods Hole
104			Waring Gordon	NMFS, Woods Hole
105			Wheaton Debra	NMFS, Narragansett
106			Ziskowski John	NMFS, Sandy Hook

*) participated also in cruises on Polish trawlers M/T ADMIRAŁ ARCISZEWSKI or M/T KULBIN

3.4. Scientific programs realized by R/V WIECZNO in 1972-1987

The largest research program implemented by Americans in cooperation with other countries, including Poland, was the program **Marine Resources Monitoring Assessment and Prediction** (**MARMAP**). MARMAP is a National Marine Fisheries Service program providing information in support of marine fishery resources management. MARMAP encompassed the collection and analysis of data to provide basic information on the composition, location, abundance, and condition of the commercial and recreational marine fishery resources of the United States. The principal elements of MARMAP include resource surveys, analyses of commercial and recreational fish catches and the environment of fish stocks (fishery oceanography). Each of these elements is important for fisheries resource assessment. Data analysis tasks combine the results of surveys, catch statistics, biometric data (age, growth, fecundity, recruitment, and mortality rates) plus information on environmental and food chain conditions to produce updated stock assessments. In addition, the survey data on fish eggs and larvae provide an effective, fishery independent means for assessing the adult spawning biomass of important fish stocks (Berrien et al., 1981; Morse, 1982; Berrien, 1983). MARMAP is presently being conducted from each of four strategically located NMFS Fisheries Centers headquartered at Woods Hole, Massachusetts; Miami, Florida; La Jolla, California; and Seattle, Washington. Three types of MARMAP fisheries surveys are conducted: **(i) ichthyoplankton, (ii) groundfish, (iii) pelagic fish** (Jossi and Marak, 1983).

The basic research strategy of MARMAP at the Northeast Fisheries Center (NEFC) integrates survey information with fine-scale, process oriented field studies and laboratory research to determine seasonal monitoring and annual variability in biological and environmental components of the shelf ecosystem that influence the size of recruiting fish populations. The survey data is used to provide descriptions of changing hydrographic conditions and patterns of distribution, abundance and production of phytoplankton, zooplankton, and fish eggs and larvae of the northeastern continental shelf ecosystem. In addition, the survey data on fish eggs and larvae provide an effective, fishery independent means for assessing the adult spawning biomass of important fish stocks (Berrien et al., 1981; Morse, 1982; Berrien, 1983).

MARMAP surveys off northeastern United States cover continental shelf waters from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia, an area of some 260,000 km^2. Survey measurements or sampling carried out on R/V WIECZNO included: zooplankton and ichthyoplankton, dissolved oxygen, temperature, salinity, primary production, chlorophyll *a*, nutrients, phytoplankton (Table 3.4). Sea bird and mammal censuses were conducted by personnel from Manomet Bird Observatory, Manomet, Massachusetts on an intermittent basis (Table 3.5). From 1978 to 1980 the mammal census was done by personnel from the College of the Atlantic, Bar Harbor, Maine, and the School of Oceanography, University of Rhode Island, Narragansett, Rhode Island Ships and scientific personnel from the German Democratic Republic, Poland, and USSR have participated in MARMAP surveys off northeastern United States (Sibunka and Silverman, 1984).

The MARMAP data base of NEFC contains station information obtained from two types of cruises: 1) those in which the principal objective was to conduct ichthyoplankton surveys with supportive biological, chemical and physical oceanographic information, and 2) bottom trawl surveys in which the principal objective was to assess the distribution and abundance of juvenile and adult fish and mollusk populations, i.e. resource assessment. The station plan for most MARMAP cruises was fixed (Fig. 3.8). Station positions for the bottom trawl survey cruises were based on a stratified random plan which changed with each cruise (Grosslein, 1969).

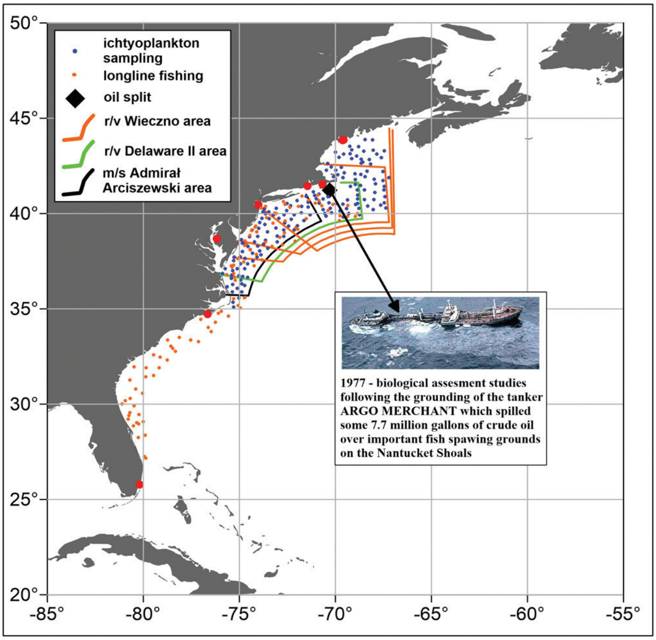


Fig. 3.8 Grid of ichthyoplankton sampling and longline fishing stations along the eastern shelf of the U.S.; marked position of crude oil spilt in 1997 - R/V WIECZNO activity; cooperation of R/V DELAWARE II and M/T ADMIRAŁ ARCISZEWSKI (graph drawn by T. Wodzinowski, NMFRI)

3.4.1. MARMAP - Ichthyoplankton studies

The MARMAP ichthyoplankton surveys of the NEFC are focused on long-term (decadal) trends in species abundance and designed to estimate also short-term changes in the abundance levels of recovery of depleted stocks, the spawning biomass of important species for which other reliable abundance indices are unavailable, are questionable, or are incomplete (e.g. silver hake, *Merluccius bilinearis,* sand eel; Atlantic herring; Atlantic mackerel; and yellowtail flounder, *Limanda ferruginea,* in some areas). Estimates of the status of biomass of these fish stocks were especially important if NMFS was to provide the best scientific information available, setting appropriate limits on fishing within the Northeast Shelf Ecosystem (Sherman, 1980, 1986; Sherman et al., 1983). These survey operations were conducted cooperatively in the Atlantic with the U.S.S.R., Poland, France, Canada, the Federal Republic of Germany, and the Democratic Republic of Germany, and in the Pacific with the U.S.S.R., Mexico and Japan. Surveys were also conducted jointly with several state and private research institutions. The **MARMAP - Ichthyoplankton studies** assesses planktonic eggs and larvae of all fish species, pelagic and demersal, as well as other zooplankton which can be sampled with plankton nets (Berrien et al., 1981; Morse, 1982; Berrien, 1983; Jossi and Marak, 1983). The 0.61-m bongo sampler (Figs. 3.9, 3.10) used to catch fish eggs and larvae is described by Posgay and Marak (1980). Standard methods employed in sampling operations are given in Smith and Richardson (1977) and Jossi and Marak (1983). Contribution of R/V WIECZNO to these studies is presented in Tables 3.1-3.2.

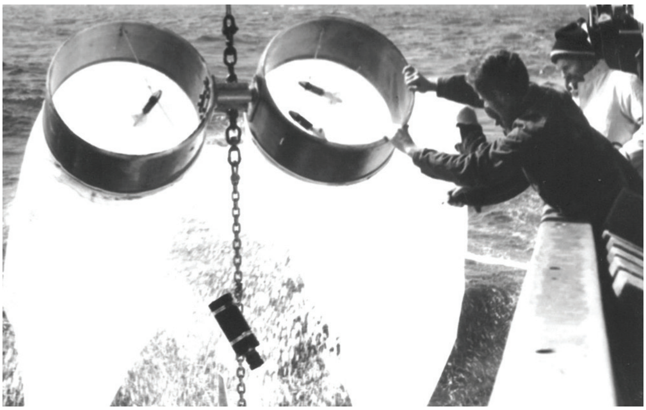


Fig. 3.9 Bongo set in operation on R/V WIECZNO; two fishermen and Thomas Morris (NMFS, Woods Hole) on the deck in 1972 (source: private archives of M. Pastuszak)

Fig. 3.10 Bongo set on the slip on R/V WIECZNO in 1972; Thomas Morris (NMFS, Woods Hole) and Marianna Pastuszak (MIR→NMFRI) (source: private archives of M. Pastuszak)

3.4.2. MARMAP - Pelagic Fish Survey

The aim of the **Pelagic Fish** Studies was to assess species that live off the bottom [Atlantic salmon (*Salmo salar*), Atlantic herring, Atlantic mackerel, tuna, squid, menhaden, and others]. Surveys of pelagic fish pose special problems. Effective stock assessment of these migratory species requires, among other things, the application of hydroacoustics and remote sensing techniques. A high degree of uniformity and standardization in ichthyoplankton operations was essential to achievement of MARMAP objectives (Jossi and Marak, 1983).

3.4.3. MARMAP - Groundfish Survey

Groundfish Survey focuses on the distribution and abundance of groundfish and shellfish species which live at or near the bottom when they reach harvestable size [e.g. cod, flounder, hake, scallop, American lobster (*Homarus americanus*), crab, and shrimp]. Bottom survey operations were conducted with ICNAF (now NAFO) nations in the northwest Atlantic from Greenland to Cape Hatteras; under contract with the state of South Carolina from Cape Hatteras to the Florida Keys; in the Mississippi delta region; and in the northeast Pacific off California, Oregon, Washington, Alaska, and in the East Bering Sea (Jossi and Marak, 1983).

3.4.4. MARMAP - Hydrological Parameters and Meteorological Observations

Hydrographic procedures used on MARMAP surveys are described by Kirschner (1980) and Patanjo et al. (1982). Both 1.7- and 5-liter PVC Niskin bottles were used to collect water samples; however, Nansen Bottles were used on some cruises (e.g. on R/V WIECZNO), either in entirety or to supplement the existing number of Niskin bottles. Normally all bottles were fitted with protected and unprotected reversing thermometers. Nominal sampling depths were: 1, 5, 10, 15, 20, 25, 30, 35, 50, 75, 100, 150, 200, 250 m and within 5 m of the bottom if water depth was <305 m or to a maximum depth of 300 m. After the hydrographic cast was completed, the reversing thermometers were read twice, allowing a minimum time lapse of 20 min from cast completion. Samples for analysis were immediately drawn from water bottles in the following order: dissolved oxygen, primary productivity, chlorophyll, phytoplankton, nutrients, and salinity. Dissolved oxygen samples, taken from all water bottles were processed at sea by the modified Winkler method (Carpenter, 1965) (Fig. 3.11). Salinity samples were taken from all water bottles and were normally analyzed ashore using a Guideline AutoSol Model 8400. On R/V WIECZNO salinity was measured on board the ship with Australian salinometer AUTOLAB.

Fig. 3.11 Determination of oxygen in water samples on R/V WIECZNO: Marianna Pastuszak (early 1970s) (MIR→NMFRI) (source: private archives of M. Pastuszak)

We would like to add here that Dr. Redwood Wright and Dr. Ronald Schlitz were the initiators of aid in the form of the purchase of laboratory equipment for Polish partners. That equipment was used not only on R/V WIECZNO, but also in the hydrochemical laboratory at MIR→NMFRI headquarters. Although almost half a century has passed, American chemical reagent dispensers, high quality pipettes, plastic cylinders are in perfect condition and are still intensely used in the chemical laboratory at MIR→NMFRI. The American chemical reagent dispensers are the best that have ever been purchased and used in the history of MIR→NMFRI.

On cruises where hydrographic casts were not made, or if additional temperature information was desired, a Sippican expendable bathythermograph (XBT) was used. An XBT is a small probe that is dropped over the side of a ship (Fig. 3.12). As it falls through the water, it measures temperature. Small wires transmit the temperate data back to the ship where it is recorded for further analysis. Because the probe falls through the water at a known rate, the depth of the probe can be inferred from the time of launch. Scientists then plot temperature as a function of depth to create a temperature profile of the water. Two probe types, one effective from 0-200 m and another from 0-450 m were utilized. In MARMAP cruises, XBT drops were generally made on all stations. Sea surface temperature was measured with a stem thermometer to the nearest 0.1°C at all stations. A Secchi disc reading was taken to index water transparency when the vessel was stopped for hydrographic observations. This reading was recorded to the nearest 0.5 m and was not taken at night or in rough sea conditions. At each station, observations were recorded for barometric pressure, wind speed and direction, wave height, air temperature, cloud type and amount of cover.

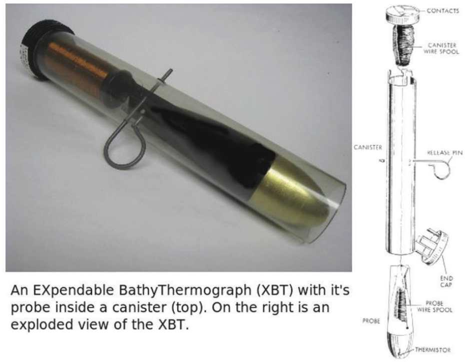


Fig. 3.12 A chat on the deck of R/V WIECZNO: left picture - Chuck Stillwell (NMFS, Narragansett), Marianna Pastuszak (MIR→NMFRI); white boxes contain XBT probes which were to be used in longline fishing; right picture - XBT probe (source: private archives of M.Pastuszak; https://www.google.com/search?q=XBT++probes+temperature&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiJ4an1p9HoAhWolYsKHSeqDlAQ_AUoA3oECAsQBQ&biw=1034&bih=727#imgrc=_FflTM_8f6uoTM) (Retrieved in May 2020)

At this point, we would like to emphasize the role of scientists responsible for measuring hydrological/chemical parameters on R/V WIECZNO, which are very important not only in the interpretation of the above mentioned biological parameters, but are extremely important in longline fishing. It is well known fact that large pelagic fish concentrate in hydrological front areas with significant temperature gradients (see Chapter 4). Because of this, it was necessary to read the XBT temperature profiles before setting out of the longline. Well understood cooperation obliged Polish partners to prepare maps of horizontal and vertical distribution of temperature and salinity on a regular basis. Prior to each cruise, NMFS in Woods Hole would provide Polish chief scientist with the so-called background maps on a semi-matt technical tracing paper on which semi-transparent land contours and isobaths of the examined region as well as longitude and latitude were marked. This allowed for systematic writing down of hydrological numbers and then plotting the maps. Plotting maps was carried out using a rapidograph pen set during the cruise, where there are not always conditions of lack of ship's roll and no vibration. The workplace was a small cabin on the ship and a small table (Fig. 3.13). At the end of each cruise, the American partners received set of maps and the preliminary interpretation of the results. This was the basis for the preparation by the Americans of the so-called cruise report, which would reach the MIR→NMFRI in a very short period of time. Today, when computers are so common, such work sounds like a science fiction story. Working at sea required a lot of determination and effort from researchers, but they never complained about work overload. Why? The answer is simple: if you love what you do, regardless of sometimes huge requirements and inconvenience, work becomes a pleasure.

Fig. 3.13 R/V WIECZNO, cabin of chief scientist, here Marianna Pastuszak (left) in company of her American friend Linda Despres (NMFS, Woods Hole); picture taken in the 1980's (source: private archives of M. Pastuszak)

3.4.5. MARMAP - Other Parameters

Depending on scientific needs, water samples were collected for determination of some other parameters e.g. chlorophyll *a,* phytoplankton, or nutrients. Detailed collecting and analytical procedures of **chlorophyll *a*** used on MARMAP cruises are described in Evans and O'Reilly (1983). Seawater samples for **phytoplankton** species composition and identification were collected on MARMAP cruises for three different studies (for details see to Sibunka and Silverman, 1984). The phytoplankton samples (Sibunka and Silverman, 1984) were collected at selected stations in the Georges Bank and Gulf of Maine area during several cruises in 1980-1981. A 500-ml sample of unfiltered seawater was drawn from the 1, 10, 20 and 30-m depth water bottles and preserved with Lugol's solution in a polyethylene bottle. At primary productivity stations, samples were taken from those water bottles nearest the desired sampling depths. Analysis was done at the Sea Fisheries Institute (MIR→NMFRI), Gdynia, Poland (Ringer, 1983). Techniques used for the collection and analysis of inorganic **nutrients** in seawater can be found in Matte et al. (1983).

3.5. BIOMAC Program

Cooperative research fishery for Atlantic mackerel, under the BIOMAC Program, was conducted by the Northeast Fisheries Science Center (NEFSC), the Polish SFI→NMFRI, and the Deep Sea Fishing Company GRYF in Poland. The specific objectives of the studies called **BIOMAC** covered: 1) estimation of absolute abundance of Atlantic mackerel in the western North Atlantic from Cape Hatteras to the Gulf of St. Lawrence using ichthyoplankton survey information, 2) collection of information on adult Atlantic mackerel population from trawling operations to assess status of stocks and impact of fishing activities, 3) evaluation of the importance of Atlantic mackerel as predators, 4) examination the relationship between water quality and chromosomal abnormalities in Atlantic mackerel eggs, 5) determination of contaminant body burden levels, 6) estimation of fecundity of adult females prior to spawning. Contribution of R/V WIECZNO to these studies is presented in Table 3.1.

3.6. Apex Predator Studies

An *apex predator*, also known as an alpha *predator* or top *predator*, is a *predator* at the top of a food chain, with no natural *predators*. *Apex predators* are usually defined in terms of trophic dynamics, meaning that they occupy the highest trophic levels (Wallach et al., 2015). Apex predators investigations of the Northeast Fisheries Science Center were conducted jointly with Polish scientists on board R/V WIECZNO from 1976 to 1986. Longline cruises usually lasted about 3 weeks. The exception was 1986, when this type of cruise lasted seven weeks with entrances to the port of Morehead City, NC and Miami, Fl. This study was accompanied by hydrological measurements (temperature, salinity, oxygen content in water). This work involved longline fishing for large pelagic species (sharks, tunas, swordfish, billfishes) in the area extending from Georges Bank to Florida (Figs. 3.8, 3.14-3.20). Studies covered tagging with standard tags (see Chapter 4) and sonic tags in telemetric experiments focused on studying large pelagic species migrations (see Chapter 4), food and reproductive habits, growth, age, behavior, parasites and other elements of their biology.

Fig. 3.14 Swordfish caught in 1976; from the left: Roman Pactwa (MIR→NMFRI), Leslie Middleton (NMFS, Narragansett), Marianna Pastuszak (MIR→NMFRI), Chuck Stillwell (NMFS, Narragansett), Stanisław Sołończyk (MIR→NMFRI), (source: private archives of M. Pastuszak)

Fig. 3.15 A big shark on the deck: Nancy Kohler (NMFS, Narragansett) in action on the deck of R/V WIECZNO (source: private archives of A. Orłowski)

Fig. 3.16 Jack Casey and Nancy Kohler (NMFS, Narragansett) in action on the deck of R/V WIECZNO (source: private archives of J. Chołyst)

Fig. 3.17 Jack Casey (NMFS, Narragansett) on the deck of R/V WIECZNO next to caught tuna fish - taking picture of some fish that must have caught his attention (source: private archives of J. Chołyst)

Fig. 3.18 A rich catch of sharks; Nancy Kohler and Chuck Stillwell (NMFS, Narragansett) - pulls the hook out of the shark on the deck of R/V WIECZNO (source: private archives of J. Chołyst)

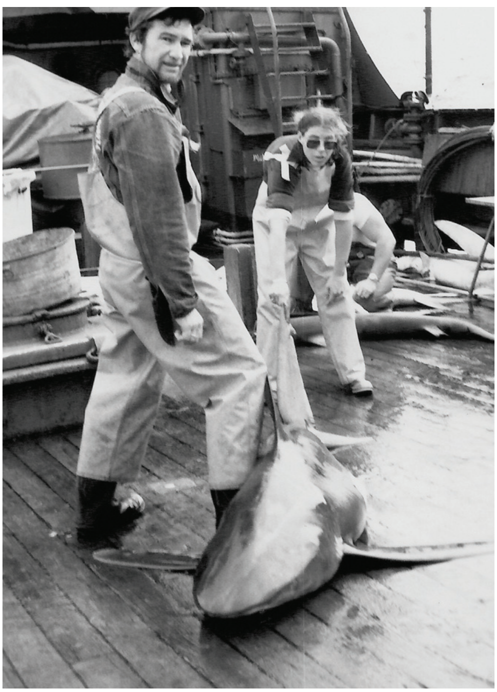


Fig. 3.19 Nancy Kohler and Chuck Stillwell (NMFS, Narragansett) with mako shark on the deck of R/V WIECZNO (source: private archives of J. Chołyst)

Fig. 3.20 A group photo of Polish and American scientists and the crew members of R/V WIECZNO; first row - Chuck Stillwell, in white T-shirt (NMFS, Narragansett), second row - second from the left, Andrzej Kosior (Polish chief scientist), Judith Manfredi, with hand on her head (NMFS, Narragansett), Harold Wes Pratt, with white lab. coat (NMFS, Narragansett), in the middle captain of R/V WIECZNO - Jan Chołyst standing next to a great cook on R/V WIECZNO - Stanisław Korab; behind the cook - Julian Knurowski (MIR→NMFRI); last row, first from the left - John Hoey, third from the left - Nancy Kohler (NMFS, Narragansett), fifth - Tadeusz Chromicz (MIR→NMFRI) - R/V WIECZNO (source: private archives of J. Chołyst)

3.7. Administrative coordination of international fisheries research

Research carried out internationally, in addition to preparing scientific assumptions adequate to the research capabilities of a given ship, required full administration, e.g. arranging permits for each entry to a given, pre-agreed American port, providing drinking water replenishment on board, supplying fuel, replenishing food, embarking and disembarking of American staff, transport of American equipment to/from the ship, everyday radio connection in order to get the first reports from the studies carried out, and delivery of mail for Polish cruise participants. It should be remembered that in the case of ships from e.g. Europe, the crew was embarked for the entire duration of the cruise, e.g. in the case of R/V WIECZNO for around 90 days. This meant that in those days the only contact with relatives in the home country were letters and incidentally radio talks. There were no mobile phones at that time. Mr. H.C. Boyar from NMFS, Woods Hole (Fig. 3.21) was responsible for administering all that and he was doing fantastic job; perfectly organized person with a great sense of humor. In each cruise he was the first American to welcome all foreign ships and the last to say good bye.

Fig. 3.21 Administrative Coordinator of International Fisheries Research - H.C. Boyar from NMFS, Woods Hole (on the left), Marianna Pastuszak (MIR→NMFRI) (in the middle), Patrick Twohig (NMFS, Woods Hole) (on the right) (source: private archives of M. Pastuszak)

3.8. Some other aspects of Polish - American cooperation

For many years, many Americans from the NMFS, Woods Hole, Narragansett and Poles from the MIR→NMFRI prepared the ground for the first meeting of scientists involved in the study of the seas and oceans and for undertaking the first joint scientific research in the Northeast Atlantic region in 1972 (see Chapter 1). Although, mentally, both sides were prepared for this undertaking, Poles were concerned about communication and the language barrier, but luckily that turned out to be unnecessary. The language barrier was an extremely strong motivation for Poles, at least some of them who proved that hard work can give such an effect that one can get a Cambridge University (U.K.) diploma confirming knowledge of English at proficiency level. This allowed not only to raise professional communication to a higher level, but also to strengthen interpersonal bonds. The Americans, seeing great commitment of Poles to joint research, invited scientists from MIR→NMFRI to joint research under scientific grants. For example, Stefan Grimm and Marianna Pastuszak were offered fellowships by our American partner and their task was to work with prominent scientists from Woods Hole e.g. Dr. Redwood Wright, Dr. David Mountain, or Narragansett e.g. Dr. Donna Bush in order to elaborate biological and hydrological/chemical data from all the research vessels operating in the region of our common interest and publish the outcome in international journals (Pastuszak et al., 1982; Grimm, 1983; Mountain et al., 1989). These, selected exemplary publications, are dealing with the following aspects of studies: (i) Georges Bank region - annual cycles, spatial and water column distribution of nutrients (nitrates, silicates, phosphates), temperature, oxygen content, salinity, related to annual variability in biological activity (phytoplankton growth), nutrient regeneration, but also influxes of nutrient bearing water from the surrounding regions e.g. Gulf of Maine and the Slope Water, thus generally speaking related to water dynamics in the region studied (Pastuszak et al., 1982), (ii) Great South Channel – indication of permanent intrusion of high salinity water in the autumn of most years (1977-1985 - 35 surveys). The intrusion represents an influx of Slope Water; it is most evident near bottom phenomenon, but high salinity values are found throughout the water column; larvae of offshore, warm-water fish species found in high salinity intrusion support reports that the presence of these larvae is associated with an influx of slope water through the channel, which in turn is associated with seasonal shelf ward movement of the shelf/slope front during the autumn (Mountain et al., 1989), (iii) Georges Bank and Nantucket Shoals (1971-1977 - 31 autumn surveys); studies aimed at changes in time and location of Atlantic herring (*Clupea harengus L.*), spawning relative to bottom temperature; delay of spawning on Georges Bank after 1973 was found to be associated with warming trend since 1971; large volumes of warm water (>13°C) on Georges Bank may affect herring spawning and/or the survival of eggs and larvae (Grimm, 1983).

3.8.1. R/V WIECZNO's port calls - moments of rest and informal meetings

Each R/V WIECZNO entry to the port of Woods Hole was warmly received by our American partners represented by directors, leading scientists, and research staff that planned to take part in each R/V WIECZNO cruise (Figs. 3.22-3.24).

Fig. 3.22 This picture was taken in 1972 during the first port call of R/V WIECZNO at Woods Hole; standing on the pier - Dr. Robert Edwards (director, NMFS, Woods Hole), Dr. Marvin Grosslein (NMFS, Woods Hole), Wiernicki's family - Americans with Polish roots (in front of the car) (source: private archives of M. Pastuszak)

Fig. 3.23 This picture was taken in 1972 during first port call of R/V WIECZNO at Woods Hole; two men standing on the pier - John Dohrman and Thomas Morris (NMFS, Woods Hole) (first Americans that participated in research on R/V WIECZNO in 1972); on the right side - Dr. Emory Anderson (NMFS, Woods Hole) (source: private archives of M. Pastuszak)

Fig. 3.24 Departure of R/V WIECZNO from Boston after completing the first joint cruise with two Americans aboard Polish ship in 1972; from the left: Jerzy Wosachło (officer from R/V WIECZNO), Stefan Grimm, Maciej Sompoliński, Marianna Pastuszak, Wojciech Skorupski (MIR→NMFRI); in the background - Nansen Bottles in a special hanger (source: private archives of M. Pastuszak)

After the arrival of R/V WIECZNO to the U.S., it was a tradition to invite important personalities from NMFS in Woods Hole and Narragansett for dinner, which was served in the captain's cabin (Fig. 3.25). It was an opportunity for informal conversations, but also a form of repaying for the enormous hospitality of Americans, who from the first R/V WIECZNO cruise dedicated their time and effort, and used to take Poles to distant towns on Cape Cod (Fig. 3.26), or even to Boston.

Fig. 3.25 Party in R/V WIECZNO captain's cabin; from the left - Dr. Emory Anderson and his wife Geraldine, Dr. Robert Edwards (director of NMFS, Woods Hole), Dr. Marvin Grosslein (NMFS, Woods Hole), Marianna Pastuszak (Polish chief scientist), Jan Chołyst (captain of R/V WIECZNO) (source: private archives of M. Pastuszak)

Fig. 3.26 Newly met American partners in science took Polish friends to Hyannis on Cape Cod in order to show us monument commemorating John. F. Kennedy, President of the U.S.; from the left: Marianna Pastuszak, Stefan Grimm (MIR→NMFRI), Ursula Nadolny (American interpreter), Andrzej Furtak (MIR→NMFRI)– picture taken in 1972 (source: private archives of M. Pastuszak)

In addition to meetings in the captain's cabin, there were also working meetings at the headquarters of the NMFS, Woods Hole or on board the ship prior each cruise leg. These concerned supplied American equipment that was to be used on R/V WIECZNO (Fig. 3.27).

Fig. 3.27 This picture was taken in the 1980s; Dr. Redwood Wright (NMFS, Woods Hole) and Marianna Pastuszak (MIR→NMFRI) on the deck of R/V WIECZNO (source: private archives of M. Pastuszak)

There were also special occasions, such as celebration of ten years' cooperation in northwest Atlantic region and participation of R/V WIECZNO in joint fisheries studies. On that occasion NMFS, Woods Hole and NMFS, Narragansett prepared a small reception, and there was an exchange of gifts. Captain of R/V WIECZNO, Jan Chołyst, received from Dr. Kenneth Sherman, Director of NMFS, Narragansett, an old type of Nansen Bottle mounted on a board and used for water sampling in oceanographic studies (Figs. 3.28, 3.29). This gift enriches the collections of the Gdynia Aquarium (see Chapter 1).

Fig. 3.28 This picture was taken in 1982; Jan Chołyst - captain of R/V WIECZNO (with the Nansen Bottle), Kenneth Sherman, Director of NMFS, Narragansett, Alicja Mann, an interpreter (source: private archives of J. Chołyst)

Fig. 3.29 This picture was taken in 1982; from the left - Jan Chołyst - captain of R/V WIECZNO, H.C. Boyar - Administrative Coordinator of International Fisheries Research, Andrzej Kosior - Polish chief scientist on R/V WIECZNO, Dr. Robert Edwards - director of NMFS, Woods Hole, Alicja Mann - an interpreter (source: private archives of J. Chołyst)

Poles often emphasize their hospitality, which is a real feature, but Americans also demonstrate great hospitality. Each time Poles entered the port, they were invited to restaurants or private apartments or houses of their American friends. Each time it was a great form of rest in a long, over 3-month cruise. Each such social meeting was an occasion of getting to know each other, but also enjoying dishes new to Poles, prepared for such occasions by our American friends. It is impossible to list all the Americans from NMFS, Woods Hole and Narragansett, who invited Poles to their homes, but a few names should be mentioned here: Dr. Robert Edwards, Dr. Redwood Wright, Dr. Marvin Grosslein, H.C. Boyar, Linda Despres and Daniel Patanjo, Thomas Morris, Elizabeth Bevaqua, Dr. David Mountain with Alicja Mann, Lorrie Sullivan, Dr. Donna Bush (see Appendix III). Whenever Poles visited Narragansett they were always warmly welcomed and invited to lunches by Dr. Kenneth Sherman, Director of NMFS, Narragansett.

In 1986, the longest longline catches were carried out, as they lasted seven weeks, with two port entrances, including Miami, FL. Everybody was very tired, that is why the American chief scientist, John Casey, in consultation with the NMFS, Miami and after receiving the minibus offered a trip, probably the most beautiful in the history of joint research studies (Fig. 3.30). It was a day trip to the Key West, Florida, with short stops and visiting all the islands with their parks and beautiful exotic nature. On the Key West, there was a chance to see historically important places, e.g. Hemingway's house, Sloppy Joe's Bar, where Hemingway used to spend a lot of time, or historic railway station (Figs. 3.31, 3.32). The attraction was also a beautiful beach and a visit to Miami Seaquarium.

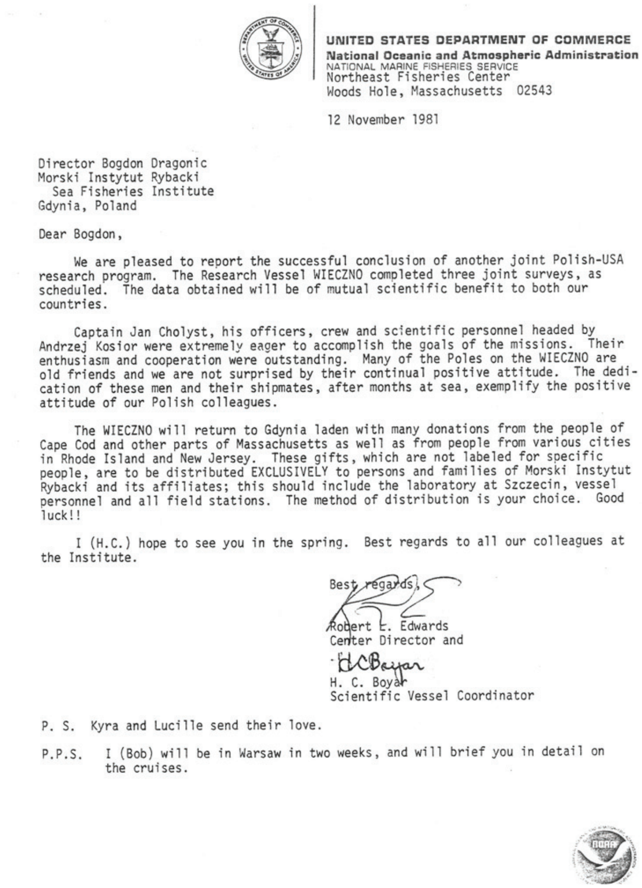
Fig. 3.30 Florida 1986; standing second from the left: Marianna Pastuszak (MIR→NMFRI), then Nancy Kohler, Jack Casey (NMFS, Narragansett); lower row first from the left: Gregory Skomal (NMFS, Narragansett) (source: private archives of M. Pastuszak)

Fig. 3.31 Key West, Florida - the Ernest Hemingway Home and Museum (source:https://www.hemingwayhome.com/) (Retrieved in May 2020)

Fig. 3.32 Key West, Florida - the Sloppy Joe's Bar (source:https://sloppyjoes.com/) (Retrieved in May 2020)

The generosity and hospitality of the Americans was partly compensated by Poles with private presents from Poland. There were also specific orders of American friends, e.g. spices such as marjoram, thyme, dried mushrooms, when these were identified in dishes served by excellent chefs employed on R/V WIECZNO. Polish herbs and mushrooms were characterized by a much more intense aroma. Friendly bonds were stronger each year, and thus goodbyes were becoming more and more emotionally difficult. Nobody even tried to hide tears and both Americans and Poles lived in the hope that we would meet next year, or maybe even sooner. Very strong bonds of friendship encouraged many of our friends from the U.S. to private visits to Poland. Among those visiting their friends in Poland were: Linda Despres (many times), Daniel Patanjo, Lorie Sullivan, Ronald Schlitz (see Appendix III).

Here, we would also like to show another side of this cooperation. Joint fisheries studies carried out on R/V WIECZNO in the Northwest Atlantic in 1972-1987 were interrupted only in 1982 due to martial law, a state of emergency, introduced on Dec. 13, 1981 throughout the Polish People's Republic. It was suspended on December 31, 1982, and abolished on July 22, 1983. In November 1981, R/V WIECZNO completed its next research cruise to the Northwest Atlantic region. It was a period when huge social and political tension in Poland was felt. It was a period of dramatic shortages in providing the population with the basic products of everyday life. Our American friends from the NMFS in Woods Hole, Narragansett, and other scientific sites in the U.S. realized this fact, and before R/V WIECZNO's departure from Woods Hole they organized a huge collection of materials of the first need, but also those that could be considered gifts for the upcoming Christmas 1981. The huge cargo hold on the ship was full of various goods that were distributed to all MIR→NMFRI employees, as intended by the donor (Fig. 3.33). It was a unique gift of heart that employees of MIR→NMFRI remember to this day. The proverb *"a friend in need is a friend indeed"* took on special significance.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

12 November 1981

Director Bogdon Dragonic
Morski Instytut Rybacki
Sea Fisheries Institute
Gdynia, Poland

Dear Bogdon,

We are pleased to report the successful conclusion of another joint Polish-USA research program. The Research Vessel WIECZNO completed three joint surveys, as scheduled. The data obtained will be of mutual scientific benefit to both our countries.

Captain Jan Cholyst, his officers, crew and scientific personnel headed by Andrzej Kosior were extremely eager to accomplish the goals of the missions. Their enthusiasm and cooperation were outstanding. Many of the Poles on the WIECZNO are old friends and we are not surprised by their continual positive attitude. The dedication of these men and their shipmates, after months at sea, exemplify the positive attitude of our Polish colleagues.

The WIECZNO will return to Gdynia laden with many donations from the people of Cape Cod and other parts of Massachusetts as well as from people from various cities in Rhode Island and New Jersey. These gifts, which are not labeled for specific people, are to be distributed EXCLUSIVELY to persons and families of Morski Instytut Rybacki and its affiliates; this should include the laboratory at Szczecin, vessel personnel and all field stations. The method of distribution is your choice. Good luck!!

I (H.C.) hope to see you in the spring. Best regards to all our colleagues at the Institute.

Best regards,

Robert L. Edwards
Center Director and

H. C. Boyar
Scientific Vessel Coordinator

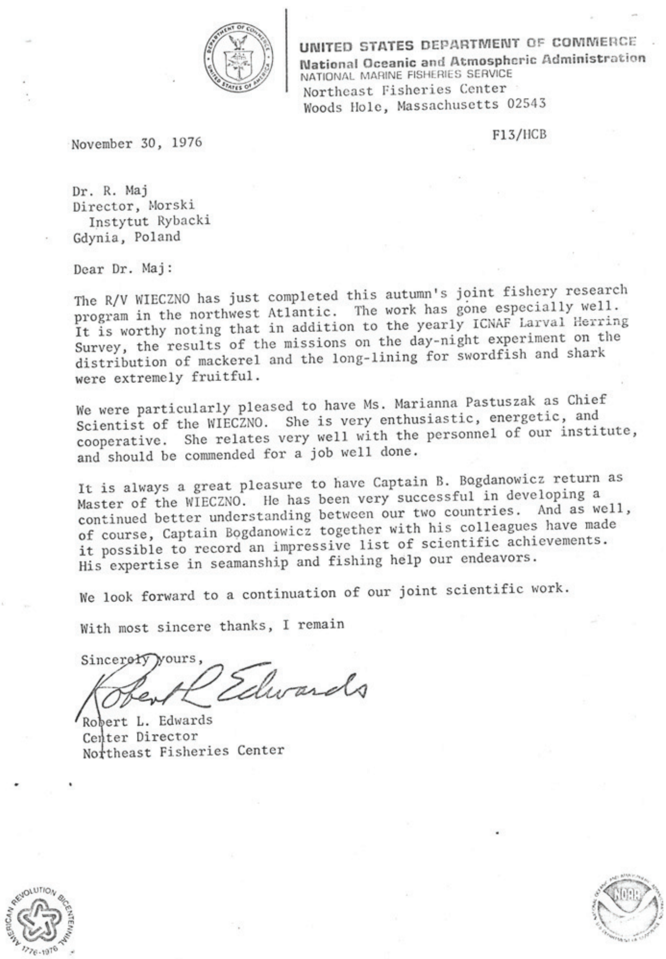
P. S. Kyra and Lucille send their love.

P.P.S. I (Bob) will be in Warsaw in two weeks, and will brief you in detail on the cruises.

Fig. 3.33 Copy of the letter sent to Prof. Bohdan Draganik, Director of MIR→NMFRI by Dr. Robert Edwards, NMFS Center Director, Hoods Hole, and H.C. Boyar, Scientific Center Coordinator, Woods Hole (source: private archives of M. Pastuszak)

3.9. Letters of appreciation

The authors of this monograph with great fondness recollect the common moments on R/V WIECZNO. Polish-American cooperation was highly appreciated by representatives of research centers in the USA. Such words were and still are an incentive for further work. The employee puts maximum effort into her/his work when she/he sees that she/he is appreciated by his supervisor. Poles have experienced such acts of appreciation from eminent American scientists many times (Figs. 3.34-3.35).



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

November 30, 1976

F13/HCB

Dr. R. Maj
Director, Morski
Instytut Rybacki
Gdynia, Poland

Dear Dr. Maj:

The R/V WIECZNO has just completed this autumn's joint fishery research program in the northwest Atlantic. The work has gone especially well. It is worthy noting that in addition to the yearly ICNAF Larval Herring Survey, the results of the missions on the day-night experiment on the distribution of mackerel and the long-lining for swordfish and shark were extremely fruitful.

We were particularly pleased to have Ms. Marianna Pastuszak as Chief Scientist of the WIECZNO. She is very enthusiastic, energetic, and cooperative. She relates very well with the personnel of our institute, and should be commended for a job well done.

It is always a great pleasure to have Captain B. Bogdanowicz return as Master of the WIECZNO. He has been very successful in developing a continued better understanding between our two countries. And as well, of course, Captain Bogdanowicz together with his colleagues have made it possible to record an impressive list of scientific achievements. His expertise in seamanship and fishing help our endeavors.

We look forward to a continuation of our joint scientific work.

With most sincere thanks, I remain

Sincerely yours,

Robert L. Edwards
Center Director
Northeast Fisheries Center

Fig. 3.34 Letter sent by R. Edwards (director of NMFS, Woods Hole) and Scientific Vessel Coordinator A.C Boyar to Director of MIR Ryszard Maj (source: private archives of M. Pastuszak)

THE FLORIDA STATE MUSEUM
UNIVERSITY OF FLORIDA

DEPARTMENT OF NATURAL SCIENCES

FSM

the florida state museum
museum road
university of florida
gainesville
32611
904/392-1721

3 LISTOP 1986
8568

10 October 1986

Dr. Andrzej Ropelewski
Morski Instytut Rybacki
Al Zjednoczenia 1
Gdynia, Poland

Dear Dr. Ropelewski:

I am writing to express my thanks for the fine hospitality and excellent technical support provided by the scientific staff and crew of the R/V Wieczno during the recent cooperative cruise off the east coast of the United States. I would particularly like to commend the efforts of chief scientist Marianna Pastuszak, who kept the cruise running smoothly despite some trying circumstances, and scientists Piotr Komasara and Andrzej Redlarski, who were always willing to help out in addition to their own duties.

I look forward to further cooperative ventures in the future.

Sincerely,

George H. Burgess
Senior Biologist in
in Ichthyolgy

cc/ Marianna Pastuszak
Piotr Komasara
Andrzej Redlarski

GHB/dc

A UNIVERSITY MUSEUM WITH RESEARCH EMPHASIS ON CARIBBEAN NATURAL AND SOCIAL HISTORY
EQUAL EMPLOYMENT OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

Fig. 3.35 Letter sent by George Burges (senior Biologist in Ichthyology) for the Florida State Museum to Prof. Andrzej Ropelewski - director of MIR→NMFRI (source: private archives of M. Pastuszak)

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4

LONGLINE FISHING AND REALIZATION OF THE U.S. SHARK TAGGING PROGRAM - EASTERN CENTRAL ATLANTIC

Wojciech Pelczarski, Emil Kuzebski, Nancy Kohler, Marianna Pastuszak

4. LONGLINE FISHING AND REALIZATION OF THE U.S. SHARK TAGGING PROGRAM - EASTERN CENTRAL ATLANTIC

Wojciech Pelczarski, Emil Kuzebski, Nancy Kohler, Marianna Pastuszak

4.1. Study area - general overview

The Eastern Central Atlantic includes waters off the west coast of Africa, from the Gibraltar Strait to the mouth of the Congo River (Fig. 4.1; Area 34; see Fig. 3.1 in Chapter 3) and covers a total of 14.2 million km^2. The continental shelf along the west African coast is generally narrow, covering only 0.65 million km^2 in the entire area. Area 34 encompasses temperate, tropical and equatorial waters, lagoons and mangroves as well as oceanographic features such as major currents, upwellings, and equatorial convergence. More than 250 species or groups of species were reported in fisheries landings taken by coastal States and 47 distant-water fishing nations in Area 34 in the period 1950–2009 (FAO, 2011; http://www.fao.org/3/i2389e/i2389e.pdf).

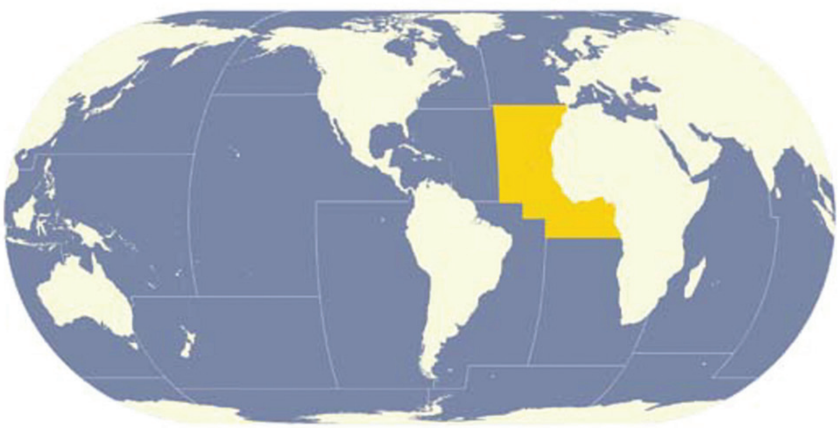

Fig. 4.1 The Eastern Central Atlantic (FAO Area 34 - see Fig. 3.1 in Chapter 3;) [source: FAO, 2011; retrieved on 17 March 2020; this work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo)]

4.2. Fisheries in the Eastern Central Atlantic (FAO Area 34)

The fisheries in Area 34 (Fig. 4.1) are diverse, and many of them are typically multispecies, thus posing additional challenges for assessment and management. The type of fishing vessels used ranges from small-scale dugout canoes, through larger motorized canoes and coastal fleets to large industrial fleets of national or distant-water origin. These distant-water vessels mostly come from Europe and Asia. In the late 1980s, changes in Eastern Europe first resulted in the appearance of a number of new distant-water fishing nations that started operating in Area 34. Subsequently, increased emphasis placed on market forces and changes in management regimes resulted in a reduction in the activities of some distant-water fleets that were mainly targeting small pelagic fishes. Since 1996, fishing effort by EU fleets on small pelagics has increased in the northwest portion of Area 34. Although there have been some fluctuations, catches have remained high since that time. Other foreign fleets are also active in Area 34, targeting small pelagics, large pelagics (tuna), shrimp, cephalopods and demersal fish (FAO, 2011; http://www.fao.org/3/i2389e/i2389e.pdf).

The total nominal catches reported from Area 34 increased almost twelve fold, changing from about 300 000 tonnes in 1950 to close to 3.5 million tonnes in 1977. Since then, catches have oscillated between 2.5 million tonnes in 1979 and the peak of 4.6 million tonnes, which was recorded in 2017 (Fig. 4.2). This variation appears to be due to changes in markets, fishing effort, fisheries agreement with coastal states and environmentally-induced changes that have affected stock productivity. European pilchard (*Sardina pilchardus*) has been the most important, in terms of cumulative catches (36 million tonnes), with species accounting for 21% share in 1950-2017, followed by sardinellas (*Sardinella* spp.) (29 million tonnes) - 16% share, and jack and horse mackerels (*Trachurus* spp.) (16 million tonnes) - 9% share.

Distant-water fishing fleets, mainly catching small pelagics and tunas, have made large but irregular contributions since the early 1970s. In the late 1960s and in the 1970s, these fleets dominated the catches. However, the coastal States steadily developed their national fisheries, increasing their contribution from 43 to 72 percent of total catches in Area 34 between 1977 and 2002. Since 2003, coastal States have contributed between 75 and 80 percent of the total catches between 1977 and 2017 (Fig. 4.3).

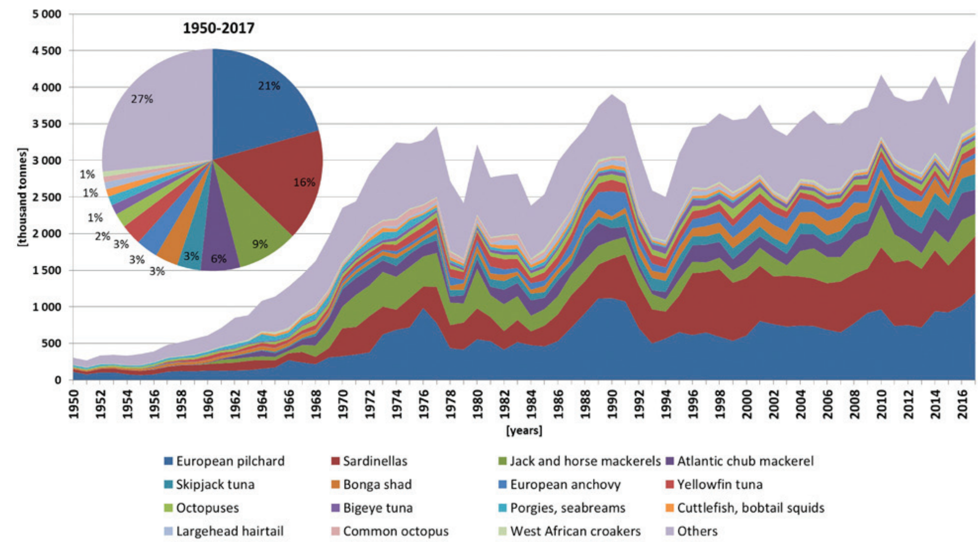

Fig. 4.2 Annual nominal catches of top 15 fish species in the Eastern Central Atlantic (FAO Area 34) in 1950-2017 (source of data: FAO, 2019)

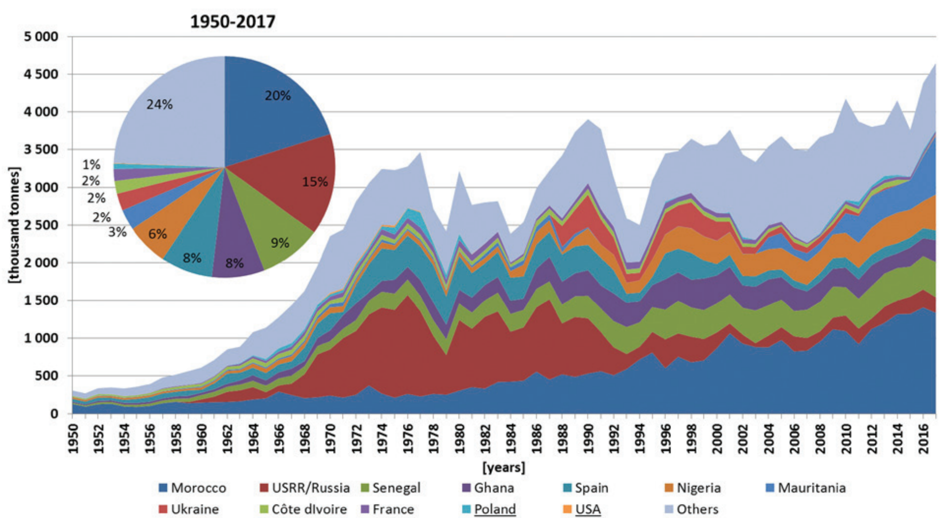

Fig. 4.3 Annual nominal fish catches in the Eastern Central Atlantic (FAO Area 34) in 1950-2017 by the top 10 countries (source of data: FAO, 2019)

Among tuna-like species, the two main species are skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*). The catches from the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) Group 36 (tunas, bonitos, billfishes, etc.) showed similar trends with time, reflecting the behavior of the fleets and the influence of climatic events on resource productivity. Catches of skipjack generally surpassed yellowfin tuna catches from 1991 onwards, with the exception of 2002, when yellowfin catches were slightly higher (Fig. 4.4). The 2017 catches of these species were 215 000 tonnes for skipjack and about 94 000 tonnes for yellowfin. Catches of bigeye tuna have decreased since mid-1990s from 90 000 to 40 000 tonnes (Fig. 4.4). Skipjack (*Katsuwonus pelamis*) has become the main contributor, generally surpassing yellowfin tuna (*Thunnus albacares*) from 1991 onwards. The skipjack tuna cumulative catches totaled to 6 million tonnes and yellowfin tuna to 5 million tonnes in 1950-2017 (FAO, 2019). Comparison of Figs. 4.4 and 4.5 allows stating that the maximum catches of selected tuna species in the 1990s-2000 cannot be related to activity of American fleet, but should be related to activity of the other fleets. Poland, with its R/V WIECZNO, was conducting longline fishing in 1981-1985 (see next subchapter).

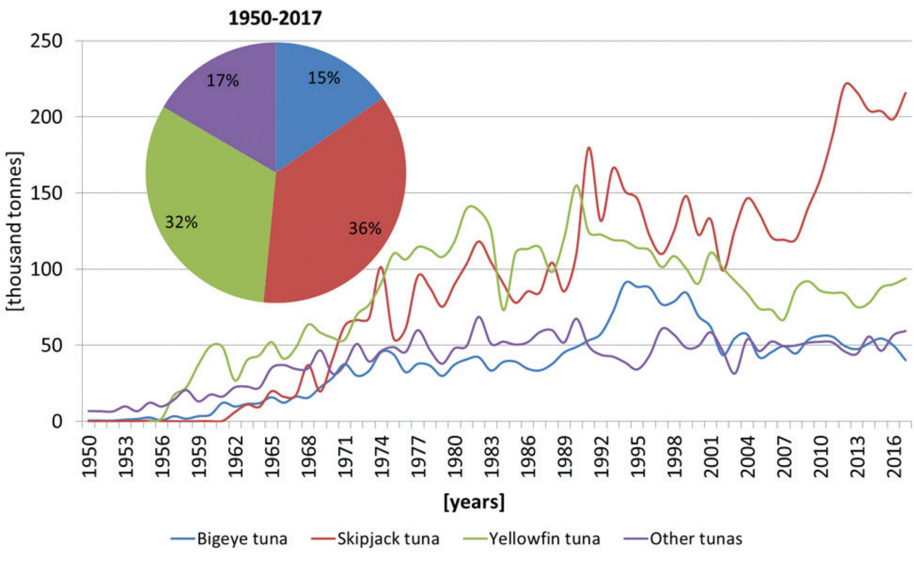

Fig. 4.4 Annual nominal catches of selected tuna species in Eastern Central Atlantic (FAO Area 34) (source of data: FAO, 2019)

The USA fishing fleet operated in the Eastern Central Atlantic for relatively short time (1970-1983) fishing for tunas species exclusively (Fig. 4.5). The first Polish research vessel appeared on African fishing grounds in 1958, catching experimentally with otter bottom trawl and pole-lines. Polish commercial catches peaked in 1977 reaching 203 thousand tonnes, then gradually decreased and stopped in 1982, to recover again in 1994 and continue till 2017 (Fig. 4.6). Polish fishing fleet benefited from the EU-Morocco and the EU-Mauritania agreement in the recent years. In 2017, Poland caught 12 500 tonnes of small pelagic fish, and then stopped its activity due to unfavorable economic outcomes.

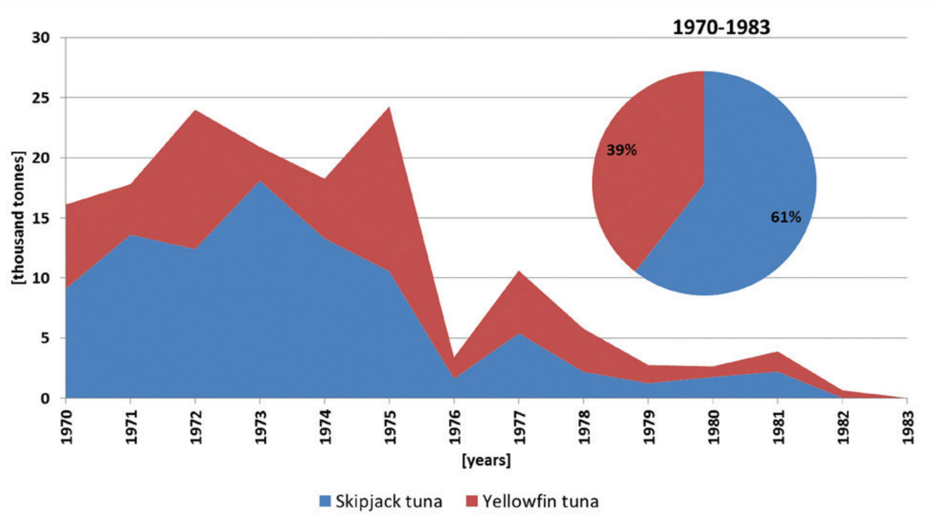

Fig. 4.5 The U.S. catches in the Eastern Central Atlantic (FAO Area 34) in 1970-1983 (source of data: FAO, 2019)

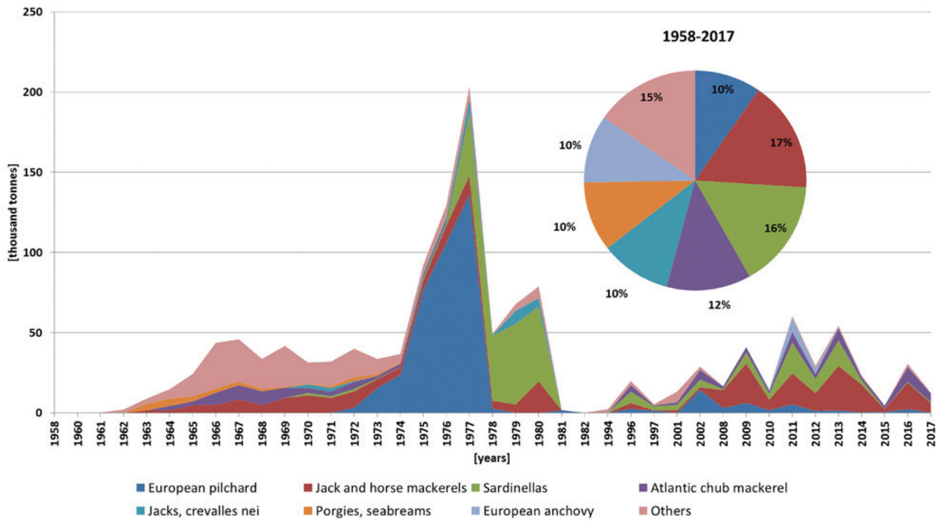

Fig. 4.6 Polish catches of main species in the Eastern Central Atlantic (FAO Area 34) in 1961-2017 (source of data: FAO, 2019)

4.3. Longline fishing in the Eastern Central Atlantic - activity of R/V WIECZNO

The apex predators study in the Northwest Atlantic was initiated on board R/V WIECZNO in 1976. The program was led by very experienced scientists from NMFS, Narragansett e.g. J. Casey, C. Stillwell, N. Kohler (see Chapter 3) and was continued during several years. Thus, by the beginning of activity in the **Eastern Central Atlantic**, R/V WIECZNO had already had some experience in longline fishing of apex predators. In 1981-1985, MIR→NMFRI implemented the Government Program, whose goal was to determine the fishing possibilities of large pelagic fish (sharks, tunas, billfishes and tuna-like fishes) in the Eastern Central Atlantic using the longline system under the industrial fishing regime (Figs. 4.1, 4.7-4.11; Blady, 1982; Długosz 1984; Ropelewski, 2001). Longline fishing in the Atlantic Ocean at that time was dominated by fleets from Japan, Taiwan, and South Korea and total yearly longline catch from that area ranged between 112 000 and 153 000 tonnes. Main target species was bigeye tuna (*T. obesus*) (Fig. 4.7), but usually a great number of shark was also caught as a by-catch and those are not covered in official statistics.

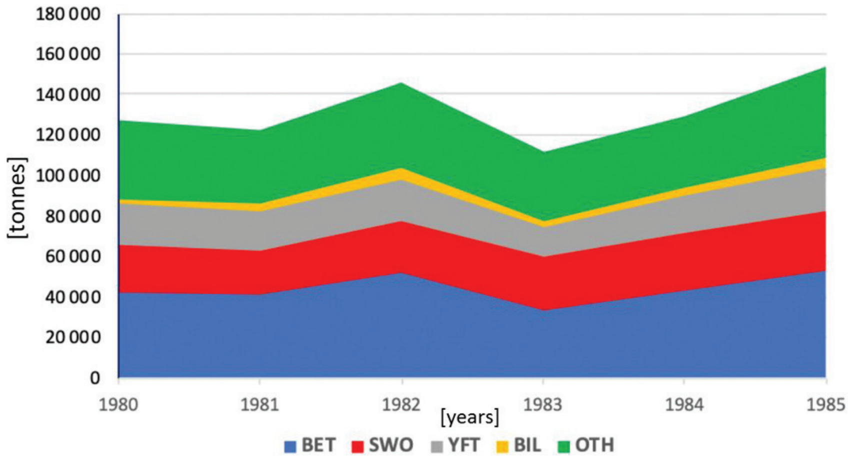

Fig. 4.7 Longline tuna catches in the Atlantic in 1980-1985 (BET- bigeye tuna (*Thunnus obesus*), SWO - swordfish (*Xiphias gladius*), YFT - yellowfin tuna (*Thunnus albacares*), BIL - billfishes, OTH - other tuna and tuna-like species (source of data: ICCAT database 2020)

Polish deep-sea fishing companies were interested in longline catches, and the MIR→NMFRI research in the Eastern Central Atlantic was to answer the question of the efficiency and potential profitability of such a large-scale undertaking. Preparing for possible industrial fishing in rich natural resources of Eastern Central Atlantic, MIR→NMFRI bought and installed Japanese longline equipment on R/V WIECZNO in 1981 (Ropelewski, 2001). R/V WIECZNO underwent some additional adaptive works in the shipyard, and in 1981 made the first survey in the Eastern Central Atlantic (Blady, 1982; Długosz, 1984). The next three longline fishing surveys of R/V WIECZNO in the Eastern Central Atlantic took place in years 1982-1985. The purpose of surveys was gathering of the all possible information related to technical and economic aspects of longline fishing in order to determine the fishing capacity of large pelagic fish when operating a vessel similar to the regime of an industrial cruise. The obtained data were to be the basis for deciding whether to undertake industrial fishing for large pelagic fish by Polish deep-sea fishing vessels in the waters of the Atlantic Ocean outside the Exclusive Economic Zones. The results of research on these fishing grounds were to provide information on the location and seasonality of fish aggregation in relation to hydrological conditions (Długosz, 1984; Kurowicki, 1987). It appeared from the analysis of data from 603 hydro-meteorological stations and 221 long-line sets (Figs 4.8-4.11) that concentrations of large pelagic fish may be found in the following areas: (i) places of eddy formation, (ii) thermal fronts, (iii) upwelling formation sites, (iv) near equatorial area, during full moon (catches of tuna, especially swordfish, increased twofold), (v) places of occurrence of seasonal thermocline originating at a depth of 180 m south of Equator, (vi) location of maximum horizontal temperature diversity (boundary between cold and warm currents) (Kurowicki, 1987). The outcome is collected and extensively commented in the Institute's internal documents, at that time considered confidential. The number of fish caught by species, the weight of each fish, fish freezing technology, technology for preparing shark meat for consumption, and all possible biological data were collected and described by Szewczuk (1982, 1984) and Pelczarski (1982, 1984, 1985).

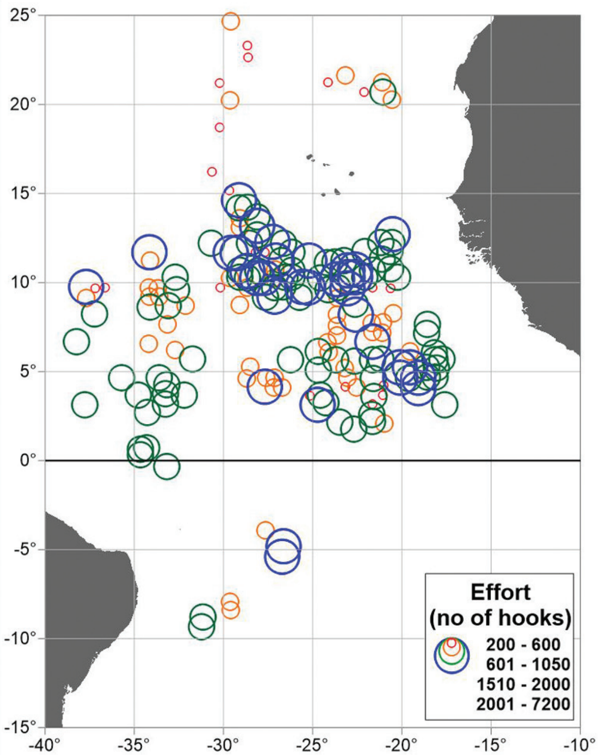

Fig. 4.8 The Eastern Central Atlantic region (see also Fig. 4.1) - region of R/V WIECZNO longline fishing for large pelagic fish in 1981-1985; number of hooks in long-line systems shown in different colors (source: figure based on data provided by W. Pelczarski; graph drawn by T. Wodzinowski, NMFRI)

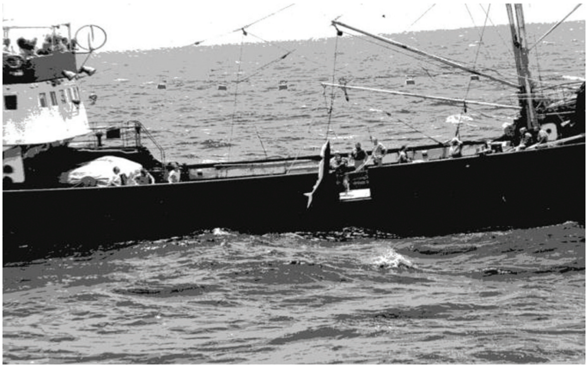

Fig. 4.9 Longline fishing on R/V WIECZNO in the Eastern Central Atlantic (source: private archives of W. Pelczarski)

Fig. 4.10 Longline fishing on R/V WIECZNO in the Eastern Central Atlantic; fish on the deck - mostly yellowfin tuna (*T. albacares*) (source: private archives of J. Chołyst)

Fig. 4.11 Longline fishing on R/V WIECZNO in the Eastern Central Atlantic (source: private archives of W. Pelczarski - in the picture)

4.4. The National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program

The National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program (CSTP) is a collaborative effort between recreational anglers, the commercial fishing industry, and NMFS to study the life history of Atlantic sharks. The CSTP was initiated in 1962 with an initial group of less than 100 volunteers. The program has expanded in subsequent years to include thousands of volunteers distributed along the Atlantic and Gulf coast of North America and Europe. The tagging methods used in the CSTP have been essentially unchanged during the past 52 years. There are two principal tags that are in use i.e. a fin tag (Jumbo Rototag) and a dart tag ("M" tag) (Kohler et al., 1998; Kohler and Turner, 2019) (Fig. 4.12).

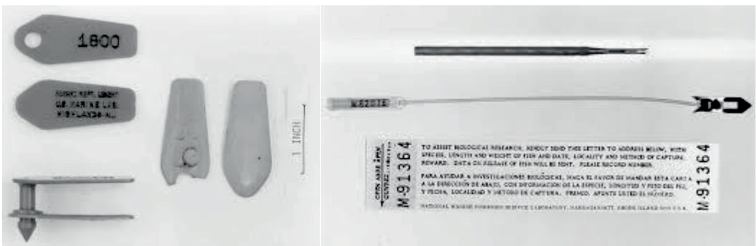

Fig. 4.12 Principal tags used in Cooperative Shark Tagging Program: a dorsal fin tag - Jumbo Rototag (left) and a dart tag, called "M" tag (right) (source: Kohler et al., 1998; with the permission of the editor Dr. Willis Hobart)

The rototag is a two piece, plastic cattle ear tag which is inserted through the first dorsal fin. These tags were primarily used by NMFS biologists on small sharks during the first few years of the CSTP. As the program expanded to include thousands of volunteer fishermen, the dart tag was developed to be easily and safely applied to sharks in the water. The "M" tag is composed of a stainless steel dart head, monofilament line, and a plexiglas capsule containing a vinyl plastic legend with return instructions printed in English, Spanish, French, Japanese, and Norwegian. These dart tags, in use since 1965, are implanted in the back musculature near the base of the first dorsal fin (https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html).

Numbered tags are sent to volunteer participants on self-addressed return post cards for recording tagging information (date, location, gear, size and sex of shark), along with a tagging needle, tagging instructions, current management information, and shark ID placards. Tagging studies have been mostly single release events in which recoveries are made opportunistically by recreational and commercial fishermen. When a previously tagged shark is re-caught, information similar to that obtained at tagging is requested from the recapture. Initially, a five dollar reward was sent as an incentive for returning tags; since 1988, a hat with an embroidered logo (Fig. 4.13) has been used (https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html).

Fig. 4.13 Cooperative Shark Tagging Program Logo designed by NOAA, NMFS, Narragansett (source: picture of embroidered logo - M. Pastuszak)

Anglers using rod and reel accomplish the majority of the tagging for all species combined. Biologists, NMFS fisheries observers, and commercial fishermen using primarily longlines, handlines, and nets (gill, trawl) account for the remainder. Conversely, commercial fishermen using longlines and net gear, and rod and reel anglers are responsible for the majority of the recaptures. Between 1962-2016, over 290 000 fish of 52 species have been tagged and more than 17 000 fish of 33 species have been recaptured. The rate of recapture ranges from 1.2% for the blacknose shark (*Carcharhinus acronotus*) to 13.5% for the shortfin mako (*Isurus oxyrinchus*). Distances traveled for the 33 species ranged from negligible movement to 3 997 nautical miles (blue shark, *Prionace glauca*). The longest time at liberty for any shark in the CSTP is 27.8 years (sandbar shark, *Carcharhinus plumbeus*) (https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html) (Fig. 4.14; Kohler et al., 1998; Kohler and Turner, 2019).

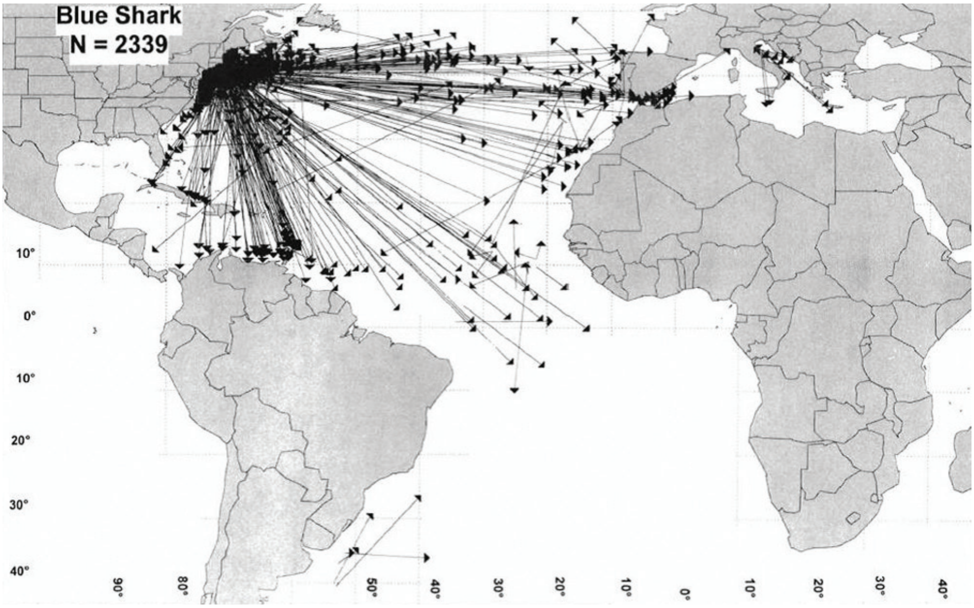

Fig. 4.14 Recapture distribution for the blue shark, *Prionace glauca*, from the NMFS Cooperative Shark Tagging Program (1962-93) (source: Kohler et al., 1998; with the permission of the editor Dr. Willis Hobart)

Among recaptures shown in Fig. 4.14 there were several originating from R/V WIECZNO tagging in the Eastern Central Atlantic. A special case was a blue shark which at that time was the first in NMFS CSTP to perform trans equatorial voyage (information from John Casey). Data from tagging programs, such as the NMFS CSTP, provide valuable information on migration and the extent of fish movements. The need for international cooperation in such work is underscored by the fact that many shark species have wide ranging distributions, frequently traverse national boundaries, and are exploited by multinational fisheries. The CSTP is also an important means to increase our biological understanding of sharks and to obtain information for rational resource management. The tagging of sharks (and other aquatic animals) provides information on stock identity, movements and migration (including rates and routes), abundance, age and growth (including verification and validation of age-determination methods), mortality, and behavior (https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html).

4.4.1. Shark tagging in the Eastern Central Atlantic – activity of R/V WIECZNO

Our American partners from NMFS, Narragansett, specialists in longline fishing (see Chapter 3), knew about Polish project related to potential industrial fisheries of large pelagic fish in the Eastern Central Atlantic and officially turned to MIR→NMFRI to use the possibilities and continue the National Marine Fisheries Service Cooperative Shark Tagging Program (Ropelewski, 2001). The shark tagging program was conducted on R/V WIECZNO as an additional commitment to the American partner. The primary goal of four R/V WIECZNO cruises in 1981-1985 in the South Central Atlantic region (Fig. 4.1) were (i) long-line fishing for large pelagic fish, with tuna and billfishes as target species, (ii) testing of new techniques of squid catching, (iii) providing representatives of the DALMOR and ODRA deep-sea fishing companies with technical and economic documentation allowing taking decisions focused on industrial scale fisheries in the subjected region. Tags and deck logs were provided by NMFS, Narragansett prior to Polish long-line fishing program in the abovementioned region. The Americans did not physically participate in these studies, but we can of course state that it was a continuation of Polish-American cooperation in the Atlantic waters, in this case, in the Eastern Central Atlantic (Pelczarski, 1982, 1984, 1985; Ropelewski, 2001).

However, the main focus was on fishing of tunas, swordfish and billfishes. Some sharks were processed on board and those which, for various reasons, could not be processed were tagged and then released. That is why the daily tagging ratio ranged 0-48 sharks (blue shark, *Prionace glauca* constituted the vast majority) (Pelczarski, 1982, 1984, 1985). Tagging took place in the water, after the shark was towed under the ship's side. In the case of small individuals, they were tagged on board. Identification of sharks was based on "*Anglers Guide to Sharks of the Northeastern United States*" (Casey, 1964) and in cruise 1985 also on "*FAO Species Catalogue Vol. 4 Sharks of the world*" (Compagno, 1984). During tagging, species, sex, approximate total length of shark and geographical position of release were noted in the documentation. The documentation was then sent to NMFS, Narragansett. In 1982, blue shark that was tagged a week earlier by R/V WIECZNO was recaptured (Pelczarski, 1982). Not all documentation has survived to this day, but according to the documents for 1981-1985, we can state that 1 566 sharks, including 1 242 blue sharks, were tagged in the Eastern Central Atlantic region; the remaining 324 were the sharks representing 5 other species, mainly oceanic whitetip shark (Table 4.1) (Pelczarski, 1982, 1984, 1985). The total numbers of sharks caught in 1982-1985 were as follows: 1067, 1058, 961, and 996 in 1981, 1982, 1984, and 1984/1985, respectively (Table 4.1).

Division and subdivision of the Atlantic Ocean is shown in Figs. 4.1 and 4.15. Subdivision 7 (Kohler et al., 1998) overlaps with the main region of R/V WIECZNO activity in the Eastern Central Atlantic in 1981-1985 (Fig. 4.8) but many sharks were also tagged by R/V WIECZNO in subdivision 6 (Pelczarski, 1982, 1984, 1985; Kohler et al., 1998; Kohler and Turner, 2019). Most sharks caught by R/V WIECZNO within subdivision 7 (Fig. 4.15) were tagged. The total number of blue sharks tagged in subdivision 6 and 7 reached 2 254 (see the Table within Fig. 4.15). So, it is clear that Polish contribution, with 1 242 blue sharks tagged (Table 4.1), to the overall number of blue sharks tagged in the Eastern Central Atlantic (Kohler et al., 1998) constituted ca. 55%. Similar assumption can be made in case of tagged bigeye thresher (*Alopias superciliosus*) and oceanic whitetip (*Carcharhinus longimanus*) in subdivision 7 (Table 4.1; Kohler et al., 1998).

Table 4.1 Number of sharks tagged by species by R/V WIECZNO in the Eastern Central Atlantic in 1981-1985 (source of data: Pelczarski, 1982, 1984, 1985)

Year	Total number of tagged sharks (in bold) and caught sharks (in brackets)	**Sharks tagged by species**				
		Blue shark (*Prionace glauca*)	Dusky shark (*Carcharhinus obscurus*)	Oceanic whitetip shark (*Carcharhinus longimanus*)	Bigeye thresher, (*Alopias superciliosus*) + Smooth hammerhead (*Sphyrna zygaena*)	Shortfin mako (*Isurus oxyrinchus*)
1981	**442** (1067)	**361**	**25**	**42**	**13 + 0**	**1**
1982	**457** (1058)	**376**	**25**	**42**	**12 + 1**	**1**
1983	**167** (961)	**76**	**19**	**31**	**38 +3**	**-**
1984/1985	**500** (996)	**429**	**20**	**31**	**20 + 0**	**-**
Total:	**1566** (4082)	**1242**	**89**	**146**	**83 + 4**	**2**

We must also remember that shark tagging was continually performed by R/V WIECZNO along the eastern continental shelf of the U.S. in 1976-1986 (see Chapter 3). According to cruise reports available at MIR→NMFRI, as many as 1 800 sharks were tagged and released in R/V WIECZNO cruises along the eastern continental shelf of the U.S. in 1976-1986. That number is substantial and greatly contributed to overall number of sharks tagged within the NMFS Cooperative Shark Tagging

Program (1962-93) carried out in subdivisions 1, 2, 3 (Kohler et al., 1998) (Figs. 4.15, 4.16).

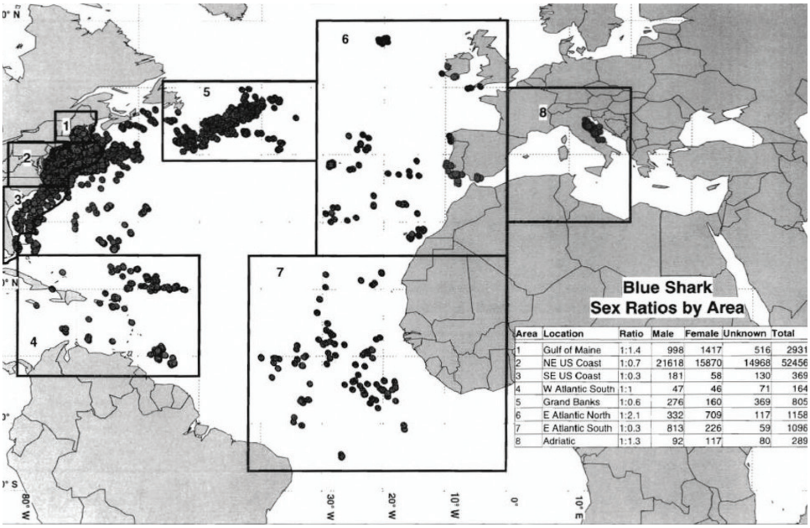

Fig. 4.15 Sex ratios of the blue shark, *Prionace glauca*, from the NMFS Cooperative Shark Tagging Program (1962-93) (source: Kohler et al., 1998 ; with the permission of the editor Dr. Willis Hobart)

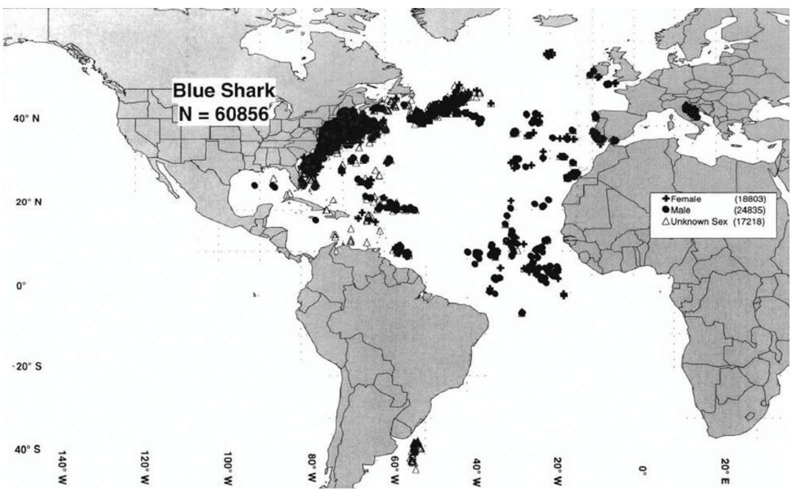

Fig. 4.16 Total tagging distribution for the blue shark, *Prionace glauca*, from the NMFS Cooperative Shark Tagging Program (1962-93) (source: Kohler et al., 1998; with the permission of the editor Dr. Willis Hobart)

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5

POLISH FISHERY AND POLISH-AMERICAN FISHERIES RESEARCH IN THE NORTHEAST PACIFIC

Jerzy Janusz, Emil Kuzebski, Marianna Pastuszak, Andrzej Orłowski†, Tycjan Wodzinowski

5. POLISH FISHERY AND POLISH-AMERICAN FISHERIES RESEARCH IN THE NORTHEAST PACIFIC

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Andrzej Orłowski†, Tycjan Wodzinowski

5.1. Study area - general overview

The Northeast Pacific (Fig. 5.1) covers almost 8 million km^2, of which 1.3 million km^2 are shelf area. It encompasses several distinct Large Marine Ecosystems (Sherman, 2000, 2016; Sherman et al., 2009; Sherman and Hamukuaya, 2016) (see Chapter 1), including the California Current, the Gulf of Alaska, and the Bering Sea. The dynamics of these systems are dominated by the Aleutian Low pressure cell – one of the most intense, quasi-permanent atmospheric systems on earth. In the Gulf of Alaska, the result is a strong coastal convergence that drives anticyclonic coastal flow around the periphery of the Gulf of Alaska. This interacts with coastal runoff to produce embedded frontal zones of concentrated biological processes. The Eastern Bering Sea is a shallow shelf system, characterized by wind and tidal mixing with shelf-sea frontal currents. Each of the three domains, California Coast Current, Gulf of Alaska Gyre and the Eastern Bering Sea, contains abundant fishery resources that support catches of a wide variety of species. In the past decade, the fisheries in the region have undergone a series of regulatory and market-driven reforms to reduce fishing effort to sustainable levels (FAO, 2011).

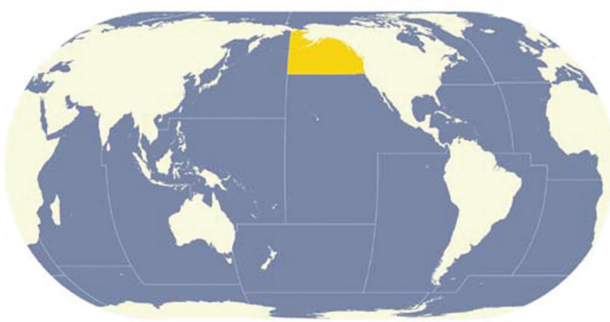


Fig. 5.1 The Northeast Pacific (FAO Area 67) (see Fig. 3.1 in Chapter 3) (source: FAO, 2011; retrieved on 15 July 2020; this work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo)]

5.2. Fisheries in the Northeast Pacific (FAO Area 67)

Total nominal catches for the Northeast Pacific (Area 67; see Fig. 3.1 in Chapter 3) increased from about 600 000 tons in 1950 to slightly more than 3.3 million tons in the 1980s and 2012-2016 (Fig. 5.2). A reduction in 2008-2010 was a result of poor pollock recruitment. Alaska (walleye) pollock (*Gadus chalcogrammus)*, former name (*Theragra chalcogramma*) has contributed the largest part of the catches since the early 1970s. Its contribution varied from 40 to 50, on average 43 percent of the total nominal catch for most of that period studied (Fig. 5.2). Over the years 1970-2016, catches of Alaska pollock varied from ca. 800 000 tonnes to 1.5-1.7 million tonnes (Fig. 5.2). The cause of the sharp decline in Alaska pollock in 2007-2010 is primarily linked to three very warm years in the Eastern Bering Sea that led to extremely poor year classes (FAO, 2011).

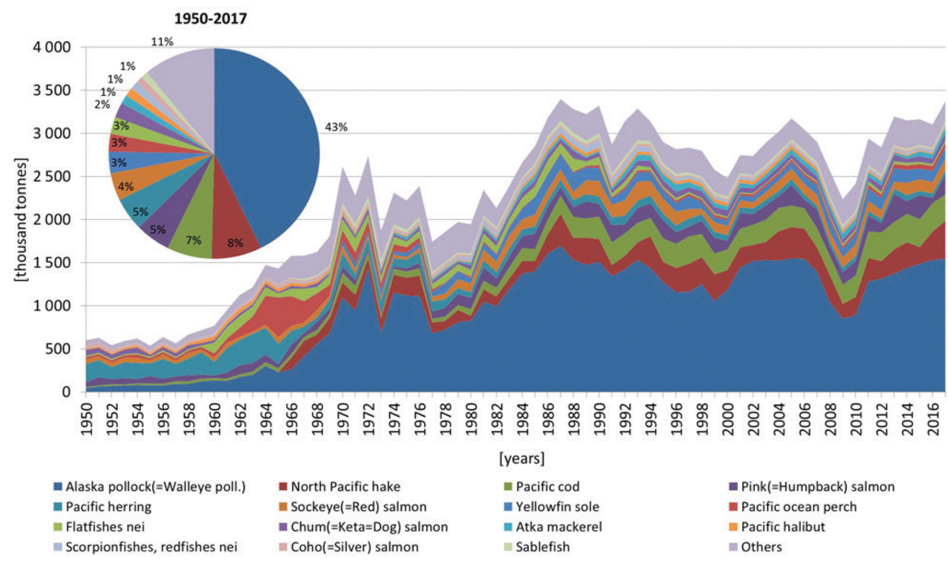


Fig. 5.2 Annual nominal catches of top 15 fish species in the Northeast Pacific (FAO Area 67) in 1950-2017 (source of data: FAO, 2019)

Catches of International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) groups: 32 (cods, hakes, haddocks), 33 (miscellaneous coastal fishes) and 34 (miscellaneous demersal fishes) species have been increasing, and catches have been regulated to comply with specific regulations. The most variable of these stocks is Pacific hake (*Merluccius productus*), also commonly called Pacific whiting, which exhibits highly variable recruitment. It underwent a climate-driven decline in the 1990s followed by a recovery starting with a strong 1998 year class. Similarly, the largest stock in the group, Bering Sea pollock, declined strongly following extremely low recruitment in 2001–03 (FAO, 2011; Fig. 5.2).

As these poor year classes became of fishable and reproductive age, catch limits were reduced dramatically in 2008-10. Currently, above-average recruitment has been estimated from the 2006 and 2008 year classes and the stock has recovered above Bmsy[1)] levels. The biomass of Eastern Bering Sea Pacific cod (*Gadus macrocephalus*) increased from the late 1970s to the mid-1980s. It declined to about half of the peak by the mid-1990s since when it has been estimated to be stable with moderate fluctuations. Generally, cod catch trends mirror pollock, and the catch has ranged between 200 000 and 300 000 tonnes since 1990 (FAO, 2011; Fig. 5.2).

In the early 1950's there were just three countries involved in the Northeast Pacific fisheries - the U.S., Canada and Japan. The USRR joined the fishery in 1960, which led catches exceeding one million tonnes in 1962 (Fig. 5.3). In 1976, there were eight states engaged in the fisheries - except for two coastal (U.S. and Canada) there were six foreign fleets (Japan, USRR, Korea, Poland, Germany, Bulgaria) operating in the waters (Fig. 5.3). The extension of the U.S.'s marine boundaries and implementation of the Fishery Conservation and Management Act (FCMA) in 1976 let started so called "Americanization" of the fishery (Bailey, 2011) and allowed the U.S. fishermen began harvesting of the resource more intensively (Strong and Criddle, 2011).

Since the mid of 1980's the U.S. fishing fleet has dominated in the area. In 2017, the U.S. fleet landed 3.2 million tonnes of fish followed by Canadian catches (176 thousand tonnes only) (Fig. 5.3). Alaska pollock was the fish most caught by the U.S. fishermen, with 1.5 million tonnes brought in. It was ahead of North Pacific hake (350 thousand tonnes) and Pacific cod - 300 thousand tonnes (Fig. 5.4).

[1)] B_{msy} - biomass level at which natural production of the stock (in biomass) is at a maximum (Monaco and Prouzet, 2014)

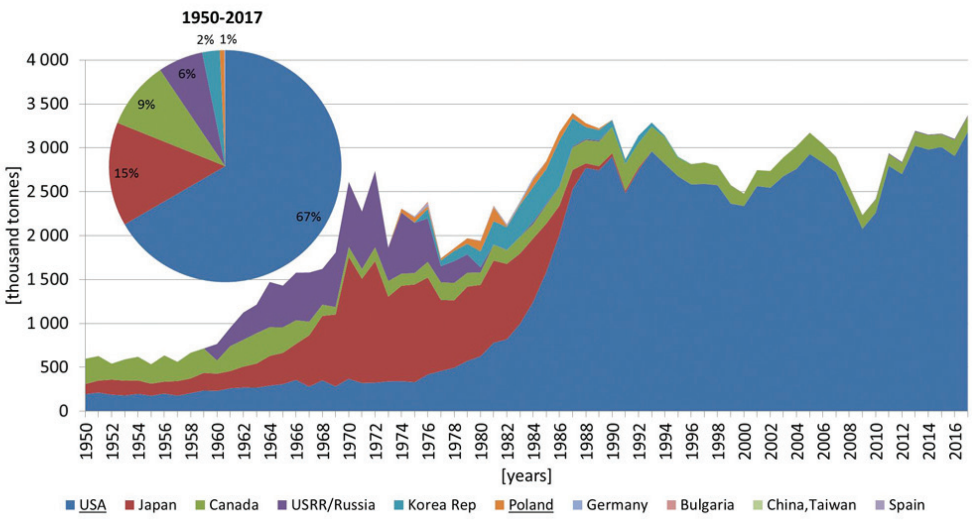


Fig. 5.3 Annual nominal fish catches in the Northeast Pacific (FAO Area 67) in 1950-2017 by countries (source of data: FAO, 2019)

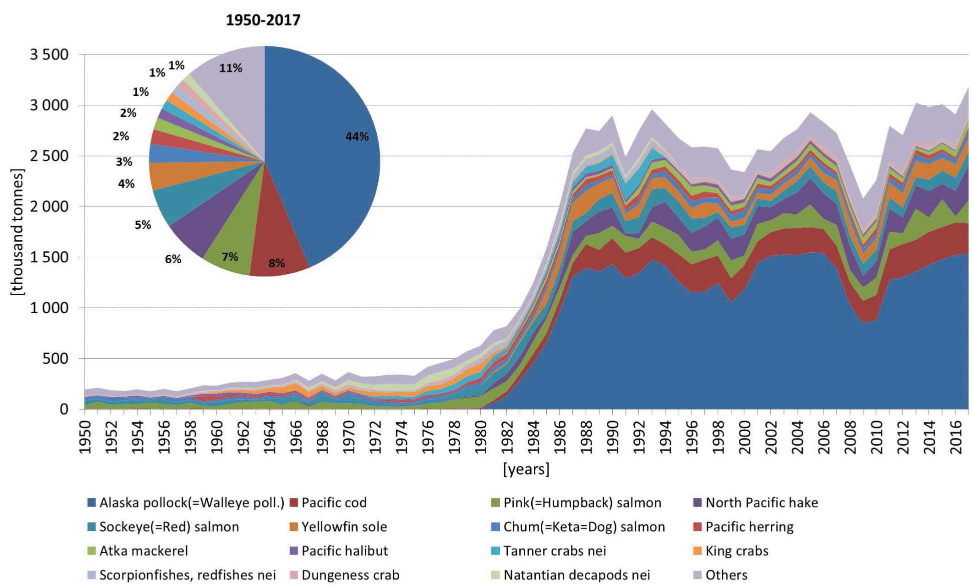


Fig. 5.4 The U.S. catches of main species in the Northeast Pacific area (FAO 67) in 1950-2017 (source of data: FAO, 2019)

The first Polish fishing vessel showed up in the area in 1973 (see subchapter 5.3.1.), and the commercial exploitation commenced a year later. Extension of Exclusive Economic Zone (EEZ) to 200 nautical miles caused that Poland could not benefit free fisheries any longer and had to sign soon agreements regulating fishing activity of its fleet in the area with the USA (August the 2nd, 1976) and Canadian (May the 14th, 1976) governments. In 1979, Polish vessels were granted the first Alaska pollock quotas in the Gulf of Alaska, Aleutian Islands and the Eastern Bering Sea shelf (see subchapter 5.3.1). In the peak years (1980-1981) there were 35 vessels (about 30% of the total number of Polish deep-sea vessels) operating in the Northeast Pacific area fishing up to 160 thousand tonnes of fish (1981). As a consequence of the U.S.A. restriction imposed after martial law implemented in Poland (December, 1981), Polish fleet could operate in Canadian waters only, and in 1982 catches dropped to 10 thousand tonnes (Fig. 5.5). The fisheries were reopened in 1984, however, it continued shortly. In 1985, Poland did not receive any fishing quotas in the USA EEZ but continued cooperation with the U.S. fishermen in the form of "klondyking" (i.e. "transhipping" - purchasing of fish on fishing grounds; transferring fish from the catch vessel to a factory vessel) till 1988.

Starting from 1985, most of the fleet was transferred to international waters of the Bering Sea (see more in subchapter 5.3.3) and part of the fleet was fishing in Canadian waters (until 1991) or continued "klondyking" cooperation with Canadian fishermen (until 2001).

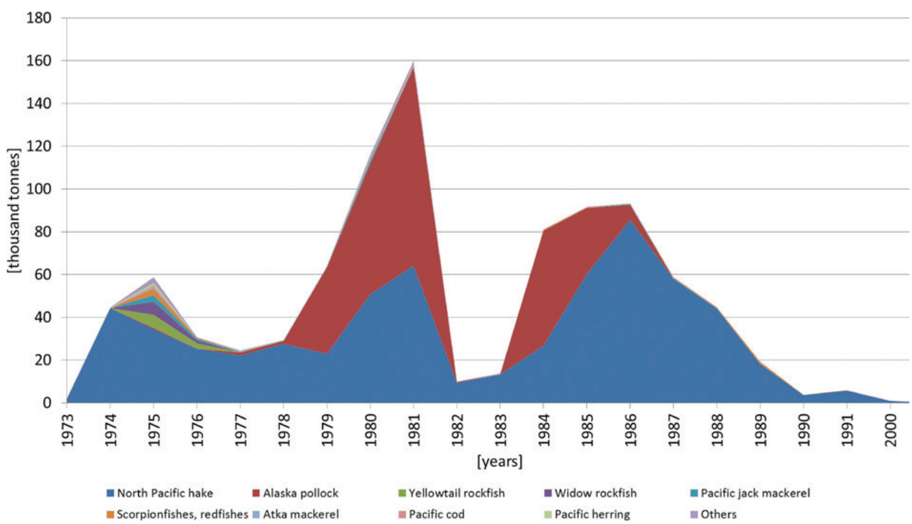


Fig. 5.5 Polish catches of main fish species in the Northeast Pacific (FAO Area 67) in 1973-2001 (source of data: FAO, 2019)

5.3. Polish contribution to fisheries research in the Northeast Pacific

5.3.1. Sea Fisheries Institute research activity in the USA and Canadian Exclusive Economic Zones in the Northeast Pacific - historical overview

In the early 1970s, fisheries in the Northeast Pacific, beyond the 12-mile territorial waters of the U.S. and Canada, were freely available to “foreign” fleets. The Polish fishery in the Northeast Pacific started in 1973 with reconnaissance cruise of M/T HUMBAK in the area off the western coast of the United States and Canada, the Gulf of Alaska and the eastern shelf of the Bering Sea (Borowski et al., 1974). The cruise aimed at examining the possibilities of commercial exploitation of Pacific hake (*Merluccius productus*), herring (*Clupea pallasii*), and walleye (Alaska) pollock (*Gadus chalcogrammus*), former name (*Theragra chalcogramma*) stocks. The Sea Fisheries Institute in Gdynia (MIR→NMFRI) was a co-organizer of the cruise during which biological and fishing data were collected. The findings of the reconnaissance led to start the commercial fishery on Pacific hake in 1974, outside 12 Nm of the U.S. western shelf in the Washington-Oregon-California area (WOC). The area of Polish fishing and research activity in the Northeast Pacific and international waters of the Bering Sea (Donut Hole) during the years 1973-1999 is presented in Fig. 5.6.

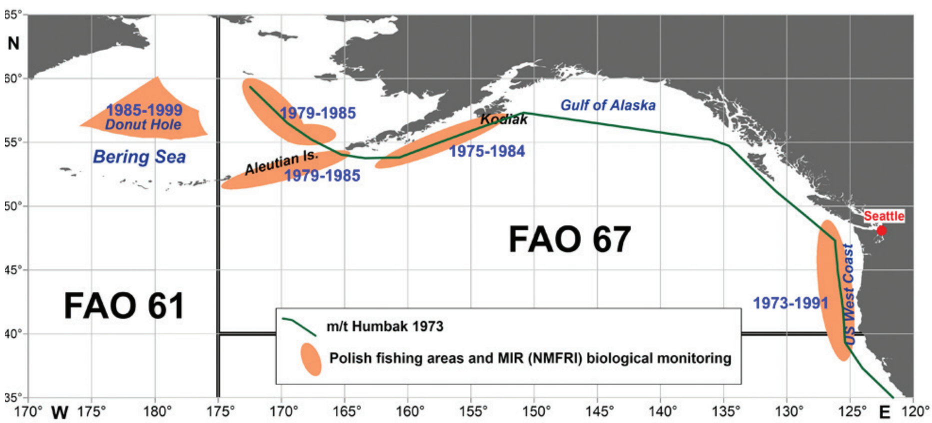


Fig. 5.6 Area of Polish fishing and biological monitoring activity in the Northeast Pacific and international waters of the Bering Sea (Donut Hole) (map drawn by T. Wodzinowski, NMFRI)

Starting from 1974, each year, the Sea Fisheries Institute (MIR→NMFRI) conducted biological and fisheries monitoring in Northeast Pacific on commercial vessels of Polish deep-sea fishing companies DALMOR, ODRA and GRYF. Research activities were related to the fishing activities of the Polish deep-sea fleet. The first unofficial meeting of Polish (MIR→NMFRI - Gdynia) and the U.S. [National Marine Fisheries Service (NMFS) – Seattle] scientists took place in August 1975 on board Polish fishing vessel M/T ANDROMEDA. The U.S. side was represented by T. Dark, D. H. Larkins and J. Pruter while the Polish side by C. Żukowski, E. Jackowski, J. Romer and J. Barthelke (Ropelewski, 2001). Already in 1977, scientists from NMFS, Seattle and MIR→NMFRI had sufficient data to compare hake age readings from otoliths (Anon., 1977).

First Agreement regarding fisheries in the Northeast Pacific was signed in Washington on May 30, 1975 (Anon., 1975). Bearing in mind the common concern for rational management, protection and optimal use of fish stocks along the coast of USA the new *Agreement Between the Government of the United States of America and the Government of Polish People's Republic Concerning Fisheries Off the Coasts of the United States* was signed August 2, 1976 (Anon., 1976). The purpose of this agreement was "*to ensure effective conservation, optimum utilization and rational management of the fisheries of mutual interest off the coasts of the United States*". Article XI of the Agreement stipulated an obligation to "*... conduct of scientific research required for the purpose of managing and conserving living resources … including the exchange of information and scientists, regularly scheduled meetings between scientists to prepare research plans and review progress, and the implementation and maintenance of a standardized system for the collection and archiving of relevant statistical and biological information ...*". The Sea Fisheries Institute in Gdynia (MIR→NMFRI) was appointed to carry out this task. Similar agreement between the Government of Poland and Canada was signed on May 14, 1976, in which there were also records regarding activities related to research of Polish parties and scientific cooperation with the Pacific Biological Station in Nanaimo (Canada). In 1976, the Magnuson Conservation and Management Act, the primary law regulating comprehensively the rules for fishing in the U.S. waters by foreign fleets, came into force (https://www.fisheries.noaa.gov/resource/document/magnuson-stevens-fishery-conservation-and-management-act). In 1977, the United States and Canada introduced the 200-mile Exclusive Economic Zone (EEZ) (http://www.marineregions.org/eezdetails.php?mrgid=8493).

Each year, in the U.S. EEZ, quotas for individual fish species and fishing conditions for Polish fleet were determined. Fishing seasons and areas, fishing gear, protected species, by-catch, closed areas (so-called "gardens") were set. Compliance with these arrangements was also monitored by the U.S. observers placed on board Polish vessels (Anon., 1978a). In connection with the intensification of Polish fishing in this area, the MIR→NMFRI decided to establish the Northeast Pacific Group within the Department of Ichthyology. This body focused on biological and fisheries research of the resources of the Northeast Pacific in accordance with the programs established in the Poland-USA and Poland–Canada Agreements. Based on bilateral Agreements an extensive United States-Poland-Canada cooperative survey along the west coast of the United States, Vancouver Island and the Gulf of Alaska was carried out in the third quarter of 1977. Joint Polish - USA - Canada scientific expedition was organized by the Sea Fisheries Institute (MIR→NMFRI), the National Marine Fisheries Service (NMFS, Seattle), and the Pacific Biological Station (Nanaimo) in which research vessels from Poland R/V PROFESOR SIEDLECKI, the USA R/V MILLER FREEMAN, and Canada R/V J.B. REED took part (see subchapter 5.3.2.).

On the west coast of the USA and Canada (Vancouver) shelves, hake stock was monitored most intensively in the period 1974-1981, as a target species in Polish catches. During 1979-1981, Poland received significant catch quotas for pollock in the U.S. Exclusive Economic Zone (EEZ) in the Gulf of Alaska, Aleutian Islands and in the Eastern Bering Sea shelf. Monitoring of catches by MIR→NMFRI was significantly expanded during this period. Polish catches and fishing effort data (by small squares) as well as monitoring results were reported to the NMFS, Seattle. In 1982-1983, fishing and monitoring activities were discontinued following suspension of fishing quotas for Poland as a result of U.S. restrictions introduced in response to the martial law in Poland. Polish fishing and monitoring in the U.S. EEZ was resumed in 1984, but the quotas were much more limited. One of the reasons was the rapid expansion ("Americanization") of the U.S. fishing fleet (Bailey, 2011). Starting from 1985, Polish fishing activity in the U.S. EEZ was continued only on the basis of fish "klondyking". Scientific cooperation between NMFS and MIR→NMFRI was continued but it was limited mainly to monitoring of fish stocks exploited by Polish fisheries.

During the period of 1973-1984, in the U.S. EEZ in the Northeast Pacific, scientists and technical staff of the MIR→NMFRI monitored 32 fishing cruises on board of Polish commercial vessels. Observations covered catch, catch rates, species compositions of catches, length and age composition of main fish species, weight, sexual maturity, and stomach contents. Following the agreements signed by Poland, the USA, and Canada, the reports from monitored cruises were forwarded to NMFS in Seattle - USA, and to the Pacific Biological Station in Nanaimo - Canada. The activity of MIR→NMFRI at that time was mainly focused on the implementation of tasks resulting from bilateral agreements signed with the USA and Canada, and from the needs of Polish fisheries industry. These included reporting the catches, monitoring fishing cruises, collection and processing of biological and fisheries data, scientific cooperation with the National Marine Fisheries Service in Seattle, and the participation in the Symposia of the International North Pacific Fisheries Commission.

The results of research and monitoring activities in the U.S. west coast area, Gulf of Alaska and the Eastern Bering Sea shelf were presented in the cruise reports, annual and scientific studies, and expert opinions regarding the state of resources and the possibilities of its exploitation by the Polish fleet. The scope of the issues was very broad and related to catch and fishing effort data (Janusz, 1981), species composition of catches, analysis of by-catch of limited species in Polish hake fisheries (Jackowski and Czech, 1987), biological characteristics of fish stocks exploited by Polish fleet (Janusz, 1986; Jackowski and Trociński, 1988) attempts to estimate fish stocks (Orłowski, 1981). During the years of Polish fishing in the Northeast Pacific a number of studies were undertaken to meet the needs of the Polish fishing fleet. Results of these studies and fishing forecasts for Polish fishing companies were presented annually in internal MIR→NMFRI studies: "Ocena stanu zasobów w …. roku. Łowiska Północnego Pacyfiku" (*State of resources in …. year. Northeast Pacific fishery*), and „Prognoza stanu zasobów dla łowisk Atlantyku i Pacyfiku" (*Forecast for the Pacific fishing area*) (Anon., 1993, 2001). Many employees of the MIR→NMFRI were involved in collection of biological materials on commercial vessels, among others the following names most frequently appear in documentation: E. Jackowski, J. Barthelke, J. Romer, K. Czech, R. Nowakowski.

5.3.2. Polish - USA - Canadian scientific research in the Northeast Pacific in 1977

Based on bilateral agreements between Poland-U.S., and Poland-Canada an extensive United States-Poland-Canada cooperative hydroacoustic-fishing-oceanographic survey along the west coast of the United States (Washington-Oregon-California) and Gulf of Alaska and along Vancouver Island, British Columbia (Canada), was carried out from 4 July to 22 September 1977 (Fig. 5.7). The cruise plan was developed by all sides and the responsible government institutions. Research vessels from Poland - R/V PROFESOR SIEDLECKI, the USA - R/V MILLER FREEMAN, and Canada - R/V J.B. REED were involved in the surveys (Fig. 5.8).

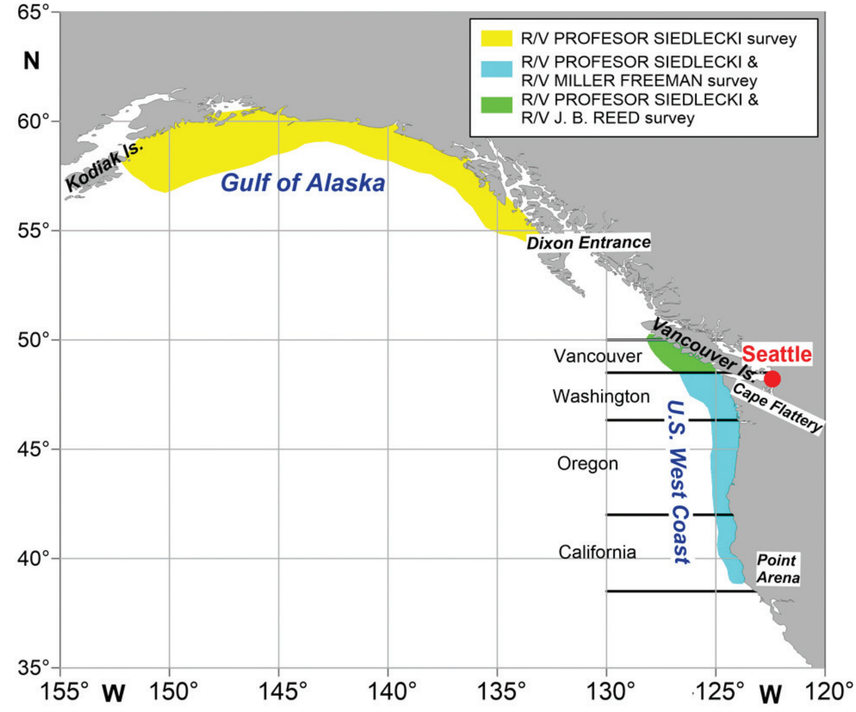


Fig. 5.7 The area of R/V PROFESOR SIEDLECKI survey and areas where research was conducted jointly with R/V MILLER FREEMAN, and R/V J.B. REED (map drawn by T. Wodzinowski, NMFRI)

Fig. 5.8 R/V PROFESOR SIEDLECKI and R/V MILLER FREEMAN [source: archives of MIR→NMFRI and https://en.wikipedia.org/wiki/NOAAS_Miller_Freeman_(R_223)] (Retrieved in May 2020)

Tentative Cruise Plan of R/V PROFESOR SIEDLECKI for the U.S.-Polish Fishery and Oceanographic Research was prepared at the Northwest and Alaska Fisheries Center (NWAFC) in agreement with Polish side. The basic goals of the survey were:

1. to obtain useful information about the size and condition of principal semi demersal fish resources and,
2. to estimate fish stocks using echo integration trawl surveys.

In addition to these main tasks, a number of other studies were conducted:

- Oceanographic study of the continental shelf and slope to a depth approximately 1000 meters. A cooperative effort was made between the U.S. and Polish oceanographers to study the physical, chemical and biological characterstics of marine environment on continental terrace. During the entire cruise, in all investigated areas (Fig. 5.7), 321 hydrological stations were surveyed where 3525 measurements of water temperature and salinity were collected, and 2777 water samples were taken to determine salinity, oxygen, phosphate, nitrate and nitrite;
- Plankton sampling with bongo and Copenhagen nets near shore stations was conducted. During the cruise 99 plankton stations were surveyed; at 88 - Bongo net, at 38 - Neuston net, and at 15 - Copenhagen net sampling was performed;
- Food technology study involving preservation of fish to determine the storage life of fresh pollock which was kept in refrigerated sea water by organoleptic, chemical, microbiological testing. The purpose of the study was also to assess the health status of demersal and pelagic fishes, mainly Pacific cod, pollock and Pacific ocean perch (*Sebastes alutus*) and to examine the occurrence of parasites in fish muscle tissue;
- Collection of tissue samples from five species of rockfish for biochemical genetic analysis;
- Stomach samples of Pacific ocean perch and pollock were collected to investigate potential niche overlapping between these species by examining diet composition;
- Observation and evaluation of the Polish hydroacoustic techniques during working together with partners from Fisheries Research Institute of the University of Washington;
- A separate Polish project focused on (i) evaluation of fishing gear by studying the effect of light on the stregth of net material, and on (ii) fishing gear selection.

Fishing operations were carried daily to assess fish biomass of rockfish, genus *Sebastes* and Pacific hake (*Merluccius productus*) in the U.S. west coast, and walleye pollock in the Gulf of Alaska, thus fish species which were of main interest.

The resarch conducted by R/V PROFESOR SIEDLECKI was synchronized with studies performed by the U.S. R/V MILLER FREEMAN in the west coast of U.S. shelf and Canadian Vancouver area. Modern hydroacoustic system of R/V PROFESOR SIEDLECKI was produced by Norwegian company SIMRAD. An extremely interesting, four-day experiment was conducted during September 11-16, 1977. Hydrocoustic intercalibration survey off Cape Flattery with the U.S. R/V MILLER FREEMAN, Polish R/V PROFESOR SIEDLECKI and Canadian R/V G. B. REED involved the comparison and intercalibration of the results of hydroacoustic measurements between three research vessels (Anon, 1978b). All vessels were equipped with various acoustic systems and used different methods of signal processing. That experiment provided interesting research material, and turned out to be a successful attempt at joint international ventures on such a large scale. The measurement results of individual ships did not differ significantly (Orłowski, 1978). The hydroacoustic survey allowed also collection of extensive cartographic material, enriched with hydroacoustic bottom classification, all conducted according to the MIR→NMFRI patented method. Fish resource maps and an indicative map of seabed types were developed, and turned out to be useful in the case of bottom fishing.

Team of 24 American scientists and technicians, mainly from NWAFC/NMFS, one Canadian scientist, and 23 Polish scientists and technicians from MIR→NMFRI participated in research in three surveyed areas on board of R/V PROFESOR SIEDLECKI (Table 5.1). The cruise tasks which were to be carried out during the survey were discussed in detail before the cruise.

Table 5.1 Alphabetical list of scientists, technicians and students taking part in cruise on R/V SIEDLECKI in 1977 (source: based on documents available at MIR→NMFRI)

	Polish staff		American and Canadian staff	
	Surname and name	**Affiliation**	**Surname and name**	**Affiliation**
1	Anaszkiewicz Paweł	NMFRI	Bledsoe Samuel	NMFS, Seattle
2	Blady Wiesław	NMFRI	Carlson Tom	
3	Furtak Andrzej	NMFRI	Cefak Charles	
4	Gurbiel Ryszard	NMFRI	Clark Jay	
5	Jackowski Edward	NMFRI	Greager Jay	
6	Janusz Jerzy	NMFRI	Crumpton Bryan	
7	Kalinowski Andrzej	NMFRI	Funk Fritz	
8	Kochanowski Jerzy	NMFRI	Gazarek Suzyanne	
9	Kunicki Andrzej	NMFRI	Gronlund William	
10	Kurzyk Sławomir	NMFRI	Hunter Patrick	NMFS, Seattle
11	Maciejewski Joachim	NMFRI	Ingraham James	
12	Majewicz Andrzej	NMFRI	Ingraham Tim	
13	Netzel Jan	NMFRI	Kudo George	
14	Orlowski Andrzej	NMFRI	Love Cuthbert	
15	Pactwa Romuald	NMFRI	Marlowe Christopher	
16	Rakowski Kazimierz	NMFRI	McCrory Jan	
17	Romer Jerzy	NMFRI	McCain Bruce	
18	Sankiewicz Marek	NMFRI	Mesmer Karen	
19	Schwartz Jerzy	NMFRI	Myers Mark	
20	Stancel Wiesław	NMFRI	Roberts Glenn	
21	Szpiganowicz Bogusław	NMFRI	Somerton David	
22	Sztajnduchert Wojciech	NMFRI	Stone Frederick	NMFS, Seattle
23	Wocial Marek	NMFRI	Thorne Richard	
24			Wishard Lisa	
25			Sels J.	Pacific Biological Station, Nanaimo

Gulf of Alaska Survey conducted between Dixon Entrance and Portlock Bank lasted from 4 July to 2 August 1977 (Fig. 5.7). The main goal of the research was estimating of fish stocks in the Gulf of Alaska waters using echo integration trawl survey. The studies concentrated mainly on *Sebastes* sp., and Alaska pollock. On top of that, biological research was carried out to determine species composition as well as quantitative composition of ichthyofauna and the biological characteristics of the main fish species. During this part of the cruise, 3846 Nm hydroacoustic transects were crossed and 71 control hauls were done. Almost 73 tonnes of fish of various species were caught, of which most were pollock (34 tonnes), Arrowtooth flounder (*Atheresthes stomias*) (16 tonnes), and Pacific ocean perch (*Sebastes alutus*) (8 tonnes). In total, 8782 fish of various species were measured and 2973 fish were analysed in detail. Total biomass of fish in this area equalled 1805 thousand tonnes of which 925 thousnad tonnes were different species of flatfishes, 479 thousand tonnes pollock, 154 thousand tonnes of rockfishes, and 247 thousand tonnes other species.

The results are presented in elaborations by Orłowski (1977a, 1978) and Thorne and Carlson (1977). A visit of Polish vessel in port of Kodiak was extensively commented by the local press (Fig. 5.9).

THE KODIAK DAILY

Vol.37 No. 140 Wednesday, July 20, 1977

By Jerry D. Martini, staff photographer

In seas from pole to pole, research vessel gives Poles gypsy maritime laboratory

By BRUCE LITTLE
Daily Mirror Staff Writer

From Gdynia, Poland to Kodiak, Alaska is a far piece, but the research vessel Profesor Siedlecki has prowed through more remote — and icier — waters than those in the Gulf of Alaska.

Like Antarctic waters, for starters. The floating laboratory spent months earlier this year testing the oceans near the South Pole, studying marine biology, hydrology and hydro-acoustic technology.

IN FACT, Profesor Siedlecki may be nearing a long-distance record for oceanographic research. It left Poland near Christmas, sailing the North Sea and then crossing the Atlantic and dipping south along the east coast of South America. After its tests near Antarctica, the ship came north along the coasts of Argentina and Chile and called into Callao, Peru.

At Callao, many of the 30 scientists aboard flew home to Poland and were replaced by another group of scientists. They have come north, with stops in Los Angeles and Seattle, and have been testing the Gulf of Alaska for the last few days. After stopping in Kodiak Tuesday, the Profesor Siedlecki was to ship out today, perform more tests in the Gulf, then turn back and head to Seattle.

The vessel's purpose, according to Jan Netzel, the Polish professor of fisheries biology, who is the chief scientist aboard, is "assessment of fish stocks and resources" in the Gulf. The study, which is being conducted in cooperation with the Northwest and Alaska Fisheries Center in Seattle, is targeted mainly at pollock and rockfish.

POLAND HAS an allotment for pollock in the Gulf, Netzel said, and the tests will help determine the economic worth of harvesting that resource.

The hydrological studies will aid the Polish fishing industry in predicting fish migration patterns and species characteristics. Oceanographer Andrzej Majewicz explained that environmental tests are taken for salinity, temperature and other factors at various depths, and those tests are coordinated with the biologists' finding of fish.

The ship's equipment varies from chemical laboratories for analyzing bottom samples to trawling equipment for taking samples. It also has satellite navigation equipment, which Netzel proudly displays to visitors, and a computer system fed by over 3,000 ft. of wiring from around the 300-ft. vessel.

BOTH NETZEL and Majewicz speak fluent English, and many other scientists and crew members know a smattering of the language. Six Americans work aboard the vessel and two women — the captain's wife and the ship's doctor — are also aboard.

While the ship was moored at Kodiak, members went ashore to visit the third American port of their trip. Some brought back souvenirs of American life, such as a copy of Penthouse one scientist carried and a six-pack of Budweiser held by another.

The ship's name, appropriate for a research vessel, is taken from Michal Marian Siedlecki. According to an English-language brochure distributed by the crew, Siedlecki was an outstanding biologist who worked for the protection of whales, sturgeon and salmon-like fish and was chairman of the Gdynia Sea Fisheries Institute. He died in a Nazi concentration camp in 1940.

THE PROFESOR SIEDLECKI will continue its voyage until the end of the year. It is due back in Seattle Aug. 8, and beginning Aug. 13 will join in a scientist exchange program with the National Oceanic and Atmospheric Administration vessel Miller Freeman.

On Oct. 1, the Profesor Siedlecki will leave Seattle and pass through the Panama Canal on its return trip to Poland, its globe-trotting research nearing its end.

Fig. 5.9 A commemorative excerpt from the press in Alaska, devoted to the visit of R/V PROFESOR SIEDLECKI in the port of Kodiak; Dr. Jan Netzel – chief scientist (source: private archives of Andrzej Orłowski)

The United States West Coast shelf was the next stage of research, conducted from August 15 to September 2, 1977. The area was surveyed in parallel by the U.S. ship R/V MILLER FREEMAN. The area surveyed was closed between Point Arena and Cape Flattery, limited by isobath of 50 m from the land side and up to 1000 m from the open ocean (Fig. 5.7).

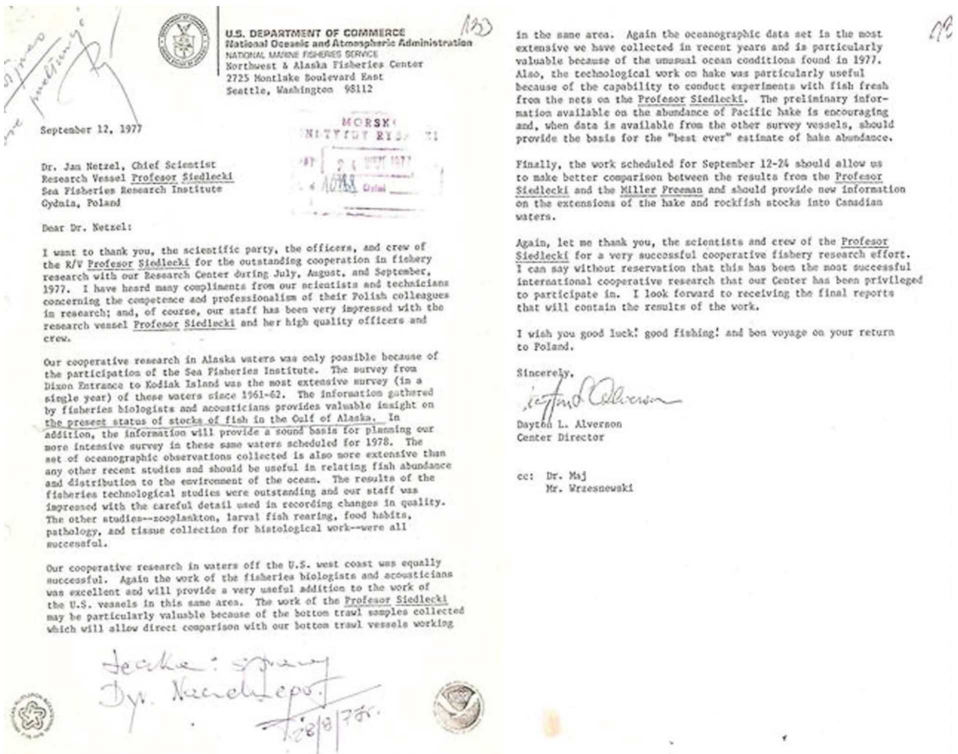
The same hydroacoustic equipment and methods were used as during the survey of the Gulf of Alaska. The grids of hydroacoustic transects were prepared by the American side, taking into account complementary research of the Polish and U.S. vessels (Anon., 1978b). The total number of miles of hydroacoustic transects was 2818, of which more than half represented full-fledged echo integration samples. Due to the scattering of fish at night, hydroacoustic data were collected mainly during the daytime. The night time was used to conduct oceanographic research.

Total biomass of fish in the West Coast area was estimated at 2.743 million tonnes, including hake stocks amounting to 1.015 million tonnes and redfishes reaching 512 thousand tonnes (Orłowski, 1977b). During the study of the U.S. West Coast shelf, 63 control hauls were performed (Fig. 5.10). The purpose of biological and fisheries research was to determine the species and quantity composition of ichthyofauna and biological features of the main fish species. The basic research species, as suggested by the American parties, were Pacific Ocean perch (*Sebastes alutus*) and Pacific hake (*Merluccius productus*). In total, 68 species of fish were identified during the cruise, 7271 fish were measured and of this number, 3976 were subjected to ichthyological analyzes. During controlled fishing, a total of over 124 tonnes of various species of fish were caught, including the largest hake - 39 tonnes, Pacific redfish - 11 tonnes, Pacific cod and turbot 7 tonnes each (Netzel and Love, 1977; Anon., 1978c).

Fig. 5.10 Results of catches are always surprising; the U.S. biologists examine the catch (source: private archives of A. Orłowski)

West Coast of Canada (Vancouver Island) hydroacoustic and biological-fishing survey were conducted from 8 to 22 September 1977, including hydrocoustic intercalibration during September 11-16. The hydroacoustic cross-sectional grid proposed by the Canadian side was implemented jointly by R/V PROFESOR SIEDLECKI and Canadian R/V G. B. REED. During this part of the cruise, data were collected on 552 Nm hydroacoustic transects. Fish stocks were estimated at 615 thousand tonnes, with the predominance of flatfishes, redfishes and black cod (*Anoplopoma fimbria*). Biological and fisheries data were also collected from 14 trawls (Anon, 1978c).

It should be emphasized that all three countries have conducted research on the resources of the huge Pacific coast region of the United States and Canada very efficiently and in a very good scientific and friendly atmosphere. This was due to all managers and research team members, with the very important organizational role of Dr. Dayton Lee Alverson, director of the Northwest and Alaska Fisheries Center. A summary of mutual cooperation is contained in the letter of Director D. L. Alverson to the chief scientist, Dr. Jan Netzel and the director of the Sea Fisheries Institute in Gdynia, Dr. Ryszard Maj (Fig. 5.11).



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest & Alaska Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112

September 12, 1977

Dr. Jan Netzel, Chief Scientist
Research Vessel Profesor Siedlecki
Sea Fisheries Research Institute
Gydnia, Poland

Dear Dr. Netzel:

I want to thank you, the scientific party, the officers, and crew of the R/V Profesor Siedlecki for the outstanding cooperation in fishery research with our Research Center during July, August, and September, 1977. I have heard many compliments from our scientists and technicians concerning the competence and professionalism of their Polish colleagues in research; and, of course, our staff has been very impressed with the research vessel Profesor Siedlecki and her high quality officers and crew.

Our cooperative research in Alaska waters was only possible because of the participation of the Sea Fisheries Institute. The survey from Dixon Entrance to Kodiak Island was the most extensive survey (in a single year) of these waters since 1961-62. The information gathered by fisheries biologists and acousticians provides valuable insight on the present status of stocks of fish in the Gulf of Alaska. In addition, the information will provide a sound basis for planning our more intensive survey in these same waters scheduled for 1978. The set of oceanographic observations collected is also more extensive than any other recent studies and should be useful in relating fish abundance and distribution to the environment of the ocean. The results of the fisheries technological studies were outstanding and our staff was impressed with the careful detail used in recording changes in quality. The other studies--zooplankton, larval fish rearing, food habits, pathology, and tissue collection for histological work--were all successful.

Our cooperative research in waters off the U.S. west coast was equally successful. Again the work of the fisheries biologists and acousticians was excellent and will provide a very useful addition to the work of the U.S. vessels in this same area. The work of the Profesor Siedlecki may be particularly valuable because of the bottom trawl samples collected which will allow direct comparison with our bottom trawl vessels working in the same area. Again the oceanographic data set is the most extensive we have collected in recent years and is particularly valuable because of the unusual ocean conditions found in 1977. Also, the technological work on hake was particularly useful because of the capability to conduct experiments with fish fresh from the nets on the Profesor Siedlecki. The preliminary information available on the abundance of Pacific hake is encouraging and, when data is available from the other survey vessels, should provide the basis for the "best ever" estimate of hake abundance.

Finally, the work scheduled for September 12-24 should allow us to make better comparison between the results from the Profesor Siedlecki and the Miller Freeman and should provide new information on the extensions of the hake and rockfish stocks into Canadian waters.

Again, let me thank you, the scientists and crew of the Profesor Siedlecki for a very successful cooperative fishery research effort. I can say without reservation that this has been the most successful international cooperative research that our Center has been privileged to participate in. I look forward to receiving the final reports that will contain the results of the work.

I wish you good luck! good fishing! and bon voyage on your return to Poland.

Sincerely,

Dayton L. Alverson
Center Director

cc: Dr. Maj
Mr. Wrzesnewski

Fig. 5.11 The letter of Director D. L. Alverson to the chief scientist, Dr. Jan Netzel and the director of the Sea Fisheries Institute in Gdynia, Dr. Ryszard Maj (source: archives of MIR→NMFRI)

Primary report from the cruise was prepared by the Sea Fisheries Institute in Gdynia (MIR→NMFRI) and the Northwest and Alaska Fisheries Center, (Ingraham and Netzel, 1977; Netzel and Love, 1977). More research detailed results, including hydrological and hydroacoustic/trawl studies, fishery biology, plankton, techniques and technologies of the fishing raw material were elaborated by the MIR→NMFRI (Anon, 1978c). On the basis of the materials collected during the cruise a few scientific papers have been published, also by the U.S. scientists (Gunderson and Nelson, 1977; Ingraham and Love, 1978; Dark et al., 1980; Gunderson and Lenarz, 1980; Wishard et al., 1980).

5.3.3. Polish fishing and research activity in the international waters of the Bering Sea (Donut Hole)

Due to the lack of pollock fishing quotas in the USA Exclusive Economic Zones, Poland began exploiting pollock resources in the international waters of the Bering Sea. The international waters of the Bering Sea (called Donut Hole) are located in the central part of the Bering Sea (Anon, 2018), between the U.S. and Russian EEZ, and statistically related to the Northwest Pacific (FAO Area 61) (Fig. 5.12; see Fig. 3.1 in Chapter 3). However, due to the fact that pollock stock occurring in this area spawns in the U.S. economic zone in FAO Area 67 near the Bogoslof Island (Bogoslof (518) area (Fig. 5.12), a description of fishing and research activities is presented in this chapter.

From 1985 to 1991, the exploitation of pollock resources in international waters of the Bering Sea was carried out by Polish fishing fleet; scientific cooperation between the MIR→NMFRI and the NMFS was continued as part of international scientific cooperation between coastal and fishing countries.

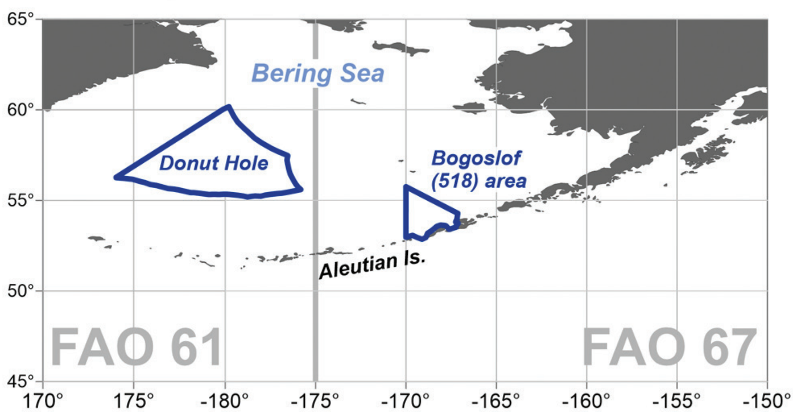


Fig. 5.12 The Bering Sea - international waters (Donut Hole) and the spawning area of pollock (Bogoslof Area- 518) (map drawn by T. Wodzinowski, NMFRI)

Fishing in the international waters of the Bering Sea was initiated by Japan and South Korea in 1984. In 1985, Poland and China joined pollock fishing in this area, and from 1987 also Russia. Catches increased sharply from 181 thousand tonnes in 1984 to 1.45 million tonnes in 1989, followed by a rapid decline to 294 thousand tonnes in 1991 and 10 thousand tonnes in 1992 (Fig. 5.13).

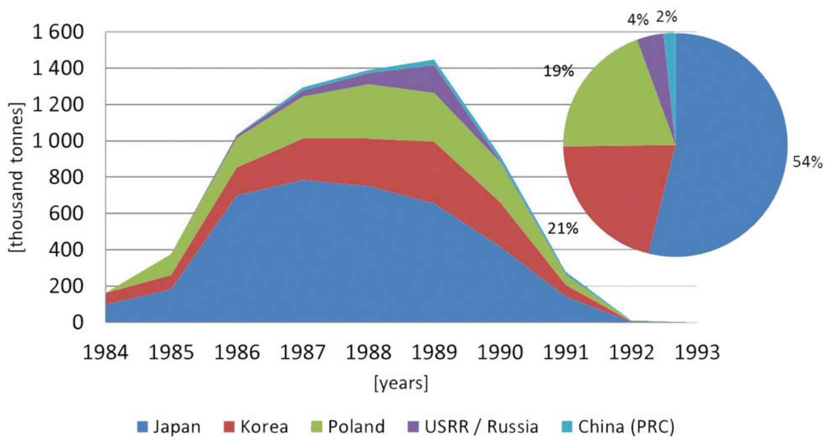


Fig. 5.13 Catches of pollock in the international waters of the Bering Sea (source of data https://archive.fisheries.noaa.gov/afsc/REFM/CBS/convention_documents.htm)

From the beginning of Polish pollock fisheries in international waters of the Bering Sea, the Sea Fisheries Institute in Gdynia (MIR→NMFRI) conducted extensive biological and fisheries observations by monitoring of pollock resources on board of commercial vessels. In 1985-1991, employees of MIR→NMFRI participated in 21 cruises on Polish commercial vessels. Observations included: catch, catch rates, species compositions, length and age composition, weight, sexual maturity, stomach contents and occasionally - meristic and morphometric features of pollock and occurrence of parasites. Research was also carried out on the size of pollock biomass, determining the parameters of rational exploitation of the stock, as well as the impact of fisheries on resources. The results of these studies were presented at working groups, scientific symposia and international conferences, and constituted Polish contribution to understanding the studies on biology and resources of pollock. The outcome was used in the discussions essential for establishing new rules for managing these resources. Scientists from the Northwest and Alaska Fisheries Center (Seattle) together with

MIR→NMFRI employees monitored catches and collected biological data on board Polish commercial vessels (Dawson, 1988; Janusz and Dawson, 1990).

Until 1992, the international waters of the Bering Sea were not subject to any regulations and fishing. Significant catches in this area during 1985-1991 aroused concern of the coastal states: the United States and Russia. International scientific symposia, presenting research on the biology and resources of pollock in the Bering Sea, as well as the hydrological conditions of this area were convened on the initiative of the USA. In the 1988-1990, four international scientific symposia took place: in Sitka - USA (1988), Anchorage - USA (1988), Shimizu - Japan (1989), and Khabarovsk - USSR (1990). These symposia were attended by Polish scientists, among others: Z. Karnicki, and J. Janusz, the fishery administration representatives: L. Łukasik, M. Kucharski, E. Budziński, J. Purchla, and representatives of fishing companies: J. Latanowicz, J. Sprus and others. At these meetings, the Polish side presented the results of Polish research based on the data collected during commercial cruises (Janusz et al., 1988; Jackowski and Trociński, 1988; Janusz, 1989; Trociński, 1989; Horbowy and Janusz, 1989; Kowalewska-Pahlke, 1990). Below, we wish to present the commemorative envelope from the first symposium in Sitka, with signatures of the heads of delegation (Fig. 5.14).

Fig. 5.14 International Scientific Symposium on the Bering Sea Fisheries; July 19-21, 1988, Sitka, Alaska USA; commemorative envelope with signatures of the delegation chairmen (source: archives of MIR→NMFRI)

Despite a number of studies and papers describing the biology and resources of pollock, it was not possible to obtain satisfactory results determining both the origin and resources of pollock from the Aleutian Basin stock, which includes international waters. In February 1991, at the initiative of the USA, an international Conference on the Conservation and Management of Living Resources of the Central Bering Sea was convened in Washington. In the resolution adopted, the governmental delegations of China, Japan, South Korea, Poland, Russia, and the USA agreed that, taking responsibility for the state of living resources, in accordance with the United Nations

Convention on the Law of the Sea, they consider the urgent need to introduce the conservation measures of living resources in this area. Due to drastic decline in pollock resources in the central part of the Bering Sea, the countries participating in the conference held in August 1992, adopted a joint resolution on voluntary, temporary suspension of fishing in international waters of the Bering Sea, and areas adjacent to those waters located in the economic zones of the coastal states. The voluntary moratorium, as agreed, entered into force at the beginning of 1993 and lasted till the proper convention, taking over the responsibilities related to the management of pollock resources, was established. During the years 1991-1994, in total ten International Conferences were held, which indicated complexity of the issue. Polish delegations of the fisheries administration, scientists (MIR→NMFRI) and industry representatives participated in all of them. At the 10th Conference in Washington, on February 11, 1994, the *Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea* (called Central Bering Sea Pollock Convention - CBSPC) (Anon., 1994) was agreed by representatives of the two coastal states (USA and Russian Federation) and four fishing nations (China, Japan, Republic of Korea, and Poland). The Convention was set up in order to protect the pollock stock in the international waters of the Bering Sea from over-exploitation. Since 1994, fishing for pollock in this area was subject to the decisions of the Conference of the Convention. Representatives of the Polish administration, science and fishing companies participated in all Conferences and later in the meetings of the CBSPC. It is difficult to name all the people participating in these meetings, but the name of Dr. Zbigniew Karnicki from MIR→NMFRI, who played very important role in Polish delegations for establishing the Bering Sea Convention, should be mentioned.

During the exploitation of pollock resources in international waters and later, when the moratorium and the provisions of the Convention were in force, intensive scientific research was conducted by coastal states and fishing countries, both in the waters of the Aleutian Basin and on the shelves. Number of scientific symposia and workshops took place before the Convention entered into force, as well as, after the Convention, regardless of the activities of the Scientific and Technical Committee of the Central Bering Sea Pollock Convention (Table 5.2). Two of the meetings were organized by MIR→NMFRI and took place in Gdynia (Poland). The aim of the workshops was to gather scientists from all countries fishing pollock in the Bering Sea and discuss all available data on pollock biology and population dynamics. Representatives of coastal states and fishing countries, including those from the USA and Poland, participated in all these scientific meetings.

Table 5.2 List of Meetings and Workshops regarding the study of pollock from the Central Bering Sea (source: based on documents available at MIR→NMFRI)

Year	Dates	Location	Description
1990	**September 10-14**	**Gdynia, Poland**	**Workshop on Aging Methodology of Walleye Pollock**
1991	February 4-8	Seattle, USA	Meeting of the Science Group on the Bering Sea Pollock Stock Assessment
1992	February 24-28	Seattle, USA	Bering Sea Pollock Assessment Workshop
1994	February 22-25	Seattle, USA	Meeting of the Science Group
1995	February 5-12	Seattle, USA	Meeting of the Science Group
1996	October 9-11	Seattle, USA	Meeting of the Science Group
1997	**September 3-5**	**Gdynia, Poland**	**Meeting of the Science Group**
1998	March 17-20	Seattle, USA	Second Workshop on Aging Methodology of Walleye Pollock
1998	September 2-4	Seattle, USA	Inter-session Meeting of the Scientific and Statistical Committee
1999	September 7-9	Yokohama, Japan	Workshop on Pollock Stock Structure and Identification
2000	July 17-21	Seattle, USA	Workshop on factors affecting recovery of Aleutian Basin Pollock stock
2003	May 19-21	Busan, Republic of Korea	Workshop on comprehensive surveys and review of significant scientific achievements
2005	June 6-9	Seattle, Washington, USA	Workshop on the Central Bering Sea Pollock Allowable Harvest Level and Stock Identification

The results of Polish research which focused mainly on pollock's biology were presented at these meetings (Anon, 1991; Janusz, 1990, 1991, 1996, 2001; Nishimura et al., 1998; Loh-Lee Low et al., 1999; Janusz and Trella, 1999). The research was further expanded to the assessment of pollock biomass in the Aleutian Basin based on cohort analysis which included Polish fisheries data (Horbowy and Janusz, 1990). The results of surveys from workshops and scientific meetings were forwarded to the Scientific and Technical Committee which prepared recommendations for the Annual Conferences of the CBSPC.

After 1992, when the moratorium was in force and fishing was stopped, estimation of pollock biomass was carried out by hydroacoustic methods in the pollock spawning area in the USA EEZ near Bogoslof Is. (Specific Area) (Fig. 5.12). In accordance with the requirements of the Convention only trial fishing in Donut Hole area were permitted. In total, in the years 1993-2007, Member States carried out 27 trial fishing, of which Poland's share, with 8 trips, was significant (Table 5.3). The results of Polish trial fishing were presented during Annual Conferences of the CBSPC (https://archive.fisheries.noaa.gov/afsc/REFM/CBS/Default.htm).

Table 5.3 Summary of Trial Fisheries on Pollock in the Central Bering Sea Donut Hole area in 1993-2007 (source: based on documents available at MIR→NMFRI)

Year	Dates	Nation	No. of vessels	Vessel Name	Vessel Days	No. hauls	Data Source (Annual Conference Report)	Pollock Catch (KG)	Catch Number
2008-19				No vessels participated					
2007		Korea	2	?	20	40	S&T, Appendix 3, 13th		2
2006	Jul 31-Aug 5	Korea	1	Oriental Angel (Keuk Dong Co)			12th	0.0	0
2006	Jul 31-Aug 8	Korea	1	Nambuk Ho (Nambuk Fish Co)			12th	0.0	0
2006	Jul 31-Aug 8	Korea	1	Joosung Ho (Hansung Enterprise Co)			12th	0.7	1
2003	Mar 12-26	Korea	2	Man Jeck No. 21, O Yang Ho - 2	27		9th	2.6	2
2003	Oct - Nov	Korea	1	O-Ryong 503	15		9th	0.0	2
2003	Nov 15-27	Russia	1	Pioner Nikolayeva	13		9th	1.6	1
2001	Nov 11-14	China	2	Ming Zhu, Kai Feng	8		7th	0.0	0
2001	Jun 7 - Jul 14	China	1	Kai Tuo	38		6th	*~24.0*	16
2000	Jan 12 - Feb 3	Korea	1	Oriental Discoverer	23		5th	0.0	0
2000	May 11-20	Korea	1	Oriental Angel	10		5th	0.0	0
2000	May 20 - Jun 28	China	1	Kai Chuang	40		5th	*~64.5*	43
1999	**Aug 17-30**	**Poland**	**1**	**Homar**	**14**	**10**	**5th**	**2.3**	**2**
1999	**Apr 29 - May 3**	**Poland**	**1**	**Acamar**	**5**	**5**	**4th**	**2.9**	**2**
1998	**Sep 3-8**	**Poland**	**1**	**Acamar**	**6**	**5**	**4th**	**3.3**	**2**
1997	**Oct 12-15**	**Poland**	**1**	**Acamar**	**4**	**3**	**STC, Sep. 1998**	**0.0**	**0**
1997	Aug 16-19	Russia	1	?	4		2nd	0.0	0
1997	Jun & Aug	China	2	?	8		2nd	*< 900.0*	*< 600*
1996	?	China	1	?	?		2nd	?	?
1996	**Sep 1-11**	**Poland**	**1**	**Acamar**	**11**	**11**	**2nd**	**244.2**	**184**
1995	**Oct 18 - Nov 12**	**Poland**	**1**	**Acamar**	**25**	**16**	**1st**	**40.3**	**31**
1995	**Oct 13 - Nov 10**	**Poland**	**1**	**Homar**	**29**	**6**		**15.6**	**12**
1993	**Jul 2 - Sep 4**	**Poland**	**1**	**Adm. Arciszewski**	**63**	**69**	**Bull. SFI. 2(138) 1996**	**627,500**	**570,454**
1993	Jun 6-14	Japan	1	?	9		unpub ms	?	?
1993	Jul 13-22	Japan	1	?	10		unpub ms	?	?
1993	Nov 12-17	Japan	1	?	6		unpub ms	?	?
1993	Dec 8-17	Japan	1	?	6		unpub ms	?	?

? indicates unknown

Italics indicate non-reported estimated numbers

Starting from 1988, the USA was conducting hydroacoustic surveys on the NOAA research vessel R/V MILLER FREEMAN in order to estimate spawning biomass of pollock in the Bogoslof area (Fig. 5.12). In some years Japanese research vessel R/V KAIYO MARU also participated in the studies. These studies were part of international cooperation in assessing the size of pollock resources in the Aleutian Basin. Scientists from the USA, China, Poland, Russia, Japan and South Korea participated in the cruises and investigation of the distribution and characteristics of spawning pollock population in the south-eastern Aleutian Basin near Bogoslof Island (Anon, 1997). These studies are currently the only indicator of the size of the Aleutian Basin pollock stock. In four cruises on the Japanese research vessel R/V KAIYO MARU the following scientists from the MIR→NMFRI participated: E. Jackowski in 1989, A. Paciorkowski in 1990 and 1993 (Sasaki, 1990), and J. Janusz in 1996 (Janusz, 1996; Fig. 5.15). In 1997, Dr. J. Janusz took part in the Echo Integration-Trawl Survey cruise on the U.S. ship R/V MILLER FREEMAN (Anon., 1997). In 2001, Dr. J. Janusz was invited to Alaska Fisheries Science Center (AFSC) in Seattle to take part in NOAA program for compiling catch and effort data on pollock fishing vessels in the Central Bering Sea in 1985-1992 (Janusz, 2001).

Fig. 5.15 International team of scientists from Japan, Poland, Russia and the U.S. on board Japanese R/V KAIYO MARU during Echo Integration-Trawl Survey of Southeastern Alutian Basin near Bogoslof Island, March 1996 (source: private archives of J. Janusz)

Starting from 2003, the acoustic trawl surveys were conducted every second year by the new NOAA R/V OSCAR DYSON during pollock spawning season (February-March) in the Specific Area. The last survey took place in 2018 and the biomass of spawning pollock was estimated at the level of about 663 thousand tonnes (McKelvey and Levine, 2018). The 2018 survey indicated a distinct increase in biomass of the spawning stock of pollock from 70 thousand tonnes in 2012 to 663 thousand tonnes in 2018. Annual Conference of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, hosted by the Russian Federation during Virtual Process (25 October-19 November

2019), decided setting the Allowable Harvest Level (AHL) at zero for the year 2020 because the minimum biomass level has not been reached in accordance with rules of the Convention (Anon., 2019). It is allowed to conduct only trial fishing on the same terms and conditions as in previous years, but none of the countries expressed a desire to conduct such fishing in 2020.

Till 2020, 24 meetings of the Scientific and Technical (S&T) Committee and Annual Conferences of the Parties to the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea were held on rotation among the Parties (Fig. 5.16). The Polish delegation took part in all the meetings of the Annual Conferences, and representatives of MIR→NMFRI participated in all the meetings of the Scientific and Technical Committee, except for one in 2003.

Fig. 5.16 Seventh Annual Conference of the CBSPC, September 16-19, 2002, Moscow, Russia (source: private archives of J. Janusz)

During the research period in the Donut Hole area and during scientific meetings many NMFS, (Seattle) and MIR→NMFRI scientist cooperated together. Among the many names from the U.S. there are: Dr. James W. Balsiger, Dr. Richard J. Marasco, Dr. Loh-Lee Low, Dr. Neal Williamson, Dr. Vidar G. Wespestad, Dr. Jimmie J. Traynor, Dr. William Karp, Mr. Pierre Dawson and many others. All scientists named here, as well as many others, are very warmly remembered in MIR→NMFRI.

5.4. Some other aspects of Polish – American cooperation

Very friendly Polish-American relations were established not only on the occasion of joint fisheries research carried out in the Northeast Pacific Ocean and port calls in Seattle, but also through contacts with American Polonia. These friendships gave rise to the idea of creating the Seattle-Gdynia Sister City Association (SGSCA). It should be emphasized that in the 15-member Polish initiative group of SGSCA, there were as many as 9 scientists of the MIR→NMFRI, including two former directors of the Institute (Dr. Z. Karnicki and Dr. D. Dutkiewicz). The number of members of the Association in Gdynia was constantly expanding and many other scientists of MIR→NMFRI got involved in this initiative, e.g. Dr. M. Pastuszak, who was elected a Secretary of the Association. Seattle and Gdynia formalized their friendship in April 1994 by signing a sister city agreement - Seattle-Gdynia Sister City Association (Figs. 5.17, 5.18); Gdynia became one of Seattle's twenty-one sister cities.

Fig. 5.17 Seattle, April 1994 - the conference room of the city Mayor - the moment of signing the sister city agreement Seattle-Gdynia Sister City Association by Mr. Norman B. Rice - Mayor of Seattle city and Mrs. Franciszka Cegielska - Mayor of Gdynia city; in the background - Mr. Michael Waske, president of the Seattle-Gdynia Association (left), and the moment of giving a present to Major of Gdynia, Franciszka Cegielska; it was a large painting showing the city of Seattle (right) (source: private archives of M. Pastuszak)

Fig. 5.18 Seattle airport in April 1994; Polish delegation ready for departure after signing the sister city agreement Seattle-Gdynia Sister City Association; first row from the left -– Mr. Piotr Milewski - Gdynia City Council, Mrs. Franciszka Cegielska – Mayor of Gdynia city, Dr. Maciej Brzeski - deputy Mayor of Gdynia city (earlier employee of the MIR→NMFRI), Mr. Wojciech Szczurek - current Mayor of Gdynia city; second row from the left - Dr. Marianna Pastuszak (MIR→NMFRI) with an Indian hat on - a gift from the Seattle City Council - a Secretary of the Seattle-Gdynia Association (in Gdynia), Michael Waske -president of the Seattle-Gdynia Association (in Seattle) (source: private archives of M. Pastuszak)

A sister city, county, or state relationship is a broad-based, long-term partnership between two communities in two countries. A relationship is officially recognized after the highest elected or appointed official from both communities sign off on an agreement to become sister cities. A city may have any number of sister cities, with community involvement ranging from a half dozen to hundreds of volunteers. In addition to volunteers, sister city organizations can include representatives from nonprofits, municipal governments, the private sector, and other civic organizations. Each sister city organization is independent and pursues the activities and thematic areas that are important to them and their community including municipal, business, trade, educational, and cultural exchanges and projects with their sister city (https://sistercities.org/about-us/what-is-a-sister-city-3/).

SGSCA is an organization, staffed entirely by volunteers who are committed to sharing and promoting business, cultural and academic exchanges between the two cities. Over the years SGSCA:

- Produced 27 Seattle Polish Film Festivals,
- Hosted 70+ Polish students who attended the Washington Business Week summer program,
- Sent Company Advisors from Seattle to lead students at Gdynia Business Week,
- Led Trade, Civic & Seattle business delegations to Poland,
- Sent computers, books, clothing, toys to orphanage in Gdynia,
- Hosted Gdynia Port Directors & Gdynia Police Chief and staff for consultations with Seattle city officials,
- Provided funds to help build Gdynia's City & Maritime Museums,
- Established Gdynia Business Week (https://www.seattlegdynia.org/).

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6

POLISH-AMERICAN FISHERIES RESEARCH - ATLANTIC ANTARCTIC (SOUTHERN OCEAN)

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Ireneusz Wójcik, Emil Kuzebski, Jerzy Janusz

6.1. Study area - general overview

The Southern Ocean surrounds Antarctica and represents about 15% of the world's ocean area. It extends from the coast of the continent north to the Antarctic Convergence. The Antarctic Convergence is a physically and biologically distinct frontal zone where the cold, northward-flowing Antarctic water encounters, and flows under the warmer and more saline sub-Antarctic water of the Atlantic, Indian and Pacific Oceans. The Southern Ocean is characterized by an eastward-flowing Antarctic Circumpolar Current and a series of clockwise-rotating gyres that contribute to a westward-flowing East Wind Drift along the Antarctic coast (Hoffman, 1985; Orsi et al., 1995, 1999; Smith et al., 1999; Rintoul et al., 2001; Mingshun et al., 2013). The Southern Ocean has three distinct ecological zones: an ice-free zone to the north; an extensive seasonal pack-ice zone between about 55-60°S and 70–75°S; and a permanent pack-ice zone adjacent to the continent. Associated zones of mixing and upwelling create high biological productivity, especially of Antarctic krill (*Euphausia superba*). The convergence separates two hydrological regions with distinctive marine life and climate. The position of the Antarctic Convergence varies seasonally and geographically, but is generally located near 50°S in the Atlantic and Indian sectors of the Southern Ocean and near 60°S in the Pacific sector (Witek et al., 1982). For statistical purposes the Southern Ocean is divided into: Area 48 (Antarctic Atlantic), between 70°W and 30°E; Area 58 (Antarctic Indian Ocean), between 30°E and 150°E; and Area 88 (Antarctic Pacific) between 150°E and 70°W (FAO, 2011; Fig. 6.1). Polish studies were conducted mainly in Area 48 (Fig. 6.1; Kalinowski, 1978; Wensierski and Woźniak, 1978; Kalinowski and Kuptel, 1979; Kalinowski and Witek, 1980, 1985; Kittel and Rakusa-Suszczewski, 1988; Witek et al., 1981; 1982, 1988; Godlewska and Klusek, 1991) and this Chapter focuses on this region.

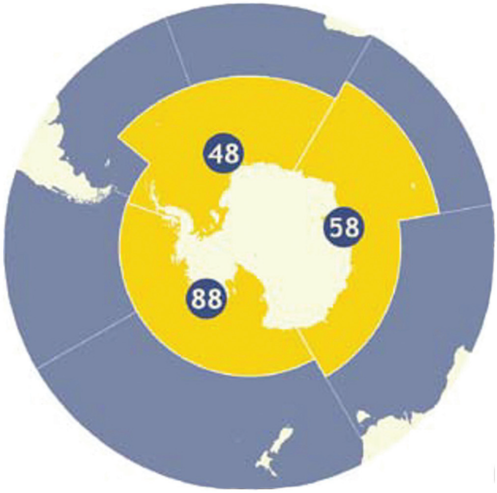

Fig. 6.1 The Southern Ocean (FAO Areas 48, 58, 88) [source: FAO, 2011; retrieved on 17 March 2020; this work is made available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo)]

6.2. Fisheries in the Antarctic Atlantic (Southern Ocean)

Antarctic krill (*Euphausia superba*) is a keystone circumpolar species of the Southern Ocean (Kalinowski J., 1978; Kalinowski and Kuptel, 1979; Kalinowski and Witek, 1980; Witek et al., 1981, 1982, 1988; Kittel and Rakusa-Suszczewski, 1988; Loeb et al., 1993). It is abundant in the seasonal pack-ice zone, where it provides the staple food for many species of whales, seals, penguins and other seabirds as well as fish that inhabit the region. This is especially true in the Antarctic Atlantic region, and this is the area where commercial krill fishing is focused. *Euphausia superba* is also dominant in Area 58, while another species *Euphausia crystallorophias* is abundant in Area 88, but these populations are not currently fished. The marine living resources of the Southern Ocean have been harvested since 1790, when sealers first hunted fur seals for their pelts. By 1825, hunting has led some fur seal populations almost to extinction. Sealers then began hunting elephant seals and some species of penguins for their oil. Whaling in Areas 48, 58 and 88 began in 1904, and all seven species of whales found in the Southern Ocean were extensively exploited. Large-scale fishing did not begin until the late 1960s. Important species fished included lanternfish (*Myctophidae*), mackerel icefish (*Champsocephalus gunnari*), marbled rockcod (*Notothenia rossii*) and Patagonian rockcod (*Patagonotothen guntheri*). By the late 1970s, certain species of finfish had been severely overfished in some regions. The management of marine living resources in the Southern Ocean is the mandate of several international organizations. The International Whaling Commission (IWC), established in 1946, is responsible for management and conservation of whales. The Convention for the Conservation of Antarctic Seals, ratified in 1978, reports to the Scientific Committee on Antarctic Research, which undertakes the tasks set out in the convention. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), established in 1982, is responsible for the conservation of marine species including seabirds and the management of fisheries in the Southern Ocean. It intentionally has a broad mandate that encompasses all ecological aspects of the area for which it has competence. Under this mandate, the CCAMLR pioneered the implementation of the precautionary principle and the ecosystem-based approach to fisheries management. The CCAMLR meets annually and the extensive reports of its Scientific Committee and those of the Commission are available on its Website (www.ccamlr.org) (FAO, 2011).

The krill fishery is the dominant fishery in the Antarctic Atlantic (Area 48; Fig. 6.1). In the early and late 1980s, its catches reached 374 000 tonnes (in 1982) and 400 000 tonnes (in 1987) (Fig. 6.2).

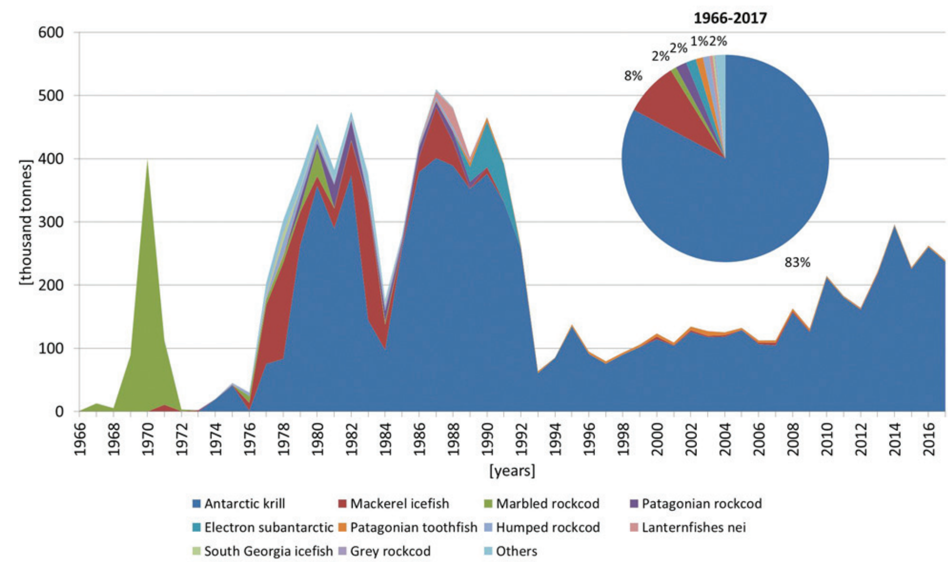

Fig. 6.2 Annual nominal catches of top 10 species in the Antarctic Atlantic (FAO Area 48) in 1966-2017 (source of data: FAO, 2019)

These large catches were made prior to the breakup of the then Soviet Union and the disbanding of the Soviet fishing fleet. Krill catches have been between 100 000 tonnes and 150 000 tonnes in 1999-2008, and then increased nearly to 300 000 tonnes in 2014 (Fig. 6.2). The lower catches in 1999-2008 reflect a decrease in fishing effort rather than overfishing. The fishery has operated predominantly in Area 48, around the South Shetland Islands (Subarea 48.1) and South Orkney Islands (Subarea 48.2). It generally occurs in those subareas in summer when pack-ice is at its minimum extent and adjacent to South Georgia (Subarea 48.3) in winter. In 2008-09, 126 000 tonnes of krill was reported from Subareas 48.1, 48.2 and 48.3 (see sub-chapter 6.3.). In 2009-2010, 211 984 tonnes of krill was harvested from the same subareas. As a result, the krill fishery in Subarea 48.1 was closed following the highest recorded catch. This was the first time that a subarea had been closed because catches had reached the threshold amount (155 000 tonnes). Intentions to catch 410 000 tonnes in 2010-11 had been indicated by the main fleets in this fishery, i.e. from Norway and the Republic of Korea (Fig. 6.3) (FAO, 2011).

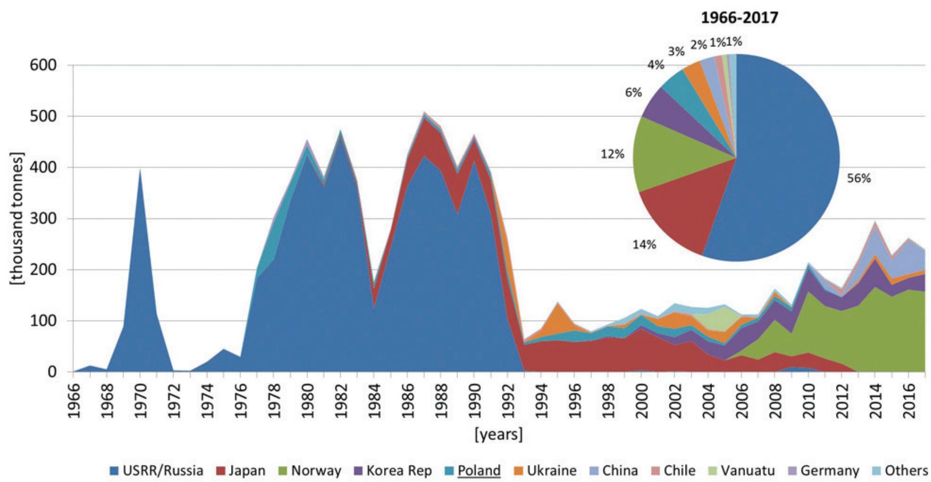

Fig. 6.3 Annual nominal catches in the Antarctic Atlantic (FAO Area 48) in 1966-2017 by top 10 countries (source of data: FAO, 2019)

A change in the fishing pattern for krill had been observed over the last two decades, with the catches coming mostly from Subarea 48.2 in 2008-09 and from around Bransfield Strait in Subarea 48.1 in 2009-10. It is worth mentioning the fishery targeting rockcods (*Nototheniidae*) in Subarea 48.1 in the decade starting in 1966, with the highest catches at the level of almost 400 000 tonnes in 1970. The CCAMLR implemented long-term prohibitions on the directed fishing on rockcods and other finfish species in Subarea 48.1 and 48.2, and on Marbled rockcod in Subarea 48.3 between 1984 and 1986. The results of repeated scientific surveys to investigate recovery from this intense period of fishing have been inconclusive (Kock et al., 2004; Gregory et al., 2014; FAO, 2011). The collapse of the Marbled rockcod fishery was followed by the expansion of a fishery for Mackerel icefish (*Champsocephalus gunnari*), which peaked at about 190 000 tonnes in 1983. This fishery also was soon depleted by a combination of regional overfishing and highly variable annual recruitment. The icefish fishery is now managed by the CCAMLR, and fishing is permitted in Subarea 48.3 at a relatively low level - just less than 2000 tonnes in 2009. Landings in 2009 were dominated by krill (95.7%), followed by Patagonian toothfish (*Dissostichus eleginoides*) (2.6%). The toothfish catch represented 59.5% of non-krill landings, followed by Mackerel icefish (*Champsocephalus gunnari*) (31.4 % of non-krill landings) (Fig. 6.4). Of these, Patagonian toothfish is the most valuable species. It is the dominant toothfish species in Subarea 48.3. Antarctic toothfish (*Dissostichus mawsoni*) dominates the catch in the Subareas 48.4 and 48.6. The increased landings of krill have attracted considerable international attention because of the important role of krill as a prey species in regional ecosystems (FAO, 2011).

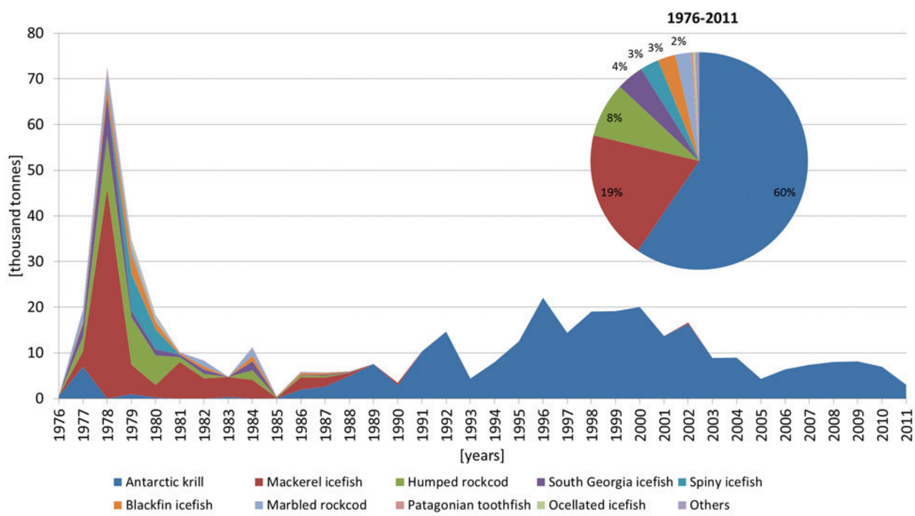

Fig. 6.4 Polish catches of main species in the Antarctic Atlantic (FAO Area 48) in 1976-2011 (source of data: FAO, 2019).

Poland started experimental commercial catches in the Antarctic Atlantic area a year after the first Polish scientific Antarctic expedition which took place in 1975/1976. The catches were primarily aimed at krill; however, possibilities of exploitation of other species like Mackerel icefish, Humped rockcod, South Georgia icefish or Marbled rockcod were also tested. In 1977, Polish fishing fleet caught 19 500 tonnes of fish including 7 000 tonnes of krill. The next year Polish catches peaked to 72 600 tonnes of which 46 000 tonnes constituted Mackerel icefish. Subsequently, as a consequence of excessive exploitation of non-krill species catches declined and since 1989 until 2011 (when Poland stopped fishing in FAO 48 area) were directed at krill exclusively (Fig. 6.4).

The USA fishing fleet was moderately engaged in the Antarctic Atlantic region. Cumulative catches of this fleet in the 1986-2006 period amounted to 35 000 tonnes (12 200 tonnes in 2002 - a peak year) including 34 700 tonnes of krill (FAO, 2011).

6.3. Polish contribution to fisheries research in the Antarctic Atlantic - historical overview

Polish fishing exploitation of Antarctic resources was preceded by literature studies and two short MIR→NMFRI expeditions on board R/V PROFESOR SIEDLECKI in the area from the Falkland Islands to the Drake Strait in the season of 1973/1974, and on the shelf of the Kerguelen Islands in April 1975. The purpose of these expeditions was to identify fishery resources and to carry out oceanographic and fisheries research, which allowed for proper preparation and organization of Antarctic expeditions. In 1975, the MIR→NMFRI (Świnoujście Branch) organised scientific seminar on Antarctic krill resources (*"Antarctic krill and its exploitation - informational materials"*) which gathered about 100 scientific and economic representatives (Garbacik-Wesołowska, 1975). The conclusions of this meeting contributed to the organization of scientific research expeditions to Antarctic waters.

The first Antarctic Expedition was organized by the MIR→NMFRI and the Institute of Ecology of the Polish Academy of Sciences (Polish: Polska Akademia Nauk - PAN) in the season of 1975/1976 (Dec. 22, 1975 to July 1, 1976). The research was conducted by the MIR→NMFRI on board R/V PROFESOR SIEDLECKI and also on board the commercial vessel M/T TAZAR from the Deep Sea Fishing Company "ODRA" in Świnoujście. During the Expedition comprehensive studies of the marine environment and fishing resources were carried out (Anon., 1976).

During the years 1975-1989 ten Antarctic Expeditions were organized by the MIR→NMFRI in which R/V PROFESOR SIEDLECKI completed 9 cruises, whereas 2 cruises were made by another MIR→NMFRI research vessel R/V PROFESOR BOGUCKI (Sosiński et al., 2004). The basic area of research was the Atlantic part of Antarctica, but during some expeditions survey was also carried out in the Antarctic Indian Ocean sector. During the Third Expedition in the 1977/1978 season, R/V PROFESOR BOGUCKI and chartered fishing vessel M/T SAGITTA sailed around Antarctica colecting the fishery and biological data. An important element, during the first expeditions, was the identification of resources in terms of the possibility of their commercial exploitation. Apart from that, chartered commercial fishing vessels supported the survey during the Third and the Fourth Expeditions. The MIR→NMFRI research vessels and those chartered by the MIR→NMFRI searched for concentrations of fish and krill in broad area of Antarctic waters. Observations covered physical and chemical characteristics of water, distribution of fish species and krill, catch, catch rates, species compositions of catches, biology of main fish species (length and age composition, weight, sexual maturity, stomach contents). Very important surveys goals covered estimation the biomass by the swept area and hydroacoustic methods, distribution of important commercial fish and krill, fishing techniques, as well as krill processing technology and its mechanization.

Polish Academy of Sciences (PAN) was co-organizer of some MIR→NMFRI expeditions. As many as 14 of Polish scientific centres participated in fishing surveys in the Antarctic waters on board the MIR→NMFRI research vessels, and among those there should be mentioned: the Institute of Ecology of Polish Academy of Sciences (Warsaw), Academy of Agriculture (Szczecin), Universities of Warsaw, Gdańsk and Łódź, Maritime School (Szczecin), Medical Academy (Gdańsk). The MIR→NMFRI maintained particularly close contacts with the Academy of Agriculture in Szczecin and the University of Gdańsk, to which some data and materials collected during the surveys were provided for elaboration and then publication, as well as for educational purposes. In 1975, during a joint scientific expedition with the Institute of Ecology of Polish Academy of Sciences (PAN) led by Prof. D. Dutkiewicz (MIR→NMFRI) and Prof. S. Rakusa-Suszczewski (PAN), scientists from the MIR→NMFRI participated in the organization of the **Polish Antarctic Station of the Polish Academy of Sciences** on King George Island **named after Henryk Arctowski**. Personnel from the MIR→NMFRI was also temporarily employed by the PAN during expeditions to the Arctowski Station and in research programs such as FIBEX and SIBEX within the scope of the BIOMASS (Biological Investigations of Marine Antarctic System and Stocks) program (e.g. Kalinowski, 1982; Błachowiak-Samołyk and Żmijewska, 1995).

During 10 Antarctic Expeditions organized by the MIR→NMFRI, as many as 175 scientists and technicians from the MIR→NMFRI and other scientific institutions took part in surveys on board the research and chartered vessels. It should be mentioned that MIR→NMFRI scientists also participated in research programs of the Polish Academy of Sciences. Short information on the cruises of R/V PROFESOR SIEDLECKI and R/V PROFESOR BOGUCKI during 10 Antarctic Expeditions and the names of scientists and technicians participating in the survey are presented in the study: *Przegląd biologicznych badań rybackich zasobów Antarktyki prowadzonych przez Morski Instytut Rybacki w Gdyni (Review of biological research of Antarctic fisheries resources conducted by the Sea Fisheries Institute in Gdynia)* (Sosiński et al., 2004).

The second area of activity of the MIR→NMFRI was the biological and fisheries monitoring of exploited resources on board of commercial fishing vessels. In order to fulfill this task, the MIR→NMFRI would sent research teams, usually two persons, to the vessels fishing in this area for collecting the fishery and biological data. In the years 1977-2002, 34 scienists and technicians of the MIR→NMFRI participated in 22 cruises of Polish commercial vessels fishing in the Atlantic sector of Antarcic. The main area of Polish surveys and monitoring of catches in the Antarctic was the Atlantic sector (FAO Area 48) - Fig. 6.5.

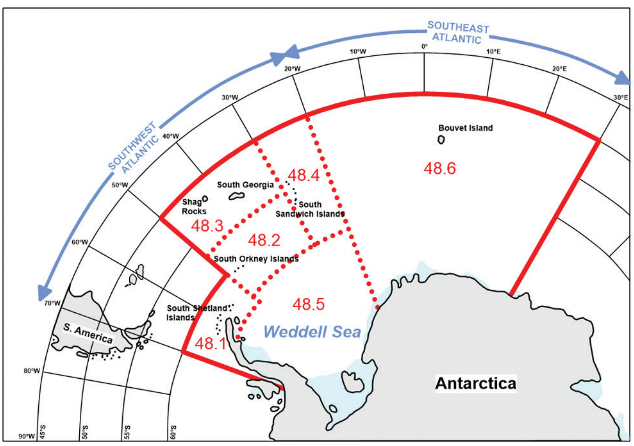

Fig. 6.5 The main areas of Polish surveys and monitoring in the Antarctic Atlantic (Area 48) Subareas: 48.1 Antarctic Peninsula; 48.2 South Orkneys; 48.3 South Georgia; 48.4 South Sandwich Islands; 48.5 Weddell Sea; 48.6 Bouvet (source: map drawn by T. Wodzinowski, NMFRI)

The cooperation of the MIR→NMFRI with foreign scientific centers dates back to 1964/1965, when Dr. S. Woźniak (MIR→NMFRI) took part in the survey on board of the USSR research vessel R/V AKADEMIK KNIPOWICZ on Antarctic waters and collected various valuable materials which were useful later on while organizing Polish expeditions to Antarctica. As part of international scientific cooperation, the MIR→NMFRI scientists participated in surveys on foreign research vessels. Such cooperation was conducted with Great Britain, the United States, the USSR, India, and Italy. Two joint Polish-USA surveys in the Antarctic waters (Atlantic sector) were carried out on board of R/V PROFESOR SIEDLECKI with a team of the U.S. researchers. Most valuable was the cooperation with the Imperial College that was responsible for organizing of British Antarctic Surveys on board of British vessels, and in 5 such surveys Polish scientists took part. The results of joint studies were used to assess the stocks of commercial fish in the area of South Georgia. Several joint scientific papers were published and this cooperation was highly appreciated by the parties. The Imperial College particularly highly rated contribution to the research of Dr. Wiesław Ślósarczyk (MIR→NMFRI). An expression of this recognition was the establishment of a scholarship by the Imperial College for the period of 10 years after sudden death of Dr. Ślósarczyk, a very promising young scientist. Scientists of MIR→NMFRI (Dr. Z. Witek, Dr. T. Linkowski, Dr. W. Ślósarczyk) participated also in scientific internships (academic training) related to Antarctic research.

The results of studies carried out in the Antarctic Atlantic were presented at meetings of working groups, scientific symposia and international conferences related to Antarctic resources. The MIR→NMFRI scientists also participated in work of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); they joined Polish official delegations as advisors, and also represented governmental agencies. Materials collected during the surveys were used by the MIR→NMFRI scientists in over 255 scientific and technical publications, as well as in popular science articles presenting the results of Anarctic surveys. The articles were published in: Bull. Sea Fish. Inst. Gdynia, Pol. Arch. Hydrobiol., Pol. Polar Res., J. Fish. Biol., Pol. Arch. Biol., Acta Ichthyol. Piscat., Oceanol., CCAMLR Science, CCAMLR Doc., ICES C.M. Doc. and many others, as well as in the proceedings of International Ichthyology Congresses and Polar Symposiums. It is difficult to list all of the autors but those most active were: Dr. J. Kalinowski, Dr. A. Kompowski, Dr. J. Sosiński, Dr. W. Ślósarczyk, Dr. Z. Witek. The list of these publications is presented in Sosiński et al. (2004).

Exploration of Antarctic waters, scientific research and monitoring of the resources were possible thanks to modern research vessels of MIR→NMFRI R/V PROFESOR SIEDLECKI and R/V PROFESOR BOGUCKI, very good cooperation with the Polish deep-sea fishing companies: DALMOR, ODRA and GRYF, and support of these activities by Polish government as well as fisheries administration.

6.4. Polish - USA research in the Antarctic Atlantic

Agreements on cooperation in Antarctic Research between the Sea Fisheries Institute (MIR→NMFRI) in Gdynia and the Northeast Fisheries Center (NEFC), the National Marine Fisheries Service (NMFS) Narragansett, the Oceanic and Atmospheric Administration (NOAA) USA, were signed in September 1986 and in 1987. The Agreements on cooperation in Antarctic between the MIR→NMFRI and the NMFS, Narragansett concerned, *inter alia*, the chartering of research vessel for work in Antarctic waters for four to six months per year. R/V PROFESOR SIEDLECKI was selected, and the extensive experience of the MIR→NMFRI staff in research in Antarctic waters was a decisive factor. The main goal was to implement the U.S. Antarctic Marine Living Resources (AMLR) research program, ensuring that the U.S. conducts its own policy with respect to problems of international fisheries exploitation and conservation of marine living resources in Southern Ocean.

The first joint MIR→NMFRI - NMFS (Narragansett) investigations were carried out on board R/V PROFESOR SIEDLECKI in 1986/1987 season (Mucha, 1989; Sosiński, 1987). The cruise lasted from September 16, 1986 to April 1, 1987 and the survey in Antarctic waters covered the period from November 11, 1986 to February 19, 1987. During the survey, many programs were implemented, both by the MIR→NMFRI and the U.S. scientific teams, but also by the Polish Academy of Sciences. Apart from the U.S. team, there participated also scientists from the Consejo Superior de Investigationes Cientificos (CSIC) (Spain), the British Antarctic Survey (Great Britain), and the Swedish Museum of Natural History (Sweden). Programs were implemented by 26 scientists from Poland (11 from the MIR→NMFRI and 15 from PAN), 22 from the USA, 3 from Spain, 1 from UK, and 1 from Sweden. A total of 53 scientists took part in the survey (Table 6.1). Scientific leader of the Expedition in first part of the cruise was Dr. Stanisław Rakusa-Suszczewski (PAN) and in the second part Dr. Józef Sosiński (MIR→NMFRI). The U.S. team was headed by Mrs. Wendy Gabriel. The master of the vessel was Captain Zbigniew Ossowski.

Table 6.1 Alphabetical list of scientists and technicians taking part in the cruise on R/V SIEDLECKI in season 1986/1987 (source: based on documents available at NMFRI)

	Polish staff		American staff [x/]	
	Surname and name	Affiliation	Surname and name	Affiliation
1	Długosz Roman	NMFRI	Agusti Julia	Instituto de Ciencias del Mar, Spain
2	Grelowski Alfred	NMFRI	Ballester Toni	Instituto de Ciencias del Mar, Spain
3	Groza Kazimierz	PAN	Bengtson John	NMML, Seattle
4	Kalinowski Janusz	NMFRI	Bollens Steve	University of Washington
5	Kittel Wojciech	PAN	Brennan James	MLML [x/]
6	Klusek Zygmunt	PAN	Chad Walter	Smithsonian Institution
7	Kreft Krzysztof	NMFRI	Chapman Robert	The Johns Hopkins University
8	Kunicki Andrzej	NMFRI	Coggan Roger	Bluntisham Hantingdon, Cambridge, U.K.
9	Kustusz Florian	NMFRI	Ferm Lisa	NMML, Seattle
10	Ligowski Ryszard	PAN	Finan Jerry	
11	Lipski Maciej	PAN	Gabriel Wendy	NMFS, Woods Hole
12	Łukowski Aleksy	PAN	Goebel Michael	NMML, Seattle
13	Matuszak Tadeusz	NMFRI	Green Jack	NMFS, Narragansett
14	Ochocki Stanisław	NMFRI	Gutherz Elmer	NMFS, Pascagoula
15	Ociepka Emil	NMFRI	Harkonen Tero	Tjärmö Marine Biological Laboratory, Sweden
16	Rakusa-Suszczewski Stanisław	PAN	Hill Kevin	University of Hawaii
17	Simm Andrzej	NMFRI	Loeb Valerie	MLML [x/]
18	Skóra Krzysztof	UG	Macaulay Michael	University of Washington
19	Sosiński Józef	NMFRI	Merrick Richard	NMML, Seattle
20	Stolarz Włodzimierz	NMFRI	Morrison Patricia	University of Washington
21	Szeliga Jan	UG	Rovira Joan	Spain
22	Wojewódzki Tadeusz	NMFRI	Schaner Everett	
23	Zaucha Janusz	NMFRI	Shufort David	Point Reyes Bird Observatory
24	Zdanowski Marek	PAN	Spear Lavrence	Point Reyes Bird Observatory
25	Zdzitowiecki Krzysztof	PAN	Stone Gregory	College of the Atlantic
26	Zieliński Krzysztof	PAN	Weber Larry	Texas A&M University
27			Wormuth John	Texas A&M University

[x/] - NMML - National Marine Mammal Laboratory; MLML – Moss Landing Marine Lab;

The survey was divided into four stages of research and the cruise's calendar was as follows:

16.09.1986 - departure from the port in Gdynia, Poland
23.09.1986 - vessel called to port in Vigo, Spain to take on board the team of three Spanish scientists
14.10.1986 - call at Montevideo, Uruguay (refueling, provision)

17.10 - 23.11.1986 - I stage of research

18.11.1986 - call at Arctowski Station (PL) on King George I. to disembark the PAN team

23.11.1986 - call at Punta Arenas, Chile, embarkation of the first U.S. team

25.11 - 25.12.1986 - II stage of research

17.12.1986 - call at Grytviken (South Georgia) to disembark UK scientist

26.12.1986 - call at Punta Arenas, exchange of the U.S. teams

29.12.1986 - 23.01.1987 - III stage of research

01.01.1987 - Admiralty Bay, embarkation of PAN team from Arctowski Station (PL)

24.01.1987 - call at Punta Arenas, exchange of the U.S. teams, disembarkation of PAN team

26.01. - 21.02.1987 - IV stage of research

(Two U.S. scientists were disembarked for two weeks on the Seal Island to observe penguins and seals)

06.02.1987 - call at Anvers Island to visit Palmer Station (U.S.)

22.02.1987 - call at Punta Arenas, disembarkation of the U.S. team

23.02.1987 - departure for the return trip to Poland

01.04.1987 - call at Gdynia, Poland

During the cruise three main tasks were carried out:

1. BIOMASS III (Biological Investigations of Marine Antarctic System and Stocks) which was lead by Institute of Ecology, Polish Academy of Science and included:
   - Examination of selected processes taking place in the water column;
   - Investigation of Antarctic Ecosystem functioning.
2. AMLR (Antarctic Marine Living Resources) lead by NMFS (Narragansett) and carried out in cooperation with the MIR→NMFRI (Gdynia) covered the following topics:
   - Monitoring and assessment of fish stocks,
   - Hydroacoustic assessment of krill stocks,
   - Monitoring of phyto-, zoo-, and ichthyoplakton,
   - Estimation of resources of bird and mammals.
3. Biological and fishery reconnaissance - lead by the MIR→NMFRI and that covered:
   - Searching for fish and krill on new fishing grounds,
   - Fish reconnaissance on traditional fishing grounds,
   - Monitoring of commercial catches of fish and krill.

Investigations were carried out in vicinity of South Georgia, Shag Rocks, Elephant I., King George I., and Joinville I. (Fig. 6.6). Results of biological investigations are presented in publication by Sosiński and Skóra (1988).

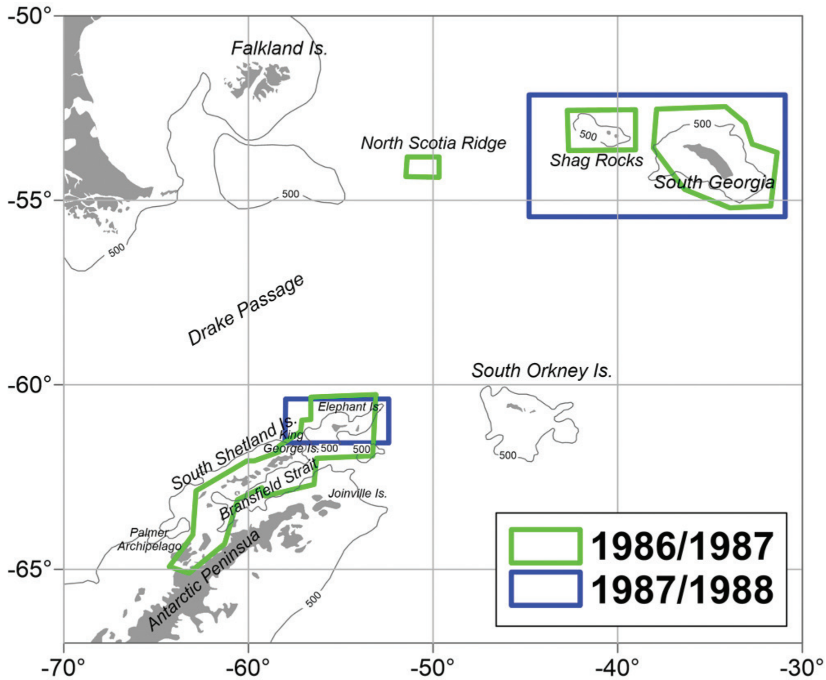

Fig. 6.6 The area of R/V PROFESOR SIEDLECKI surveys during the U.S.-Polish investigations in Antarctic Atlantic waters in seasons 1986/1987 and 1987/1988 (map drawn by T. Wodzinowski, NMFRI)

In the first part of the U.S. AMLR program i.e. monitoring and assessment of fish stocks studies were jointly carried out by the U.S. and the MIR→NMFRI teams, and the data and materials collected were available to both sides. In the second part of the program, related to hydroacoustic assessment of krill stocks, the studies were carried out separately by the U.S. and the MIR→NMFRI team, by two different methods. The results were available to both sides for comparison. In other U.S. programs the MIR→NMFRI provided technical assistance.

During the survey, the listed below tasks of the U.S., NMFS and the MIR→NMFRI were completed:

- Biomass of fish was estimated by "swept area" method in the area of South Georgia shelf on the base of catch rates of bottom hauls;
- 168 bottom hauls and 27 pelagic hauls were carried out,
- Biomass of krill was estimated in the area of Bransfield Strait and Elephant Island by hydroacoustic method on the transect of 6 347 Nm,
- Identification of 71 species of fish and collecting 79 138 length measurements and 5 390 fish for detailed analysis,
- 264 measurements of CTD and 103 of XBT; 34 stations for measurement of primary production; recording data for chlorophyll along the vessel route; 50 hauls with a plankton nets, 81 with Bongo net, 8 with RMT-8 net, and 11 with Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS), 30 stations of benthos sampling,
- Survey on distribution and abundance of mammals, penguins and seabirds.

The completed tasks significantly exceeded the planned scope of research, for example instead of the planned 80 hauls with bottom trawl (in the frame of AMLR program) 128 were performed, and the study of penguins and seals covered a wider area than expected. The AMLR program also assumed the observations of mammals, penguins and sea birds from boats, and on land in the area of South Shetland Islands. From 25 January to 12 February 1987, program of observations of fur seals was carried out from inflatable boats launched from R/V PROFESOR SIEDLECKI, and by the obsevers who landend in the area where fur seals were observed in abundance (Bengtson et al., 1988). Breeding penguin observations were also conducted primarely from two inflatable boats launched from R/V PROFESOR SIEDLECKI (Shuford and Sperar, 1988). A team of two U.S. scientists stayed for two weeks on the Seal Island (near Elephant Island) observing penguins and seals. The implementation of the AMLR program was very satisfying for both sides and was highly appreciated by the management and expressed in the words of Acknowledgements: "*Warmest thanks to the captain, crew and scientists of the Polish research ship Professor Siedlecki, who made our survey work not only possible, but most enjoyable*" (Shuford and Sperar, 1988).

The second U.S.-Polish survey on board R/V PROFESOR SIEDLECKI took place one year later, based on the Agreement between the MIR→NMFRI (Gdynia) and NMFS (Narragansett) signed in 1987. Investigations were carried out in 1987/1988 season (Anon, 1988; Mucha, 1988). The cruise lasted from November 10, 1987 to March 28, 1988 and the survey in Antarctic waters lasted from December 18, 1987 to February 17, 1988. The survey was split into two parts and the studies were carried out in the area of South Georgia, Shag Rocks, Elephant I., and South Shetland Is. (Fig. 6.6). In both years, the U.S. Chief Scientist of AMLR Program on land was Dr. Kenneth Sherman. Mirosław Mucha from the MIR→NMFRI led the scientific team and the master of the vessel was Captain Janusz Olszowy.

The MIR→NMFRI program was carried out by the team of 21 scientists and technicians (including one scientist from the Academy of Agriculture in Szczecin). The U.S. AMLR program was performed by 22, 11 scientists in each of two parts of the cruise. The following U.S. scientific institutions were involved in the survey: National Marine Fisheries Service - NWFC (Seattle, WA.) University of Washington (Seattle, WA), University of Rhode Island (Narragansett, RI), Moss Landing Marine Lab (Moss Landing, CA), Texas A&M University (College Station, TX), Johns Hopkins University (Baltimore, MD), National Marine Fisheries Service - SWFC, (La Jolla, CA), University of Hawaii (Honolulu, HI), Profish International, Inc., (Seattle, WA), Freshwater Institute (Manitoba, Canada), National Geographic Magazine (Washington DC) (Table 6.2). The U.S. team embarked in Rio de Janeiro where the head of U.S. Program, Dr. Kenneth Sherman presented NMFS tasks to be carried out during the survey.

Table 6.2 Alphabetical list of scientists and technicians taking part in survey on R/V SIEDLECKI in season 1987/1988 (source: based on documents available at NMFRI)

	Polish staff		American staff x/	
	Surname and name	**Institution**	**Surname and name**	**Institution**
1	Chmielowski Henryk	NMFRI	Busch Donna	NMFS, Narragansett
2	Cielniaszek Zdzisław	NMFRI	Butler Steve	NMFS, SWFC, LaJolla
3	Fuławka Stanisław	NMFRI	Castro Margarida	University of Rhode Island
4	Górnowicz Dariusz	NMFRI	Chapman Robert	The Johns Hopkins University
5	Kocon Zygmunt	NMFRI	Chiperzak Douglas	Freshwater Institute
6	Kompowski Andrzej	ARS x/	Christensen Chris	University of Rhode Island
7	Kreft Krzysztof	NMFRI	Crawford Richard	
8	Kurzyk Sławomir	NMFRI	Everhart Darlene	NWFC, Seattle
9	Matuszak Tadeusz	NMFRI	Folsom Scott	University of Hawaii
10	Mucha Mirosław	NMFRI	Gaudet Dave	
11	Nakonieczny Jan	NMFRI	Green Jack	NMFS, Narragansett
12	Ociepka Emil	NMFRI	Gutherz Elmer	
13	Pactwa Romuald	NMFRI	Hodgson Bryan	National Geographic Mag.
14	Rutkowska Irena	NMFRI	Johnson Ellen	
15	Szymański Mariusz	NMFRI	Loeb Valerie	MLML x/
16	Szynaka Józef	NMFRI	Macaulay Michael	University of Washington
17	Tecław Piotr	NMFRI	McKenna James	University of Rhode Island
18	Warzocha Jan	NMFRI	McKinnon Gregory	Freshwater Institute
19	Wojtasz-Pajak Anna	NMFRI	Moisan John	Texas A&M University
20	Wójcik Ireneusz	NMFRI	Morrison Pat	University of Washington
21	Zaporowski Radosław	NMFRI	Park Chul	Texas A&M University
22			Wormuth John	Texas A&M University

x/ MLML – Moss Landing Marine Lab; ARS – Academy of Agriculture (Szczecin);

The survey was divided into two stages of research and the cruise's calendar was as follows:

10.11.1987 - departure from the port in Gdynia, Poland
09.12.1987 - call at Rio de Janeiro, Brazil, embarkation of the first U.S. team
18.12.1987 - 11.01.1988 - I leg of the cruise
16.01.1988 - call at Punta Arenas, Chile, exchange of the U.S. teams
21. 01 - 17.02.1988 - II leg of the cruise
27.02.1988 - call at Rio de Janeiro, Brazil, disembarkation of the U.S. team
01.03.1988 - departure for the return trip to Poland
28.03.1988 - call at Gdynia, Poland.

All the tasks of the U.S. NMFS and MIR→NMFRI programs mentioned above were completed during the survey (Mucha, 1988) and they were as follows:

1. Investigations on krill and fish stocks within the framework of the Polish Central Research Developmental Program realized by the MIR→NMFRI covered:
    - Monitoring and assessment of biomass of commercial fish species on the shelf of South Georgia, Elephant I., and King George I., by "swept area" method. As many as 155 bottom hauls were analyzed, all fish species were identified and detailed analysis were made;
    - Hydroacoustic krill stock assessment off Elephant I., King George I., and in the Bransfield Strait was performed. Hydroacoustic observations were carried out in order to detect krill concentrations and fish shoals, especially Antarctic icefish (*Pseudochaenichthys georgianus*);
    - Technological work to obtain chitin from krill under the MIR→NMFRI research program.
2. The U.S. Antarctic Marine Living Resources (AMLR) Program was conducted by the U.S. team with cooperating scientists from the MIR→NMFRI. The U.S. Field Party Chief for fish Assessment Survey was Dr. Richard Crawford and for Krill Assessment Survey were Dr. Michael Macaulay and John Green. The objectives of the Program were to:
    - Conduct a bottom trawl survey to assess the status of South Georgia shelf and Shag Rocks fish stocks; collect biological data (e.g., sex, index of sexual maturity, index of stomach fullness) for the study of the life history and behavior of selected fish species;
    - Assess the abundance and distribution of krill *(Euphausia superba)* using hydroacoustic methods in the area of Elephant I., King George I., and in the

Bransfield Strait; and to collect information on krill population structure and on associated fish;

- Collect hydrographic data, monitor and collect ichthyoplankton samples for assessment of possible spawning habitat connected with experiments with various types of plankton nets, observation on primary productivity;
- Conduct comparative studies performed by Polish R/V PROFESOR SIEDLECKI and Japanese R/V KAIYO MARU survey teams;
- Other tasks: bottom topography, mesh selectivity analysis, collection of fish tissue samples and deoxyribonucleic acid (DNA) for stock identification analysis, analysis of stomach contents of selected fish species, sample of otoliths found in the stomachs of the marine mammals and birds, experiments with bongo nets, analysis of the impact of ultraviolet radiation on phytoplankton productivity, collection of krill and fish samples for evaluation of the mitochondrial DNA (Anon., 1988; Mucha, 1988).

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7

GLOBAL CHANGES - GREENHOUSE EFFECT - CAUSES AND CONSEQUENCES
NOAA-NMFRI COOPERATION (1992-2011)

Marianna Pastuszak, Pieter Tans,
Ed Dlugokencky, Tycjan Wodzinowski

7. GLOBAL CHANGES - GREENHOUSE EFFECT - CAUSES AND CONSEQUENCES NOAA-NMFRI COOPERATION (1992-2011)

Marianna Pastuszak, Pieter Tans, Ed Dlugokencky, Tycjan Wodzinowski

7.1. Carbon - its cycling and role in sustaining life on Earth

Carbon is the 15th most abundant element in the Earth's crust, and the fourth most abundant element in the universe by mass, after hydrogen, helium, and oxygen. Carbon's widespread abundance, its ability to form stable bonds with numerous other elements, and its unusual ability to form polymers at the temperatures commonly encountered on Earth enable it to serve as a common element of all known living organisms (Falkowski et al., 2000). Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to make Earth capable of sustaining life. Carbon forms the structure of all life on the planet, making up ca. 50% of the dry weight of living things. The cycling of carbon approximates the flows of energy around the Earth, the metabolism of natural, human, and industrial systems. Plants transform radiant energy into chemical energy in the form of sugars, starches, and other forms of organic matter; this energy, whether in living organisms or dead organic matter, supports food chains in natural ecosystems as well as human ecosystems, not the least of which are fossil forms of energy for heating, transportation, and generation of electricity (Houghton, 2003).

The global carbon cycle is usually divided into the following major reservoirs of carbon and these are interconnected by pathways of exchange shown in Fig. 7.1A: (i) the atmosphere, (ii) the terrestrial biosphere, (iii) the ocean, including dissolved inorganic carbon and living and non-living marine biota, (iv) the sediments, including fossil fuels, freshwater systems, and non-living organic material, (v) the Earth's interior (mantle and crust). Carbon exchange between reservoirs occurs as the result of various chemical, physical, geological, and biological processes. The ocean contains the largest active pool of carbon near the surface of the Earth. The natural flows of carbon between the atmosphere, ocean, terrestrial ecosystems, and sediments are fairly balanced so that carbon levels would be roughly stable without human influence (Prentice et al., 2001; Archer, 2010; Govind and Kumari, 2014).

It is worth emphasizing that in 1850, the atmospheric reservoir contained 600 Gigaton carbon (GtonC) of CO_2 (https://worldoceanreview.com/en/wor-1/ocean-chemistry/co2-reservoir/); it now (in 2020) contains 890 GtonC of CO_2 (Fig. 7.1A) and that is the effect of human activity. 1 Gigatonne or metric gigaton (unit of mass) is equal to 1,000,000,000 metric ton; GtonC is used for carbon cycle studies which keep track of the mass of carbon (C) in different chemical forms and reservoirs. GtonCO$_2$ is the unit commonly used in emission inventories. It includes the mass of the two oxygen atoms attached to the carbon atom. 1 GtonC equals 3.67 GtonCO$_2$. The main point in Fig. 7.1A is to make a distinction between the huge geological, but very slowly exchanging, reservoirs and the rapid exchange between the atmosphere and oceans and atmosphere and terrestrial biosphere. The main point in Fig. 7.1B is how emissions have grown between 1960 and 2020, now overwhelming natural processes; numbers +1.4 and +5.1 at the top of Fig. 7.1B indicate that the atmospheric burden increased by 1.4 GtonC in 1960 and 5.1 GtonC in 2020.

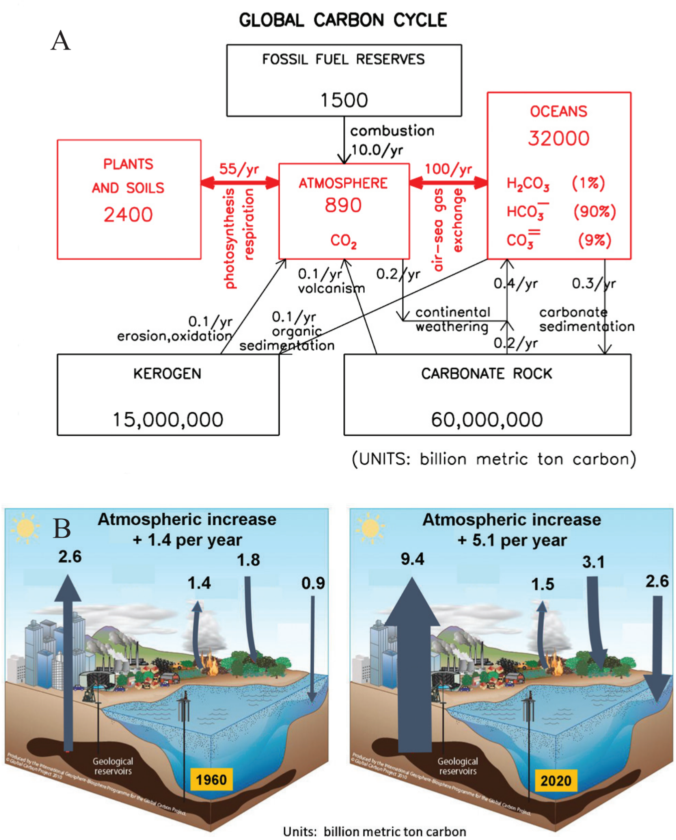

Fig. 7.1 Carbon cycle; upper graph (A) - numbers in red represent fast exchangers; lower pair of graphs (B) - carbon cycle in 1960 and 2020; units used in both graphs: Gton carbon (source: Global Monitoring Laboratory, Boulder, Colorado)

the USA meaning of a billion is a thousand million, or one followed by nine noughts (1,000,000,000); an European billion has 12 zeroes

Carbon is continuously exchanged and recycled among its reservoirs through natural processes. These processes occur at various rates ranging from short-term fluctuations which occur daily and seasonally to very long-term cycles which occur over hundreds of millions of years. For example, there is a clear seasonal cycle in atmospheric carbon dioxide (CO_2) owing to photosynthesis during the growing season when plants remove large amounts of CO_2 from the atmosphere and it enters the terrestrial and oceanic biospheres. Carbon dioxide also dissolves directly from the atmosphere into bodies of water (ocean, lakes, etc.), as well as dissolves in precipitation as raindrops fall through the atmosphere. When dissolved in water, carbon dioxide reacts with water molecules and forms carbonic acid, which contributes to ocean acidity. Carbon dioxide can be absorbed by rocks through weathering (Falkowski et al., 2000).

Respiration (from both plants and animals) and decomposition of leaves, roots, and organic compounds release CO_2 back into the atmosphere. On a scale spanning decades to centuries, CO_2 levels fluctuate gradually between the ocean and atmospheric reservoirs as ocean mixing occurs (between surface and deep waters) and the surface waters exchange CO_2 with the atmosphere. Much longer cycles also occur, on the scale of geologic time, due to the deposition and weathering of carbonate and silicate rock. Carbonate rocks like limestone are formed from the shells of marine organisms buried on the ocean floor, and they are chemically eroded by reaction with CO_2 in the air and in soils. Silicate rock reacts with carbonate rock deep underground, producing CO_2 gas coming out of volcanoes. Fossil fuels form a relatively small part of these natural geologic cycles (https://www.esrl.noaa.gov/gmd/education/carbon_toolkit/basics.html).

The majority of Earth's atmosphere is composed of a mixture of only a few gases i.e. nitrogen, oxygen, and argon. When combined, these three gases comprise more than 99.5% of all the gas molecules in the atmosphere. The most abundant atmospheric gases exhibit almost no effect on warming the earth and its atmosphere since they do not absorb visible or infrared radiation. However, there are minor gases which comprise only a small portion of the atmosphere (about 0.43% of all air molecules, most of which are water vapor at 0.39%) that do absorb infrared radiation. These "trace" gases contribute substantially to warming of the Earth's surface and atmosphere due to their abilities to contain the infrared radiation emitted by the Earth. Since these trace gases influence the Earth in a manner somewhat similar to a greenhouse, they are referred to as Greenhouse Gases, or GHGs (https://www.esrl.noaa.gov/gmd/education/carbon_toolkit/basics.html; Jain, 1993).

The processes responsible for adding carbon to and withdrawing it from the atmosphere are not well enough understood to predict future levels of CO_2 with great accuracy. These processes are a part of the global carbon cycle. Some of the processes that add carbon to the atmosphere or remove it, such as the combustion of fossil fuels and the establishment of tree plantations, are under direct human control. Others, such as the accumulation of carbon in the oceans or on land as a result of changes in global climate (i.e. feedbacks between the global carbon cycle and climate), are not under direct human control except through controlling rates of greenhouse gas emissions and, hence, climatic change (Prentice et al., 2001; Houghton, 2003; Schimel et al., 2015).

7.2. Greenhouse effect - global and local view of the problem

We use the information as well as graphic documentation contained in the huge work by Ritchie and Roser (2020) and published online. These authors offer the free of charge use of their graphics without the required consent of the authors, but on the condition that the data source is provided, without skipping the data sources on the basis of which this important scientific work was created. We have fulfilled these conditions, and would like to add with great satisfaction that in many cases Ritchie and Roser (2020) used data from the National Oceanic and Atmospheric Administration (NOAA), the American institution with which Poland has cooperated for the past 50 years (see Chapters 1-6).

7.2.1. Increasing amount of carbon in atmosphere - global scale emissions and their sources

Carbon, in the form of carbon dioxide (CO_2) and methane (CH_4), forms two of the most important greenhouse gases. Methane produces a larger greenhouse effect per kg as compared to carbon dioxide, but it exists in much lower concentrations and is more short-lived than carbon dioxide, making carbon dioxide the more important greenhouse gas of the two (Falkowski et al., 2000; Forster et al., 2007; Ciais et al., 2016). On a 20-year timescale, a mass of methane emitted, including indirect effects from stratospheric H_2O and tropospheric O_3, is about 85 times more powerful than an equal mass of carbon dioxide emitted at heating the Earth. However, on a 100-year timescale, it is projected to be only about 28-34 times more powerful, on the assumption the carbon dioxide will not be sequestered and will continue to warm the earth for decades after the methane is gone (Myhre et al., 2013).

Saunois et al. (2020) present the decadal (2008-2017) methane budget, integrating results of top-down studies (atmospheric observations within an atmospheric inverse-modelling framework) and bottom-up estimates (including process-based models for estimating land surface emissions and atmospheric chemistry, inventories of anthropogenic emissions, and data-driven extrapolations) (Table 7.1). As stated by these authors, for the 2008-2017 decade, global methane emissions estimated by atmospheric inversions (a top-down approach), reached the value of 576 Tg CH_4 yr^{-1} (Table 7.1) (Tg = 10^{12} g = 10^9 kg = million tonnes). Of this total, 358 Tg CH_4 yr^{-1} or ~60% is attributed to anthropogenic sources (Table 7.1), that is emissions caused by direct human activity. The authors conclude that the mean annual total emission for the new decade (2008-2017) is 29 Tg CH_4 yr^{-1} larger than the estimate for the previous decade (2000-2009), and 24 Tg CH_4 yr^{-1} larger than the one reported in the previous budget for 2003-2012 (Saunois et al., 2016, 2017). The difference between the top-down average emissions and average sinks of methane in 2008-2017 reached 20 million tonnes of CH_4 which constituted atmospheric growth rate in the period studied (Saunois et al., 2020; Table 7.1).

Bottom-up methods suggest almost 30 % larger global emissions (735 Tg CH_4 yr^{-1}, range 594-881) than top-down inversion methods. The difference between the average emissions and average sinks of methane in 2008-2017, calculated with this method, reached 110 million tonnes of CH_4 which constituted atmospheric growth rate in the period studied. Thus, the bottom-up growth rate is 5.5 times higher as compared with the relevant parameter of the top-down method (Saunois et al., 2020; Table 7.1). Indeed, bottom-up estimates for natural sources such as natural wetlands, other inland water systems, and geological sources are higher than top-down estimates (Table 7.1). Saunois et al. (2020) are of the opinion that the atmospheric constraints on the top-down budget suggest that at least some of these bottom-up emissions are overestimated. The latitudinal distribution of atmospheric observation-based emissions indicates a predominance of tropical emissions (~ 65 % of the global budget, < 30° N) compared to mid-latitudes (~ 30 %, 30–60° N) and high northern latitudes (~ 4 %, 60-90° N) (see to sub-chapter 7.2.3.). The most important source of uncertainty in the methane budget is attributable to natural emissions, especially those from wetlands and other inland waters.

Table 7.1 Global top-down and bottom-up (in brackets) methane budget in 2008-2017; in red - anthropogenic emissions; in brown - natural and anthropogenic emissions; in green - natural emissions (source of data: Saunois et al., 2020)

Global methane budget (2008-2017)			
Total emissions [million tonnes of CH_4/year]		Total sinks [million tonnes of CH_4/year]	
Source:		Source:	
Fossil fuel production and use	**111 (128)**	Sinks arising from the chemical reactions in the atmosphere	**518 (595)**
Agriculture and waste	**217 (206)**	Sinks in soil	**38 (30)**
Biomass burning	**30 (30)**		
Wetlands	**181 (149)**		
Other natural emissions (inland waters, geological, oceans, termites, wild animals, permafrost, vegetation)	**37 (222)**		
TOTAL:	**576 (735)**		**556 (625)**

Methane is released from previously frozen soils when organic matter thaws and decomposes under anaerobic conditions, that is, without oxygen present (IPCC, 2007). Most of the current permafrost formed during or since the last ice age and can extend down to depths of more than 700 meters in parts of northern Siberia and Canada. Thawing of part of the permafrost has not yet been fully accounted for in climate projections. The anomalous rise in temperatures over the Arctic, occurring at about twice the global rate, threatens the stability of the carbon-rich permafrost, with consequent release of volumes of methane and deleterious effects on the terrestrial and marine habitats (Friedlingstein et al., 2006; Gruber, 2011; Koven et al., 2011). In particular, Arctic permafrost, which covers almost a quarter of the Northern Hemisphere continents, is estimated to contain more than 900 billion tons of carbon (Glikson, 2018).

The remaining greenhouse gases are dealt with and these cover: nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulphur hexafluoride (SF_6) (Forster et al., 2007; Ritchie and Roser, 2020) (Fig. 7.2). Carbon dioxide equivalent (CO_2e) was adopted by Ritchie and Roser (2020) and that requires explanation, following the abovementioned authors. Greenhouse gases vary in their relative contributions to global warming; i.e. one tonne of emitted methane does not have the same impact on warming as one tonne of emitted carbon dioxide. These conversions are defined using 'Global Warming Potential' (GWP) which can be defined on a range of time-periods, however the most commonly used is the 100-year timescale (GWP_{100}). The GWP_{100} metric measures the relative warming impact of one unit mass emitted of a greenhouse gas relative to the same mass of carbon dioxide over a 100-year timescale. GWP_{100} values are used to combine greenhouse gases into a single metric of emissions called carbon dioxide equivalents (CO_2e). The sums of all gases in CO_2e provide a measure of the climate impact of total greenhouse gas emissions (Ritchie and Roser, 2020). It is worth noticing that carbon dioxide emission, measured in tonnes of carbon dioxide equivalents, increased from 15 billion tonnes in 1970 to 35 billion tonnes in 2012 (Fig. 7.2).

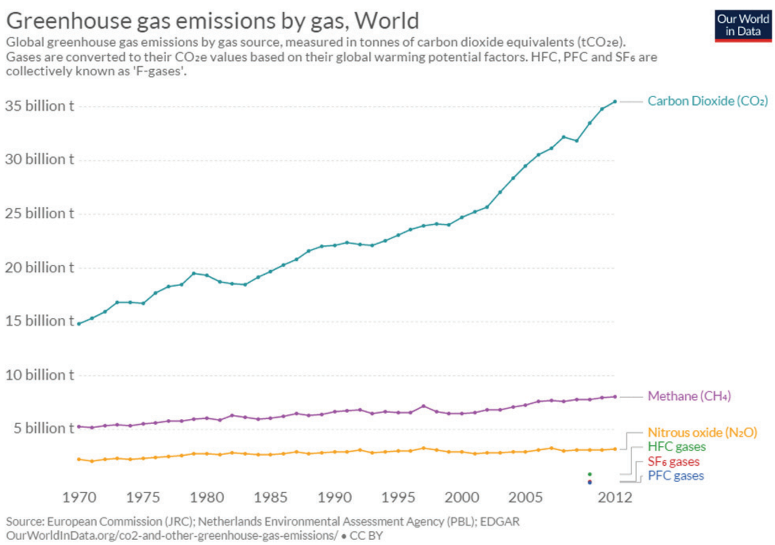

Fig. 7.2 Global greenhouse emissions by gas source, measured in tonnes of carbon dioxide equivalent (CO_2e) in 1970-2012 [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Human activities over the past two centuries have significantly increased the amount of carbon in the atmosphere, mainly in the form of carbon dioxide (Fig. 7.3), both by modifying ecosystems' ability to extract carbon dioxide from the atmosphere and by emitting it directly, e.g., by burning fossil fuels and manufacturing concrete (Jain, 1993; Falkowski et al., 2000; Worrell et al., 2001; Ritchie and Roser, 2020). Global atmospheric CO_2 was relatively stable, fluctuating between 270 and 285 ppm until the 18th century. Since the Industrial Revolution, global CO_2 has been rapidly increasing (Fig. 7.3), reaching ca. 340 ppm in 1980, and ca. 414 ppm in 2021 (Fig. 7.4).

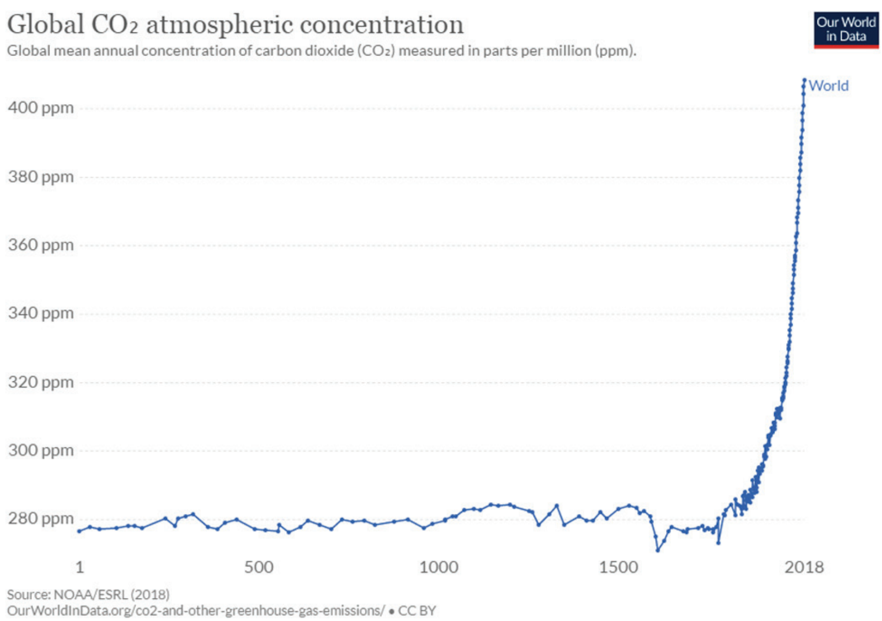

Fig. 7.3 Global mean annual atmospheric carbon dioxide (CO_2) over the past two millennia; ppm stands for parts per million, by mole (dry air) [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". *Published online at OurWorldInData.org*. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

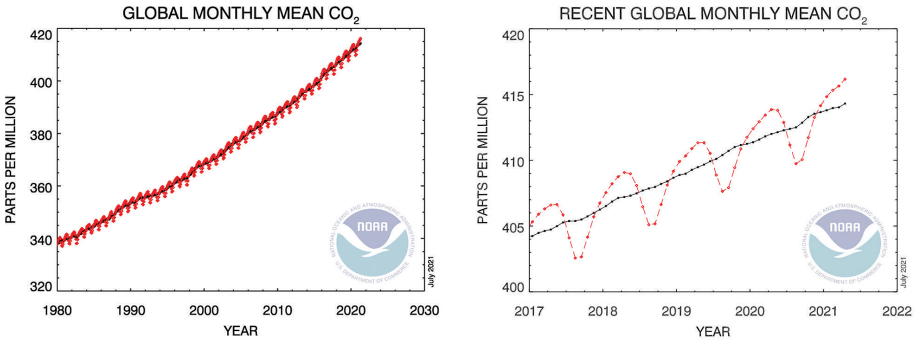

Fig. 7.4 Global monthly mean atmospheric CO_2 in 1980-2020 (left graph) and updated till 2021 (right graph); unit: ppm (source:https://gml.noaa.gov/webdata/ccgg/trends/co2_trend_gl.pdf;/https://gml.noaa.gov/ccgg/trends/global.html)

The past 800 000 years were characterized by fluctuations in CO_2 which coincided with the onset of ice ages (low CO_2) and interglacials (high CO_2); the periodic fluctuations are caused by changes in Earth's orbit around the Sun. For centuries, until the Industrial Revolution, global CO_2 did not exceed 300 ppm (Fig. 7.5). The present atmospheric CO_2 concentration has not been exceeded during the past 4 million years. The rate of increase after 1970 is unprecedented, certainly during the past 20,000 years, and likely the last million years. The present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2. Fossil fuel burning (plus a small contribution from cement production) released on average 5.4 ± 0.3 PgC yr^{-1} during 1980 to 1989, and 6.3 ± 0.4 PgC yr^{-1} during 1990 to 1999 (unit PgC - petagrams of carbon; 1 PgC = 1 GtC = 10^{15} g C). Some authors (Prentice et al., 2001; Ritchie and Roser, 2020) state that land use change is responsible for the rest of the emissions, but we have to keep in mind that in the early years of the Industrial Revolution land use change emissions were larger than coal burning, until near the end of the 19th century when coal and oil burning overtook land use emissions. Today, land use emissions are only ~10% of all emissions, while net uptake by land ecosystems is quite large, probably in part as a result of fertilization by CO_2 (50% higher than in pre-industrial times) and by reactive nitrogen (O'Sullivan et al., 2019).

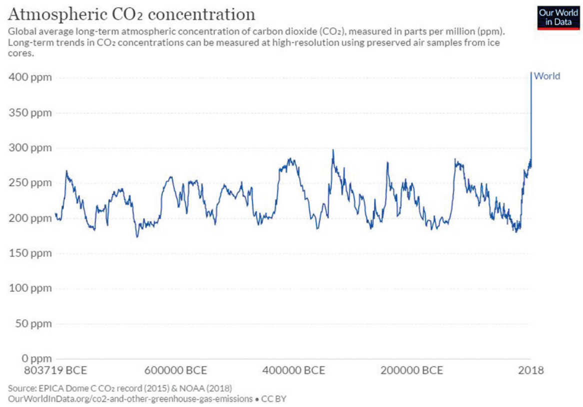

Fig. 7.5 Global average long-term atmospheric CO_2 in ppm [source: Ritchie and Roser (2020) “CO_2 and Greenhouse Gas Emissions”. Published online at OurWorldInData.org. Retrieved from: ‘https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions’; sources of input data are visible within the field of graph]

There is also an evident increase in atmospheric methane concentrations, from ca. 700 ppb in 1750 to over 1 800 ppb in 2018, and an increase in atmospheric nitrous oxide concentrations from 270 ppb in 1750 to over 330 ppb in 2016 (Ritchie and Roser, 2020) (Figs. 7.6, 7.7).

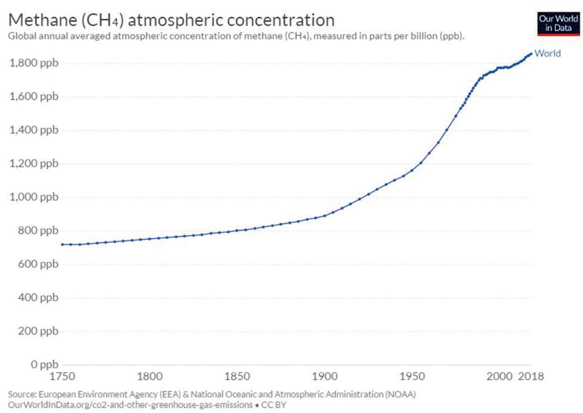

Fig. 7.6 Global annual average atmospheric of methane (CH_4) in 1750-2018; ppb stands for parts per billion, by mole (dry air) [source: Ritchie and Roser (2020) “CO_2 and Greenhouse Gas Emissions”. Published online at OurWorldInData.org. Retrieved from: ‘https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions’; sources of input data are visible within the field of graph]

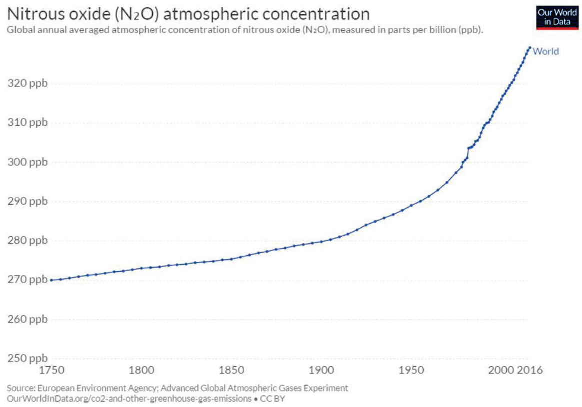

Fig. 7.7 Global annual average atmospheric of nitrous oxide (N_2O) in 1751-2016; ppb stands for parts per billion, by mole (dry air) [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Before the Industrial Era, circa 1750, atmospheric carbon dioxide (CO_2) was 280±10 ppm for several thousand years (Fig. 7.3). Forster et al. (2007) state that past emissions of fossil fuels and cement production have likely contributed about three-quarters of the current radiative forcing (RF). A dramatic increase in climate radiative forcing (RF) by greenhouse gases over the 19th to 21st century has also been reported by Tans et al. (2020; https://gml.noaa.gov/ccgg/ghgpower) (Fig. 7.8). The combined climate radiative forcing by CO_2, CH_4, N_2O, and industrial gases was slowly increasing from 0.1 W m^{-2} in 1800 to ca. 0.4 W m^{-2} in 1900, to reach the maximum of 3.2 W m^{-2} in 2019. Over the years 1800-2019 there was a predominant role of CO_2 in climate radiative forcing; in 2019 as much as 66% of climate forcing was by CO_2.

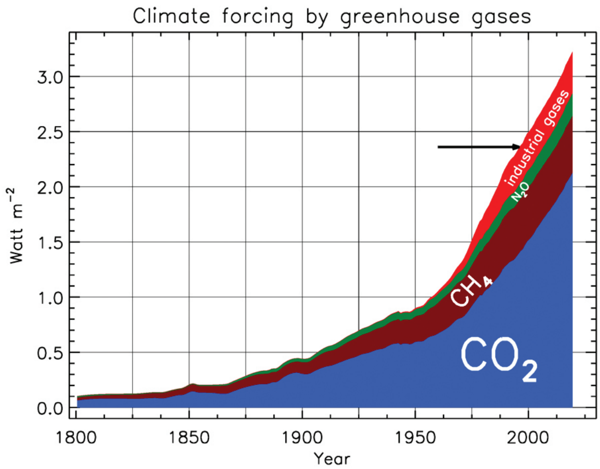

Fig. 7.8 Radiative climate forcing by all GHGs in 1800-2015. The horizontal arrow shows where climate forcing surpassed 1% of Earth's weather and climate "engine" (source: Tans et al., 2020; https://gml.noaa.gov/ccgg/ghgpower/)

A much longer time frame of radiative climate forcing by all GHGs changes is presented in Fig. 7.9. The drastic increase since 1800 is the result of human activity (Tans et al., 2020).

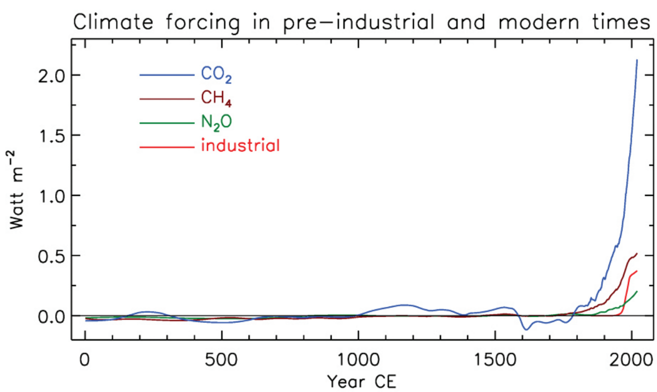

Fig. 7.9 Radiative climate forcing by all GHGs in pre-industrial and modern times (source: Tans et al., 2020; https://gml.noaa.gov/ccgg/ghgpower/); CE (Common Era) is the secular equivalent of AD (anno Domini)

Carbon dioxide concentrations in the atmosphere are strictly connected with its emissions which globally increased from 2 billion tonnes CO_2 (Gton CO_2) in 1900 to over 35 GtonCO_2 in 2017. The emission is highly variable depending on region, with highest contribution of China, the U.S., Europe (EU-28 plus Europe other), and Asia and Pacific (other) (Fig. 7.10).

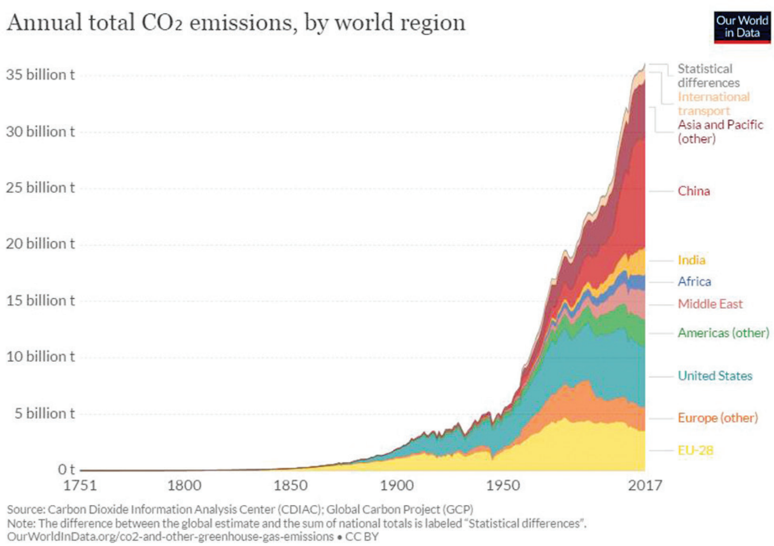

Fig. 7.10 Annual total carbon dioxide (CO_2) emissions by world region in 1751-2017 [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Hereafter, we present the tree map visualization that shows annual CO_2 emissions by country, and aggregated by region (Fig. 7.11; Ritchie and Roser, 2020). Each inner rectangle in Fig. 7.11 represents a country which is nested in a particular colored region. Tree maps are used to compare entities (such as countries or regions) in relation to others, and relative to the total. The size of each rectangle corresponds to its annual CO_2 emissions in 2017, whereas the combined rectangles represent the global total. Asia is by far the largest emitter, accounting for 53% of global emissions. As it is home to 60% of the world's population this means that per capita emissions in Asia are slightly lower than the world average. China is Asia's and the world's largest emitter: it emits nearly 9.8 billion tonnes each year, more than one-quarter of global emissions. North America - dominated by the USA - is the second largest regional emitter at 18% of global emissions. It is followed closely by Europe (28 countries of the European Union) with 17%. Africa and South America are both fairly small emitters: accounting for 3-4% of global emissions each (Fig. 7.11; Ritchie and Roser, 2020).

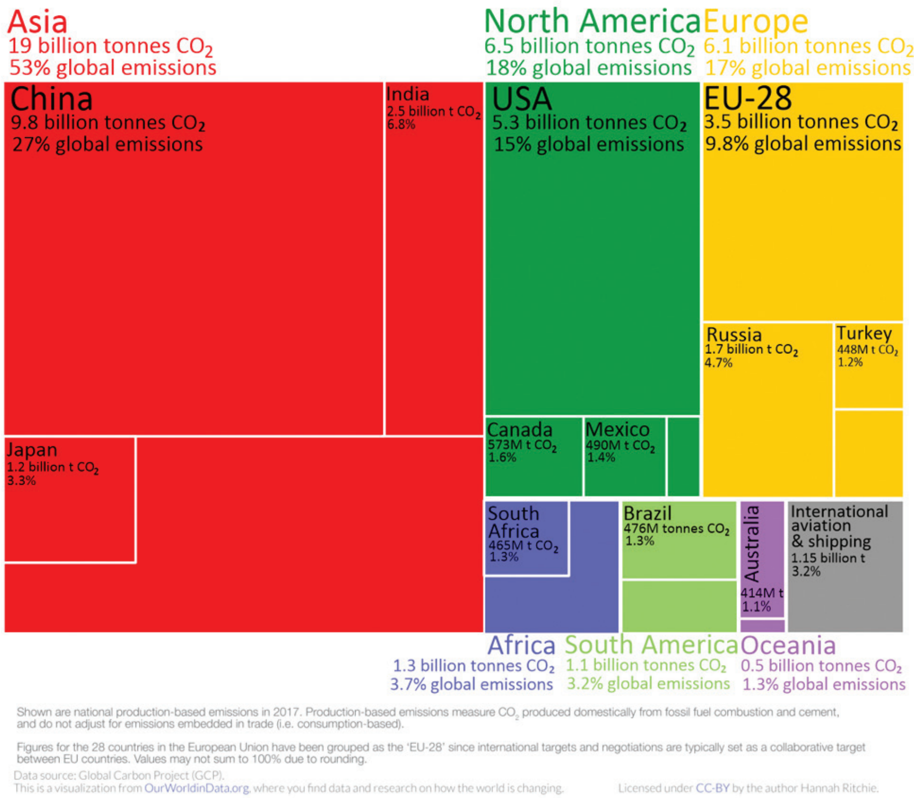

Fig. 7.11 Global carbon dioxide (CO_2) emissions by country and region in 2017 [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions" - graph modified and simplified by T. Wodzinowski, NMFRI in order to get acceptable resolution for printing; Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Studies by Leip et al. (2015) concentrate on impacts of European livestock production on nitrogen (N), sulphur (S), phosphorus (P) and greenhouse gas emissions, land-use, water eutrophication and biodiversity. The outcome shows that livestock production systems currently occupy around 28% of the land surface of the European Union (equivalent to 65% of the agricultural land). In conjunction with other human activities, livestock production systems affect water, air and soil quality, global climate and biodiversity, altering the biogeochemical cycles of nitrogen, phosphorus and carbon. The above mentioned authors explain that for each environmental effect, the contribution of livestock is expressed as shares of the emitted compounds and land used, as compared to the whole agricultural sector. Their results show that the livestock sector contributes significantly to agricultural environmental impacts. This contribution is 78% for terrestrial biodiversity loss, 80% for soil acidification and air pollution (ammonia and nitrogen oxides emissions), 81% for global warming, and 73% for water pollution (both N and P). The agriculture sector itself is one of the major contributors to these environmental impacts, ranging between 12% for global warming and 59% for N water quality impact.

Ritchie and Roser (2020) present also a graph showing cumulative carbon dioxide emissions (obtained by adding up each country's annual CO_2 emissions over time) over the period from 1751 (Industrial Revolution) through 2017 (Fig. 7.12). In this period the world has emitted over 1.5 trillion tonnes of CO_2. The United States is the largest emitter of CO_2, with overall emission reaching ca. 399 billion tonnes, which constitutes 25% of historical emissions, which is twice as much as China – the world's second largest national contributor. The European Union (EU-28) is also a large historical contributor with emission reaching 22%. Many of the large annual emitters today, such as India and Brazil, are not large contributors in a historical context. Africa's regional contribution, relative to its population size, has been very small. This is the result of very low per capita emissions, both historically and currently (Ritchie and Roser, 2020).

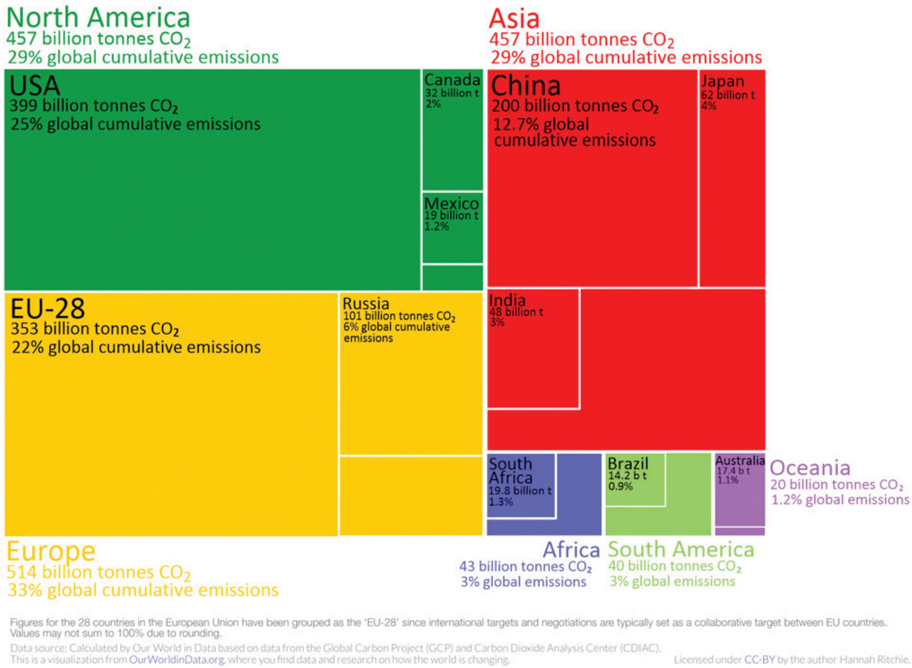

Fig. 7.12 Cumulative carbon dioxide (CO_2) emissions over 1751 to 2017; figures are based on production-based emissions which measure CO_2 produced domestically from fossil fuel combustion and cement, and do not correct for emissions embedded in trade (i.e. consumption based); emissions from international travel are not included [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions" - graph modified and simplified by T. Wodzinowski, NMFRI in order to get acceptable resolution for printing. Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Ritchie and Roser (2020) show that there is a relationship between income and per capita CO_2 emissions, and theoretically it can be expected that countries with high standards of living would have a large carbon footprint (Fig. 7.13). But, as the authors prove, there can be large differences in per capita emissions, even among countries with similar standards of living. Many countries across Europe, for example, have much lower emissions than the U.S., Canada or Australia. In fact, as shown further, some European countries have emissions not far from the global average. For example, in 2017, emissions in Portugal reached 5.3 tonnes, in France, 5.5 tonnes, and in the UK, 5.8 tonnes per person (Fig. 7.13). This is also much lower than some of their neighbors with similar standards of living, such as Germany, the Netherlands, or Belgium. The explanation lies in the choice of energy sources. In the UK, Portugal and France, a much higher share of electricity is produced from nuclear and renewable sources. There is another component, namely energy efficiency and energy conservation. The latter includes having excellent public transport, safe bicycle paths etc. This means a much lower share of electricity is produced from fossil fuels, e.g. in 2015, only 6% of France's electricity came from fossil fuels, compared to 55% in Germany. So, prosperity is a primary driver of CO_2 emissions, but policy and technological choices make a difference. Many countries in the world still have very low per capita CO_2 emissions. In many of the poorest countries in Sub-Saharan Africa – such as Chad, Niger and the Central African Republic – the average footprint is around 0.1 tonnes per year. That is more than 160 times lower than the USA, Australia and Canada (Ritchie and Roser, 2020; Fig. 7.13).

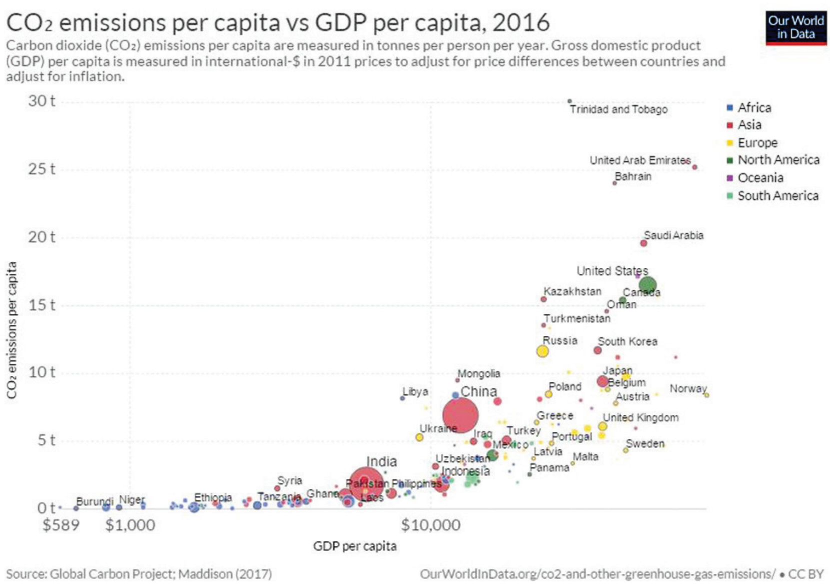

Fig. 7.13 Carbon dioxide (CO_2) emissions per capita (measured in tonnes per person per year) in 2016 vs. GDP (Gross Domestic Product per capita in 2016 measured in international dollars in 2011 prices to adjust for prices differences between countries and adjust for inflation [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

According to the Carbon Dioxide Information Analysis Center (CDIAC; https://cdiac.ess-dive.lbl.gov/trends/emis/overview_2011.html), global CO_2 emissions from coal constituted 90.5% of the total in 1920, from oil 8.4% , and from gas 1.2%; use of oil/gas did not really get started until 1890. A dramatic increase in carbon emission was observed after 1950, when there appeared two other sources of CO_2, i.e. oil and gas, which were followed by cement production. Cement production contributes insignificantly as compared with coal, oil and gas. Overall CO_2 emission from all the sources exceeded 35 billion tonnes in 2017 (Ritchie and Roser, 2020; Fig. 7.14).

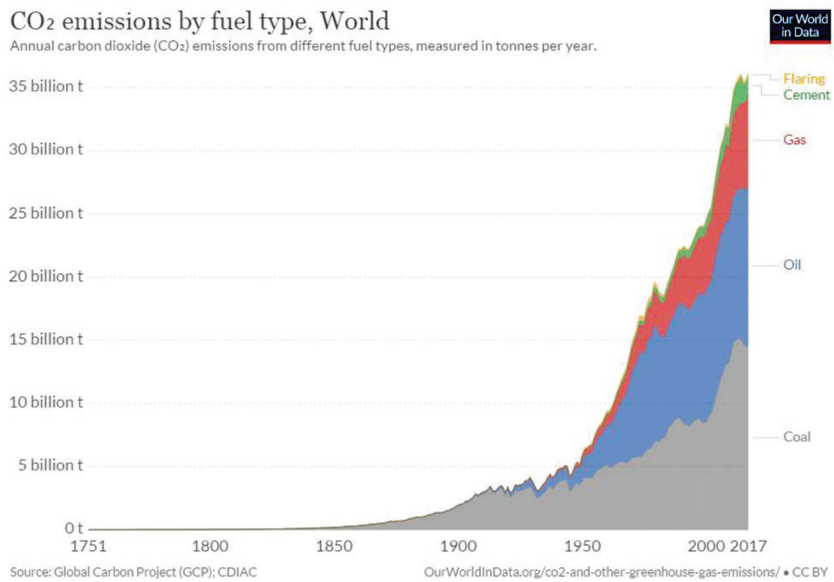

Fig. 7.14 Global carbon dioxide (CO_2) emissions by fuel type in 1751-2017 [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Global greenhouse gas emissions can be broken down by the following sectored sources: (i) energy (energy, manufacturing and construction industries and fugitive emissions), (ii) transport (domestic aviation, road transportation, rail transportation, domestic navigation, other transportation), (iii) international bunkers (international aviation, international navigation/shipping), (iv) residential (commercial, institutional and agriculture, forestry and fishery), (v) industry (production of minerals, chemicals, metals, pulp/paper/food/drink, halocarbons, refrigeration and air conditioning; aerosols and solvents; semiconductor/electronics manufacture; electrical equipment), (vi) waste (solid waste disposal; wastewater handling; waste incineration; other waste handling), (vii) agriculture (methane and nitrous oxide emissions from enteric fermentation; manure management; rice cultivation; synthetic fertilizers; manure applied to soils; manure left on pasture; crop residues; burning crop residues, savanna and cultivation of organic soils), land use (emissions from the net conversion of forest; cropland; grassland and burning biomass for agriculture or other uses), (viii), other sources (fossil fuel fires; indirect nitrous oxide from non-agricultural NOx and ammonia; other anthropogenic sources) (Ritchie and Roser, 2020).

7.2.2. Increasing amount of carbon in atmosphere - examples of local scale emissions

The Global Monitoring Laboratory (GML; formerly known as Climate Monitoring and Diagnostic Laboratory (CMDL) and ESRL/GMD) (Earth System Research Laboratory/ Global Monitoring Division) of the National Oceanic and Atmospheric Administration in Boulder, Colorado, U.S. (see subchapter 7.3) conducts research that addresses three major challenges: greenhouse gas and carbon cycle feedbacks, changes in clouds, aerosols, and surface radiation, and recovery of stratospheric ozone. Monthly average carbon dioxide data for the four baseline observatories are presented in Fig. 7.15. The observed increase, due primarily to CO_2 emissions from fossil fuel burning, is similar at all four remote locations. CO_2 remains in the atmosphere for a very long time, and emissions from any location mix throughout the atmosphere in about one year. The annual oscillations at the two Northern Hemisphere sites (Barrow, Alaska and Mauna Loa, Hawaii - see additional info. below) are due to the seasonal imbalance between the photosynthesis and respiration of plants on land. The seasonal cycle is strongest in the northern hemisphere because of the presence of the continents. The difference between Mauna Loa and the South Pole has increased over time as the global rate of fossil fuel burning, most of which takes place in the northern hemisphere, has accelerated. In 1975, average annual CO_2 was ~330 ppm, and it demonstrated a steady significant increase to reach 412 ppm in 2020 (https://www.esrl.noaa.gov/gmd/ccgg/ggrn.php; Fig. 7.15).

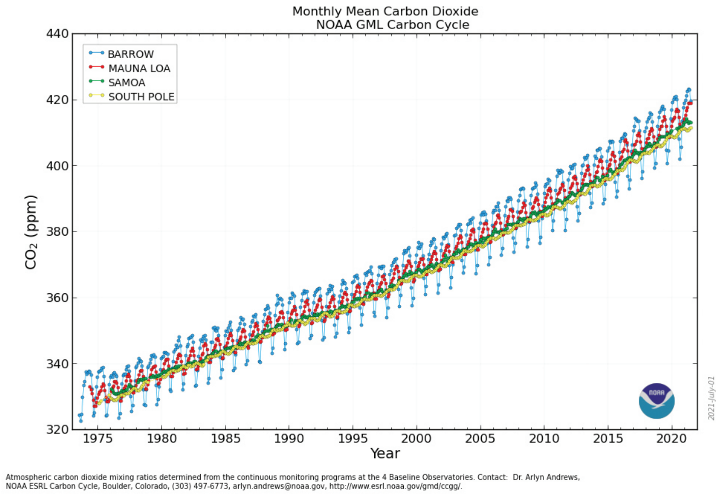

Fig. 7.15 Monthly average atmospheric carbon dioxide (CO_2) from GML baseline observatories (source: https://www.esrl.noaa.gov/gmd/ccgg/ggrn.php)

The **Barrow** Atmospheric Baseline Observatory (BRW), established in 1973, is located on the northern most point of the United States. It is about 8 km northeast of the village of Utqiaġvik (formerly Barrow) Alaska, and has a prevailing east-northeast wind off the Beaufort Sea. Although the measurements at BRW are made over open tundra, there are large lagoons and a number of lakes in the vicinity, and the Arctic Ocean is less than 3 km northwest of the site. Because of its proximity to these bodies of water and the fact that the prevailing winds are off the Beaufort Sea, BRW is perhaps best characterized as having an Arctic maritime climate affected by variations of weather and sea ice conditions in the Central Arctic. The **Mauna Loa** Observatory (MLO) is located on the north flank of Mauna Loa Volcano, on the Big Island of Hawaii, at an elevation of 3397 meters, or 11 135 feet above sea level. The observatory is a premier atmospheric research facility that has been continuously monitoring and collecting data related to atmospheric change since the 1950s. The observatory protrudes through the strong marine temperature inversion layer present in the region, which separates the more polluted lower portions of the atmosphere from the much cleaner free troposphere. The undisturbed air, remote location, and minimal influences of vegetation and human activity at MLO are ideal for monitoring constituents in the atmosphere that can cause climate change. The American **Samoa** Observatory (SMO) is located in the middle of the South Pacific, about midway between Hawaii and New Zealand. It is characterized by year-round warmth and humidity, lush green mountains, and strong Samoan culture. The observatory is situated on the northeastern tip of Tutuila Island, American Samoa, at Cape Matatula. The **South Pole** Observatory (SPO) is located at the geographic South Pole on the Antarctic plateau at an elevation of 2837 m above sea level. The South Pole Observatory was established at the geographical South Pole in 1957 as part of the International Geophysical Year (https://www.esrl.noaa.gov/gmd/).

An identical rate of increase in CO_2 in the atmosphere (from ca. 357 ppm in 1992 to ca. 396 ppm in 2011) was also found at the greenhouse gases monitoring station located on the ferry STENA BALTICA operating in the **Baltic Sea** region; the monitoring station was supervised by the National Marine Fisheries Research Institute, Poland (Fig. 16; see Fig. 3.8 in Chapter 1, and subchapter 7.4).

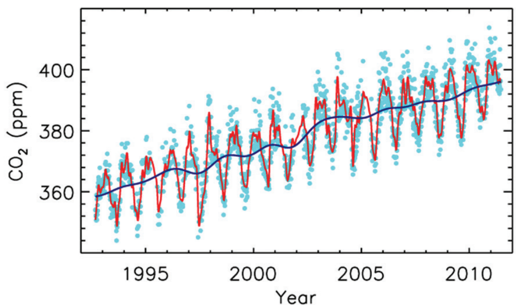

Fig. 7.16 Atmospheric CO_2 from the BALTIC sampling site for 1992-2011 (sampling frequency – twice a week) (for details see subchapter 7.4) (source: GML, Boulder, Colorado)

7.2.3. Global CO_2 and CH_4 growth rates in 2000-2020

A quantity of keen interest for each trace gas is the global-average rate of increase (“growth rate”), after removal of the seasonal cycle. The CO_2 and CH_4 growth rates are plotted as a function of time and latitude (Fig. 7.17). The CO_2 growth rate varies from year to year with a trend toward higher growth rates since 2000. The CH_4 growth rate slowed during the 1990s and early 2000s, but increased during 2007-2020. The annual variations of the CO_2 growth rate are not due to variations in fossil fuel emissions. The ups and downs in the atmospheric CO_2 increase are due to variations in the exchange of CO_2 between the atmosphere, oceans, and land ecosystems. They are primarily due to small annual fluctuations of temperature and precipitation affecting photosynthesis and respiration on land. It is very important to know that the added CO_2 does not disappear, but, as long as atmospheric CO_2 keeps rising, a portion of it transfers each year from the atmosphere to the oceans and to plants on land. The transfer of CO_2 to the oceans causes their acidification (https://www.esrl.noaa.gov/gmd/ccgg/ggrn.php).

In addition to acting as the planet's heat sink, the oceans have absorbed approximately one-third of the carbon dioxide produced by human activities. The absorption of anthropogenic CO_2 has acidified the surface layers of the ocean, with a steady decrease of 0.02 pH units per decade over the past 30 years and an overall decrease since the pre-industrial period of 0.1 pH units (Hoegh-Guldberg and Bruno, 2010). These authors emphasize that although pH decreases appear small, they are associated with a substantial decline in the concentration of carbonate ions and represent a major departure from the geochemical conditions that have prevailed in the global ocean for hundreds of thousands if not millions of years.

The variations in CH_4 growth rate (Fig. 7.17) are also related to climate anomalies (among other factors). For example, NOAA data suggest that the CH_4 increase in 2007 to 2008 was related to greater-than-average precipitation in tropical regions resulting in above average emissions from tropical wetlands. Understanding the processes that cause the CO_2 and CH_4 growth rate variations and long-term trends is crucial to enable governments and society in general to make informed decisions on energy policy and on mitigating climate change. Long-term projections of CO_2, CH_4, and N_2O depend on future emissions trajectories, which include land use, and on climate feedbacks as they are incorporated into climate-ecosystem models. An example of the latter would be Arctic warming increasing CH_4 and CO_2 emissions from melting permafrost, which would be out of human control (https://www.esrl.noaa.gov/gmd/ccgg/ggrn.php).

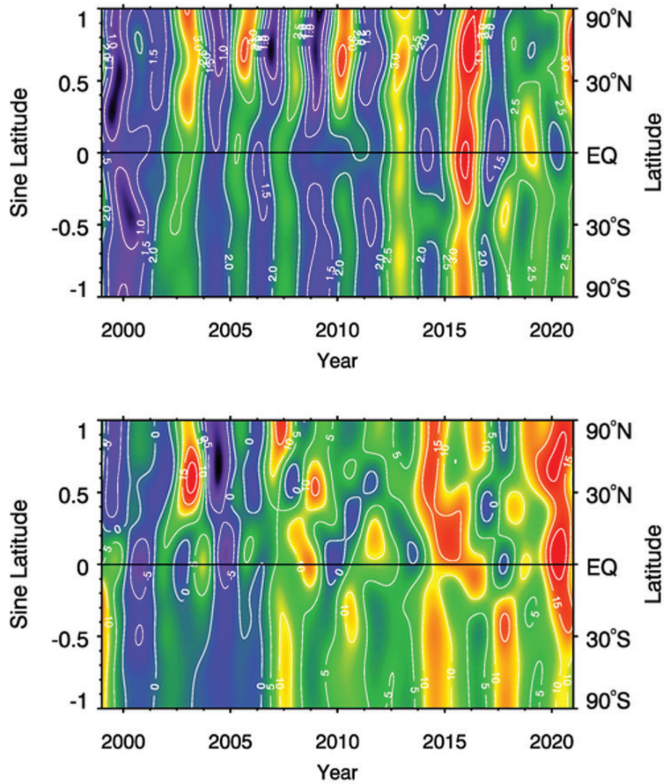

Fig. 7.17 Carbon dioxide (CO_2) (left graph) and methane (CH_4) (right graph) growth rate contours as a function of time and latitude; the warmer colors (yellow, orange) indicate periods of higher-than average growth rate and the cooler colors (blue, purple) indicate periods of lower growth rate (source: https://www.esrl.noaa.gov/gmd/ccgg/ggrn.php)

7.2.4. Increasing amount of carbon in atmosphere→climate change→global land and ocean temperature increase

The greenhouse gases contribute to a natural greenhouse effect that has kept the planet warm enough to evolve and support life (without the greenhouse effect, Earth's average temperature would be -33°C). Additions of greenhouse gases to the atmosphere from industrial activity, however, are increasing the concentrations of these gases, enhancing the greenhouse effect, and warming Earth (Houghton, 2003). Over the last few decades global temperature increased by 0.7°C as compared with 1961-1990 baseline; when this baseline is referred to 1850, it is clear that the average temperature increase reached 1.1°C (Ritchie and Roser, 2020; Fig. 7.18). The temperature increase in the North Hemisphere is higher, close to 1.4 °C since 1850, and lower in the Southern Hemisphere (close to 0.8°C) (Ritchie and Roser, 2020). Evidence suggests that this distribution is strongly related to ocean circulation patterns (notably the North Atlantic Oscillation) which has resulted in greater warming in the northern hemisphere (Delworth et al., 2016). Climatic variability has profound effects on the distribution, abundance and catch of oceanic fish species around the world. The major modes of this climate variability include the El Niño-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO) also referred to as the Interdecadal Pacific Oscillation (IPO), the Indian Ocean Dipole (IOD), the Southern Annular Mode (SAM) and the North Atlantic Oscillation (NAO). Other modes of climate variability include the North Pacific Gyre Oscillation (NPGO), the Atlantic Multidecadal Oscillation (AMO) and the Arctic Oscillation (AO) (Salinger, 2013).

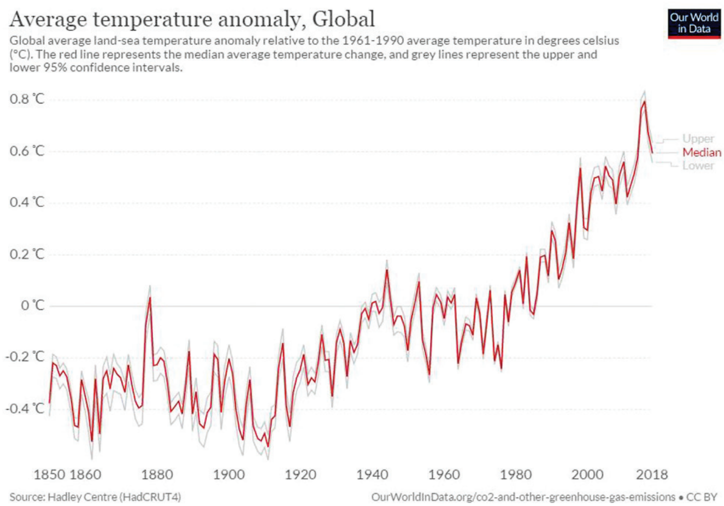

Fig. 7.18 Global average temperature (°C) relative to the average of the period between 1961 and 1990; the red line represents the median average temperature change, and the grey lines represent the upper and lower 95% confidence intervals [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions']

The temperature increase is mainly attributed to increase in CO_2 concentrations in atmosphere and atmospheric CO_2 is considered to be a principal control knob governing Earth's temperature (Lacis et al., 2010). These authors state further that ample physical evidence shows that carbon dioxide (CO_2) is the single most important climate-relevant greenhouse gas in Earth's atmosphere. This is because CO_2, like ozone, N_2O, CH_4 and chlorofluorocarbons, does not condense and precipitate from the atmosphere at current climate temperatures, whereas water vapor can and does. Noncondensing greenhouse gases, which account for 25% of the total terrestrial greenhouse effect, thus serve to provide the stable temperature structure that sustains the current levels of atmospheric water vapor and clouds via feedback processes that account for the remaining 75% of the greenhouse effect. Without the radiative forcing supplied by CO_2 and the other noncondensing greenhouse gases, the terrestrial greenhouse would collapse, plunging Earth's climate into an icebound state.

The decadal global land and ocean surface average temperature anomaly for 2011–2020 was the warmest decade on record for the globe, with a surface global temperature of +0.82°C above the 20th century average. This surpassed the previous decadal record (2001-2010) of +0.62°C. The global annual temperature has increased at an average rate of 0.08°C per decade since 1880 and over twice that rate (+0.18°C) since 1981 (Fig. 7.19). The 2020 Northern Hemisphere land and ocean surface temperature was the highest in the 141-year record at +1.28°C above average. This was 0.06°C higher than the previous record set in 2016. Meanwhile, the annual Southern Hemisphere land and ocean surface temperature was the fifth highest on record (NOAA, 2021a).

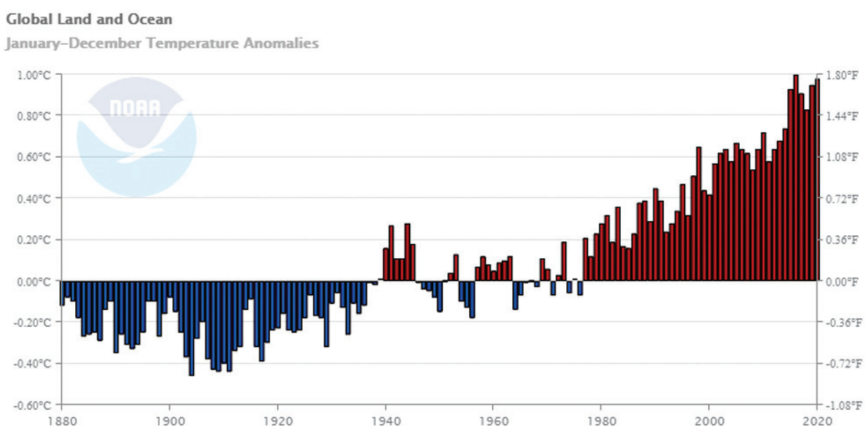

Fig. 7.19 Global land and ocean surface temperature anomalies for 1880-2020; the anomalies are relative to the 1901-2000 average (source: NOAA, 2021a; https://www.ncdc.noaa.gov/cag/global/time-series)

The year 2020 was characterized by warmer-than-average temperatures across much of the globe. Record high annual temperatures over land and ocean surfaces were measured across parts of Europe, Asia, southern North America, South America, and across parts of the Atlantic, Indian, and Pacific oceans. However, no land or ocean areas were record cold for the year. Ten warmest years on record are as follows: 2016, 2020, 2019, 2015, 2017, 2018, 2014, 2010, 2013, and 2005 (NOAA, 2021b).

Global CO_2 in Fig. 7.20 is from a combination of the Law Dome ice core record (pre-1980) and global marine atmospheric boundary layer average. The Law Dome site satisfies many of the desirable characteristics of an ideal ice core site for atmospheric CO_2 reconstructions including negligible melting of the ice sheet surface, low concentrations of impurities, regular stratigraphic layering undisturbed at the surface by wind or at depth by ice flow, and high snow accumulation rate (Etheridge et al., 1998). The marine atmospheric boundary layer (MABL) is that part of the atmosphere that has direct contact and, hence, is directly influenced by the ocean. Thus, the MABL is where the ocean and atmosphere exchange large amounts of heat, moisture, and momentum, primarily via turbulent transport (Fairall et al., 1996).

Fig. 7.20 suggests that natural temperature variations were not dominated by human influence before 1970, whereas the ongoing CO_2 increase has been dominated by human activity since then. Annual global pattern of CO_2 suggests that the increase accelerated sharply after about 1950. Natural CO_2 variations are visible in the entire record but since 1950 those variations have been dwarfed by direct human impact.

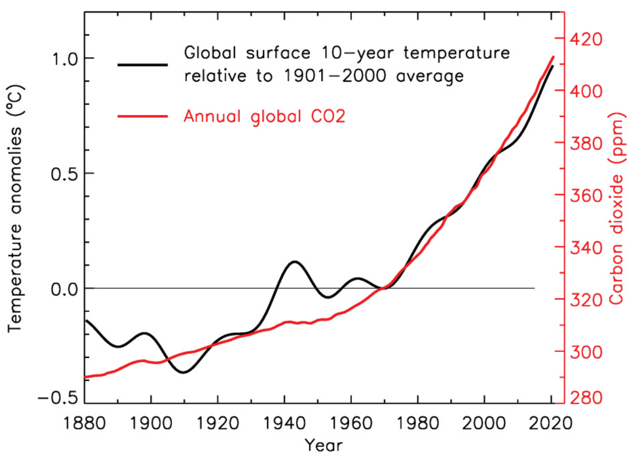

Fig. 7.20 Global surface 10-year temperature anomalies relative to 1901-2000 average, and carbon dioxide (ppm) in 1880-2020 (source: GML, Boulder, Colorado)

Delworth et al. (2016) threw new light onto the macro-scale, namely on the fact that pronounced climate changes have occurred since the 1970s, including rapid loss of Arctic sea ice, large-scale warming and increased tropical storm activity in the Atlantic. These authors state further that anthropogenic radiative forcing is likely to have played a major role in these changes, but the relative influence of anthropogenic forcing and natural variability is not well established. The above changes have also occurred during a period in which the NAO has shown marked multidecadal variations. Delworth et al. (2016) used climate models to show that observed multidecadal variations of the North Atlantic Oscillation can induce multidecadal variations in the Atlantic meridional overturning circulation and poleward ocean heat transport in the Atlantic, extending to the Arctic. Their results suggest that these variations have contributed to the rapid loss of Arctic sea ice, Northern Hemisphere warming, and changing Atlantic tropical storm activity, especially in the late 1990s and early 2000s. These multidecadal variations are superimposed on long-term anthropogenic forcing trends that are the dominant factor in long-term Arctic Sea ice loss and hemispheric warming.

7.2.5. Climate change→impact on temperature and salinity in the North Atlantic, the North Sea, and the Baltic Sea

Upper ocean temperature and salinity anomalies, normalized with respect to standard deviation, at selected locations across the North Atlantic in 2018 are shown in Fig. 7.21, whereas long-term anomalies of these parameters are presented in Fig. 7.22 (Gonźalez-Pola et al., 2019). Positive anomalies in temperature and salinity imply warm or saline conditions, whereas negative anomalies imply cool or fresh conditions. Gonźalez-Pola et al. (2019) carried out the data normalization by dividing the values by the standard deviation (SD) of the data during 1981-2010 (or the closest time-period available); a value of +2 thus represents data (temperature or salinity) measuring 2 SD higher than normal. Positive temperature anomalies (Fig. 7.22) agree with findings of Ameryk et al. (2012) pointing to a significant increase in water temperature in 0-10 water layer in the Gdańsk Basin in 1977-2010. Station 34 in the Baltic region (Fig. 7.22) falls within a larger Baltic region studied by Möllmann et al. (2000) who report negative salinity anomalies over the last few decades, observed not only in the 0-50 m water layer, but also in 50-100 m water layer (see the text and graphs that follow).

Maps of seasonal SST (Sea Surface Temperature) anomalies (°C) over the North Atlantic for 2018, presented by Gonźalez-Pola et al. (2019), are, as these authors state, from the National Oceanic and Atmospheric Administration, Optimum Interpolation Sea Surface Temperature (NOAA OISST.v2) dataset provided by the NOAA-CIRES Climate Diagnostics Center, USA (NOAA-CIRES - a partnership of NOAA and the University of Colorado Boulder) (Fig. 7.23). The data are produced on a 1° grid from a combination of satellite and in situ temperature data. The color-coded temperature scale is the same in all panels (Fig. 7.22), and the anomaly is calculated with respect to mean conditions for 1981-2010. Regions with ice cover for >50% of the averaging period appear blank. In 2018, extremely high temperatures were observed near the surface in spring-summer across the Baltic Sea and the North Sea (>1.5°C higher than normal), with less pronounced warming observed from Biscay to Ireland (+0.5-1.0°C) (Fig. 7.23).

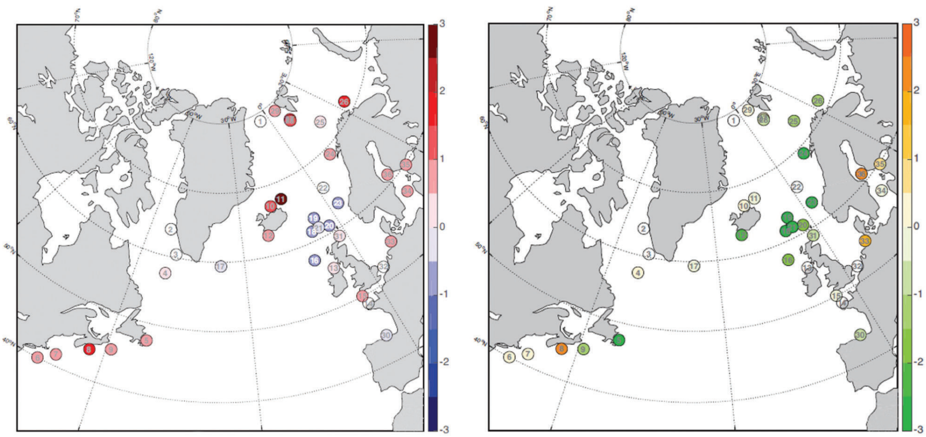

Fig. 7.21 Upper ocean temperature (left) and salinity (right) anomalies at selected locations across the North Atlantic and adjacent seas in Europe e.g. the Baltic Sea in 2018; the anomalies are normalized with respect to standard deviation (SD; e.g. a value +2 indicates 2 SD above normal) (source: Gonźalez-Pola et al., 2019; with official permission of the ICES Editor - Mrs. Ruth Anderson)

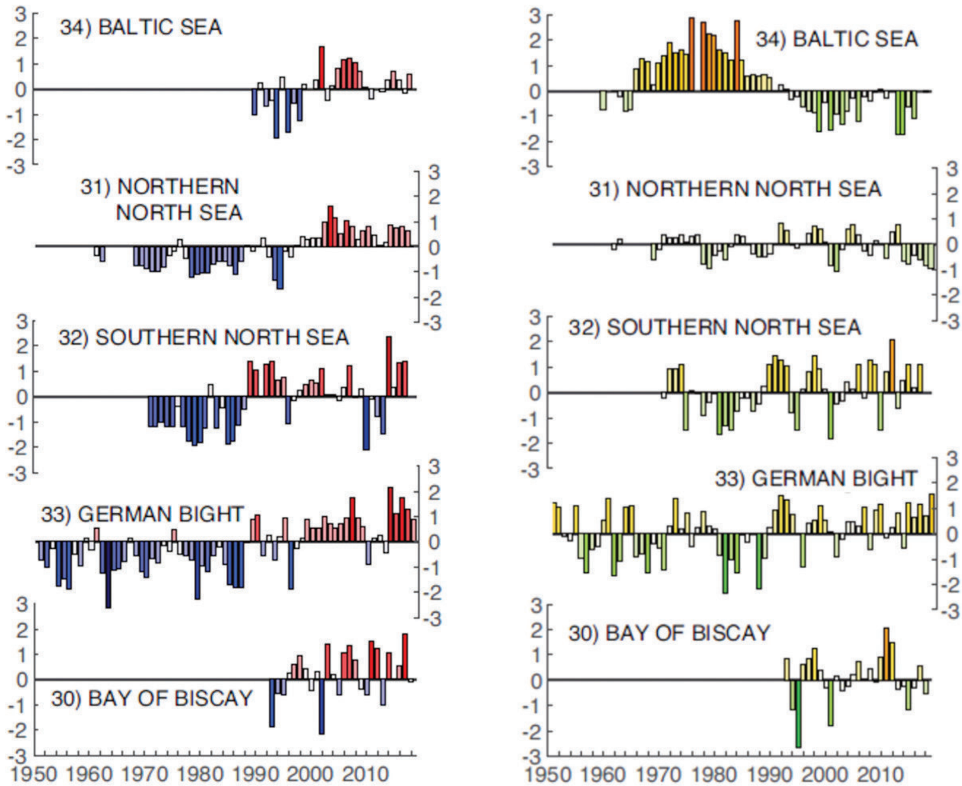

Fig. 7.22 Upper water temperature (°C) (left panel) and salinity (PSU) (right panel) anomalies in adjacent regions to the Atlantic Ocean e.g. in the Baltic Sea in 1960-2018; the anomalies are normalized with respect to standard deviation (SD., e.g. a value +2 indicates 2 SD above normal); color intervals 0.5 SD; reds: positive/warm; blues: negative/cool (source: Gonźalez-Pola et al., 2019; https://doi.org/10.17895/ices.pub.5461; with official permission of the ICES Editor - Mrs. Ruth Anderson)

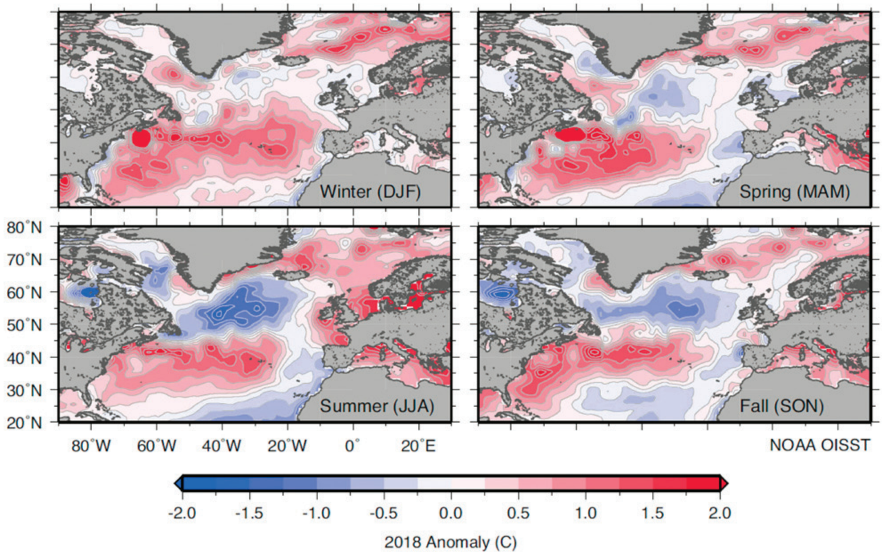

Fig. 7.23 Sea Surface Temperature anomalies (°C) in 2018 over the Atlantic Ocean and adjacent seas in Europe e.g. the Baltic Sea (source: Gonźalez-Pola et al., 2019; https://doi.org/10.17895/ices.pub.5461; with official permission of the ICES Editor - Mrs. Ruth Anderson)

The Baltic Sea is a shallow brackish sea, on the one hand supplied by rivers, on the other hand exposed to water exchange between the Baltic Proper and the North Sea (Fig. 7.24). The overall volume of the Baltic Sea water amounts to 21 547 km^3. The Baltic Sea is fed by about 250 rivers and the volume of riverine water annually supplying the sea constitutes ca. 2% (428 km^3) of the Baltic volume (Pastuszak, 2012). Like other landlocked seas in humid regions at temperate latitudes, the Baltic Sea has a positive water balance, which in turn determines the basic hydrographic and ecological properties of the sea. These properties encompass: estuarine circulation, the deepwater formation and ventilation, stratification, and the nutrient balance. Outflow of brackish surface water and inflow of saline water, combined with upwelling and vertical mixing of saline bottom water with brackish surface water, closes the estuarine circulation. The salt balance in the Baltic is maintained by advection of salty North Sea water by both intermittent barotropic and baroclinic inflows. In general, there is an outflow of low saline water in the surface layer, while compensation current transports higher saline water in the deep layer into the Baltic Sea. The mean Baltic Sea salinity is strongly related to large-scale atmospheric variability and the accumulated freshwater inflow (Elken and Matthäus, 2006; Meier et al., 2006; Lass and Matthäus, 2008). This fact has a decisive effect on structure of the water column, which is two-layered characterized by limited vertical mixing of water, which in turn causes the Baltic Sea is characterized by its natural predisposition to oxygen deficiency in the near-bottom layer.

Fig. 7.24 The Baltic Sea and its catchment area (source: map prepared and kindly made available by the *Coalition Clean Baltic*) (red dots indicate the lowermost monitoring stations on the Vistula and Oder River; IBY5 and G2 - indicate exemplary oceanographic stations belonging to grid of Polish monitoring stations)

Water exchange with the North Sea through the Sound and the Belt Sea is highly variable in direction and magnitude. The deep water of the Baltic Proper (Fig. 7.24) is replaced *via* episodic inflows of larger volumes (100-200 km^3) of highly saline (17-25 PSU - Practical Salinity Units) and oxygen-rich water; these are termed major Baltic inflows. Most major inflows occur between October and February. Although major Baltic inflows had occurred fairly regularly until early 1980s, their frequency and intensity changed after that and only a few major events have occurred since then (Elken and Matthäus, 2006; Lass and Matthäus, 2008; Mohrholz et al., 2015; Fig. 7.25). A dramatic decline in number and strength of inflows of saline and well-oxygenated waters to the Baltic Sea over the last decades is explained by climate change and predominating westerly wind direction resulting from predominating positive North Atlantic Oscillation Index (NAOI) (shortly called North Atlantic Oscillation – NAO) (Schinke and Matthäus, 1998; Meier and Kauker, 2003; Feistel et al., 2008, 2016; Mohrholz et al., 2015). Consequently, ventilation of stagnating bottom waters has considerably weakened thereby worsening oxygenation of near bottom waters in deep basins of the Baltic Sea (Hansson and Viktorsson, 2020) (Fig. 7.26), a phenomenon which should not be related exclusively to eutrophication process, but also to climatic factors affecting functioning of the Baltic Sea ecosystem (Pastuszak et al., 2018).

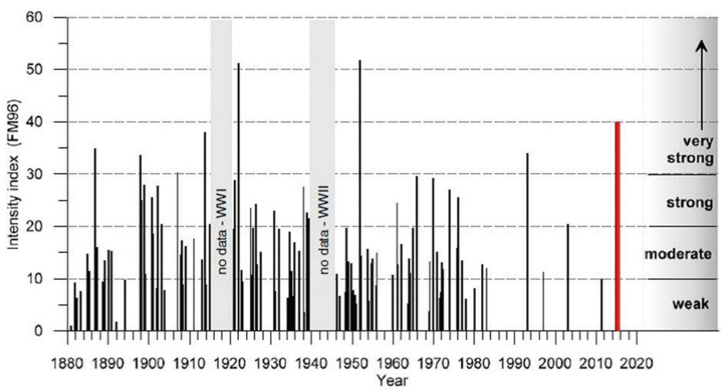

Fig. 7.25 Major inflows of saline well-oxygenated waters from the North Sea to the Baltic Sea in 1880-2013 (source: Mohrholz et al., 2015; we used this graph free of charge following the regulations contained in Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) document https://creativecommons.org/licenses/by-nc-nd/4.0/)

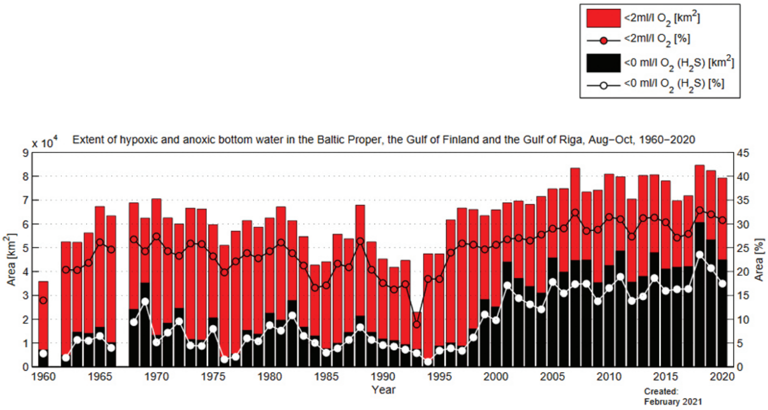

Fig. 7.26 Extent of hypoxic and anoxic bottom water in the Baltic Proper, the Gulf of Finland and the Gulf of Riga in Aug-Oct. 1960-2020 (source: Hansson and Viktorsson, 2020; with permission of the authors)

NAO phases are expressed by a standardized (normalized) difference in air pressure, measured on the sea surface, between the Azores High and the Iceland Low (Wanner et al., 2001; Lees et al., 2006; von Storch et al., 2015). The NAO index is a measure of the strength of Western air circulation. A positive NAO index means western circulation characterized by displacement from the Atlantic towards Europe of humid, warm air masses and thus increased rainfall and increased river runoff. A negative NAO index means eastern circulation carrying dry cool air masses, which in practice means reduced precipitation, lower river runoff, and cool summers. The movement of air masses has the effect of strengthening (with NAO positive), or weakening (with NAO negative) of the warm Atlantic current reaching the European continent (Hurrell, 1995; Wanner et al., 2001). Although the NAO shows long-term variability, from the mid-1960s to the mid-1990s it was in a generally positive phase, with stronger westerly winds, mild and wet winters, and increased storminess in the Baltic Sea area. After the mid-1990s, there was a trend towards more negative NAO values, resulting in weak westerly airflow and weather types that appear to be more persistent than in earlier decades (von Storch et al., 2015).

Northern Hemisphere warming has been reported by (Delworth et al., 2016), and this finding complies with other observations presented hereafter. During the past century, the Baltic Sea region was characterized by a warming trend, which was reflected in a decrease in the number of very cold days during winter as well as a decrease in the duration of ice cover and thickness in many rivers and lakes, particularly in the eastern and southeastern Baltic Sea basin. In addition, the length of the frost-free season has increased and an increasing length of the growing season in the Baltic Sea basin has been observed during this period, especially during the last 30 years (HELCOM, 2011). Von Storch et al. (2015) prove that the recent warming trend in Baltic Sea surface waters has been clearly demonstrated by in situ measurements, remote sensing data, and modeling results. In particular, remote sensing data for 1990-2008 indicate that the annual mean sea-surface temperature has increased by up to 1°C per decade, with the greatest increase in the northern Bothnian Bay and large increases in the Gulf of Finland, the Gulf of Riga, and the northern Baltic Proper. Although the increase in the northern areas is affected by the recent decline in the extent and duration of sea ice, warming is still evident during all seasons and with the greatest increase occurring in summer. The least warming of surface waters (0.3-0.5°C per decade) occurred north-east of Bornholm Island up to and along the Swedish coast, probably owing to an increase in the frequency of coastal upwelling explained by the change in atmospheric circulation (von Storch et al., 2015). These authors are of the opinion that comparing observations with the results of centennial-scale modeling, recent changes in sea-water temperature appear to be within the range of the variability observed during the past 500 years. Nonetheless, the twentieth century can be interpreted as the warmest, except for the warm anomaly around the 1730s.

MIR→NMFRI has been conducting cyclical measurements of abiotic parameters, e.g. temperature and salinity in the Baltic Proper waters since 1946. Averaged monthly temperature measurements in the water layer 0-20 m at the IBY5 station located in the western part of the Baltic Proper (see Fig. 7.24) clearly show an upward trend. In 1956-1987, the lowest temperature values would drop to -0.5°C, whereas starting from 1988 the lowest values were in the range 1.5-3°C (Fig. 7.27).

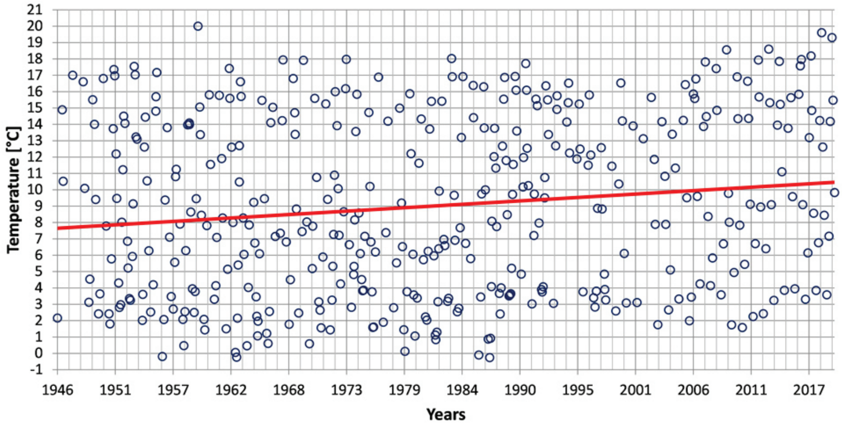

Fig. 7.27 Average monthly values of water temperature in the layer 0-20 m and the trend line at station IBY5 (western Baltic Proper - see Fig. 7.24) in 1946-2019 (source: based on the MIR→NMFRI data)

Averaged monthly salinity measurements carried out by MIR→NMFRI in 1947-2019 in the layers 0-50 m and 50-105 m at station G2 in the south-eastern Baltic Proper (see Fig. 7.24) show a declining tendency in the layer 0-50 m between 1985 and 2000, and declining trend in the layer 50-105 m between 1985 and 1993; the declines were followed by up and down trends but with values lower than those in 1950-1990 (Fig. 7.28A, C). The lowest ever recorded salinity, dropping to 8 PSU in the 50-105 layer of G2 station, was observed in 1989-1993 and that overlapped with the beginning of a long stagnation period interrupted only by 5 major water inflows from the North Sea in 1984-2015 (Figs. 7.25, 7.28C). Monthly average salinity in the 50-105 layer varied from max. ca. 13 PSU to 8 PSU in 1945-2019, thus the range of changes is much larger than in the 0-50 m layer (Fig. 7.28 A, C). We have also calculated salinity anomalies, which are differences between the average salinity values, calculated based on monthly means in 1945-2019, and a given monthly value (Fig. 7.28 B, D). The period 1992-2019 is characterized by negative salinity anomalies in the 0-50 m water layer at station G2 (Fig. 7.28 B) which remain in agreement with data presented in Fig. 7.22 (Gonźalez-Pola et al., 2019). Persistent negative salinity anomalies in 1982-1993 in the 50-105 m water layer at station G2 overlap with the stagnation period caused by lack of inflows of saline waters from the North Sea in that period of time. The number of positive salinity anomalies in deep water layer at

G2 station in 1994-2019 is much smaller than the equivalent number of anomalies in 1945-1982 (Fig. 7.28D).

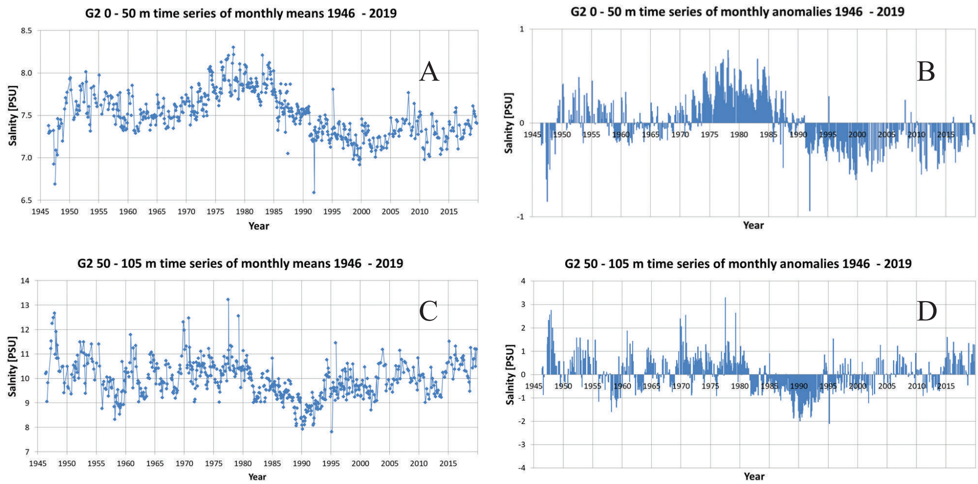

Fig. 7.28 Average monthly values of salinity (PSU) and its monthly anomalies in the layers 0-50 m and 50-105 m at station G2 (south-eastern Baltic Proper - see Fig. 7.24) in 1945-2019; please note different scales in Fig. 7.28 (A) and (C) (source: based on the MIR→NMFRI data)

7.3. Activity of NOAA in global monitoring of greenhouse gases

As carbon dioxide has been more important than all of the other greenhouse gases under human control combined, and is expected to continue so in the future, understanding the global carbon cycle is a vital part of managing global climate. **The NOAA Global Monitoring Laboratory (GML)** is a world leader in producing the regional to global-scale, long-term measurement records that allow quantification of the most important drivers of climate change today. Global monitoring of atmospheric greenhouse gases, in particular carbon dioxide (CO_2), has been part of NOAA's mission for over 50 years. GML provides and interprets high-accuracy measurements of the history of the global abundance and spatial distribution of a suite of long-lived greenhouse gases. The spatial distributions, together with models of the winds and mixing (derived from weather forecasts) allow us to infer time dependent patterns of emissions/removals that are consistent with our observations. Because the measurements are calibrated they stand on their own, and can be used far into the future with better models. They are also used as ground truth for comparisons with satellite retrievals (https://www.esrl.noaa.gov/gmd/about/theme1.html).

GML's Carbon Cycle Greenhouse Gases (CCGG) group's cooperative global air sampling network is an international effort that includes regular collection of discrete air samples from the four GML baseline observatories, cooperative fixed sites, and commercial ships. Air samples are collected approximately weekly from a globally distributed network of sites. GML CCGG group has ongoing measurements of discrete air samples from land and sea surface sites and aircraft, and continuous measurements from baseline observatories and tall towers. These measurements document the spatial and temporal distributions of carbon-cycle gases and provide essential constraints to our understanding of the global carbon cycle.

Changes in the radiative energy balance at Earth's surface and at the top of the atmosphere result from forcing by greenhouse gases, aerosols, and related changes in the global atmospheric circulation. The distribution of clouds is the primary influence on the radiation budget and is sensitive to changes in circulation, but the nature of the response of different cloud types in different climatic regions is uncertain. Cloud radiative properties are also sensitive to aerosol particles which are highly variable in space, time, and composition. The role of aerosol particles in radiative forcing is complex and can be either positive or negative and they can influence the climate directly via long term changes in light absorption and scattering. The uncertainty in cloud responses to climate forcing constituents, either through direct interaction with aerosols or through circulation changes, is the primary factor limiting our ability to narrow estimates of the climate sensitivity (the warming resulting from a change in a climate forcing agent). GML observatories host long-term measurements of globally representative, climate-critical radiation variables such as the continuous measurement of the solar energy reaching Mauna Loa Observatory that began in 1958, the longest such record on Earth. Broadband measurements of incoming and outgoing solar and terrestrial radiation are made across the U.S. and at global baseline observatories to quantify the surface radiation balance and to track changes in cloud radiative properties. GML has focused on the direct radiative effects of aerosol particles with measurements of aerosol optical properties that began in the 1970s. In response to the finding that anthropogenic aerosols create a significant perturbation in the earth's radiative balance on regional scales, GML expanded its aerosol research program to include stations for monitoring aerosol properties in regions where significant aerosol forcing was anticipated (https://www.esrl.noaa.gov/gmd/about/theme2.html).

7.4. NOAA Research Strategy - international cooperation - Poland (1992-2011)

NOAA measurements of climatically important gases began in the late 1960s and expanded in the mid-to-late 1970s for carbon dioxide (CO_2), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and upper atmospheric water vapor. Over the years other gases and isotopic ratios have been added, including methane (CH_4), carbon monoxide (CO), hydrogen (H_2), numerous hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), methyl halides, and sulfur hexafluoride (SF_6). There are four research groups in GML: **Carbon Cycle Greenhouse Gases (CCGG), Halocarbons and other Atmospheric Trace Species, Ozone and Water Vapor, and Global Radiation and Aerosols.** In this monograph, we concentrate on Carbon Cycle Greenhouse Gases; the remaining research groups and the scope of studies can be found in https://www.esrl.noaa.gov/gmd/about/research.html.

7.4.1. Sampling network, technique, and analyzes

The **CCGG *Global Greenhouse Gas Reference Network*** measures the atmospheric distribution and trends of the main long-term drivers of climate change, carbon dioxide, methane, and nitrous oxide, as well as carbon monoxide which is an important indicator of air pollution. The measurement program includes around the clock measurements at 4 baseline observatories and 8 tall towers, air samples collected by volunteers at more than 50 sites, and air samples collected regularly from small aircraft mostly in North America (Fig. 7.29).

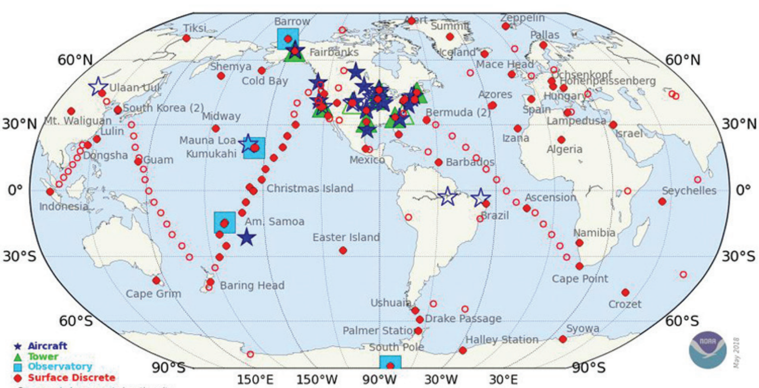

Fig. 7.29 Network of NOAA GML CCGG stations (source: https://www.esrl.noaa.gov/gmd/aggi/aggi_map.png)

Global Monitoring Laboratory produces and maintains global calibration standards for most of the climate relevant gases. The use of common standards enables measurements by different methods, and by different countries and organizations to be used together, greatly increasing the value of the international cooperative measurement system (https://www.esrl.noaa.gov/gmd/ccgg/).

Hereafter we would like to introduce the reader to the **technique of air sampling**. The air samples are collected in specially designed flasks (Fig. 7.30). Glass flasks are filled with ambient air by volunteers and scientists from locations all across the world (Fig. 7.29) in order to monitor greenhouse gases in the atmosphere. The air samples are taken in pairs. The numbers on the flasks are used to document in the database at the Flask Logistics Laboratory whether that flask is out in the field or in the lab. Each flask is surrounded with tape or plastic to protect the glass and the people handling the flasks (Fig. 7.30), but sometimes even that is not enough if the flasks are dropped. All air flasks are shipped in a foam-cushioned box to prevent damage (Fig. 7.31).

Fig. 7.30 Glass flasks used for collecting air samples. Air samples are taken in pairs as a quality assurance step (source: https://www.esrl.noaa.gov/gmd/ccgg/behind_the_scenes/surface.html)

Fig. 7.31 Shipping Box used for transporting flasks around the world (source: https://www.esrl.noaa.gov/gmd/ccgg/behind_the_scenes/surface.html)

These discrete air samples are taken twice a week (e.g. BALTIC sampling site) or weekly and are transported back to the CCGG group's Boulder Central Facility where they are analyzed for more than 50 trace gases and isotopes. This cooperative network of surface flask sampling allows CCGG to monitor how greenhouse gases are spatially distributed across the planet and how their concentration changes between seasons and years.

A portable sampling unit is used to pull outside air into the air flasks to take a sample (Fig. 7.32). It consists of an extendable air intake line, a pump, and tubing to connect two air flasks for air sampling. These devices are fairly automated and come with directions that are easy to follow, which is necessary because some of the volunteers that take air samples for the CCGG group are not scientists; in the case of the BALTIC sampling site, captains and mates of the ferry STENA BALTICA were involved in the project (Fig. 7.32).

Fig. 7.32 Portable sampling unit installed on the bridge of STENA BALTICA operating in the Baltic Sea region; in the picture - Włodzimierz Jarzyński - one of the mates on the STENA BALTICA involved in air sampling supervised by MIR→NMFRI (1992-2011) (source: picture made available by W. Jarzyński)

The air samples are returned to GML, Boulder for analysis. All measurements of up to ~55 trace gases are subject to stringent quality control procedures, and are directly traceable to internationally accepted calibration scales where possible. In fact, NOAA's Global Greenhouse Gas Reference Network maintains the World Meteorological Organization (WMO) international calibration scales for CO_2, CH_4, CO, N_2O, and SF_6 in air. WMO has a Mutual Recognition Agreement with the Bureau International des Poids et Mesures (BIPM) (https://www.bipm.org/en/about-us/), which represents the National Metrology Institutes.

The gases are measured using analyzers that use different techniques: Infrared absorption - with Non-Dispersive Infrared analyzer (NDIR) - CO_2; **VUV Fluorescence** - CO; **Gas Chromatography** - CH_4, N_2O, SF_6, and H_2. Two different gas chromatographs and 3 different detectors are used to allow complete separation of the gases we are interested in:

- CH_4 is detected using a **Flame Ionization Detector** - this consists of a hydrogen-oxygen flame, which burns CH_4 as it elutes producing ions, which are detected as a small current,
- H_2 is detected using a **Pulsed Discharge, Helium Ionization Detector** - He passing through a high-voltage discharge creates ionizing radiation that photoionizes H_2 as it elutes from the GC column producing ions that are detected,
- SF_6 and N_2O are detected using an **Electron Capture Detector** - the Electron Capture Detector (ECD) uses nickel-63, a radioactive beta (electron) emitter, to establish a current in the detector cell. As an electronegative species like SF_6 flows through the detector, it attaches electrons. The detector is operated in pulsed mode to improve linearity; as SF_6 flows into the detector, the pulsed frequency is increased to keep the current constant.

The Calibration Lab. is a vital part of CCGG's greenhouse gas measurement program. Calibration is the process of ensuring that all of the greenhouse gas measurements (in the Lab. in Boulder, at the tall towers and observatories, and at other labs. around the world) are all extremely accurate. The CCGG Calibration Lab. has been designated by the World Meteorological Organization (WMO) [The official United Nations' authoritative voice on weather, climate and water] as the world's Central Calibration Lab. (CCL) for the following greenhouse gases: CO_2, CH_4, N_2O, SF_6, and CO. The purpose of this lab. is to provide project and replacement standards with continuity over time, regardless of when and where they are used. This is how many different researchers over the world can compare and assimilate each others data without errors introduced by having different calibration scales.

7.4.2. Air sampling at the BALTIC site - Polish-American cooperation

Air sampling at the BALTIC sampling site was initiated in August 1992, following an agreement signed by MIR→NMFRI and the National Oceanic and Atmospheric Administration, Global Monitoring Laboratory, Boulder, Colorado, USA. The project lasted until 2011 and it was coordinated by Dr. Pieter Tans and Dr. Thomas Conway from the U.S. side and by Dr. Marianna Pastuszak from the Polish side.

Sampling was from the bridge of the ferry STENA BALTICA (Fig. 7.33) operating between Gdynia, Poland and Karlskrona, Sweden. The location of the air sampling site in the middle of the Baltic Sea ensured that there were no direct sources of greenhouse gas emissions that are on land. The geographical position of sampling site on STENA BALTICA was: 55°21’N 017°13’E (Fig. 7.34). Similar to other sampling sites, air samples were collected with a semi-automatic sampling system operated by captains and mates of the ferry, all of them trained in sampling. Official visits of L. Waterman, C. Prostko-Bell, and E. Dlugokencky from GML, Boulder, Colorado to Poland were connected not only with installing and checking the sampling system and training the captains and mates, as well as project coordination, but also with scientific discussions. In 2001, on the occasion of the visit by Dr. Ed Dlugokencky the MIR→NMFRI organized a seminar and the guest from the U.S. had a presentation entitled *The Global Carbon Cycle and Climate Change*. In the 1990s, L. Waterman and Polish project coordinator M. Pastuszak, embarked on the STENA BALTICA to watch live the sampling procedure on the way to Sweden and on the way back to Poland.

Air samples from the STENA BALTICA ferry were collected twice a week and the American Embassy in Warsaw, personally Ewa Kurhanowicz, was involved in sample shipment from Poland to GML in Boulder, Colorado, U.S. The BALTIC station was considered to be among the best organized stations in the whole sampling network and that fact was acknowledged by NOAA in 2003; Dr. Marianna Pastuszak, captains and mates of the STENA BALTICA involved in air sampling were rewarded with NOAA Environmental Hero Awards (see Chapter 1).

Fig. 7.33 STENA BALTICA involved in air sampling on the BALTIC station in 1992-2011 (source: https://commons.wikimedia.org/wiki/File:MS_Stena_Baltica_2007-08-31_001.jpg)

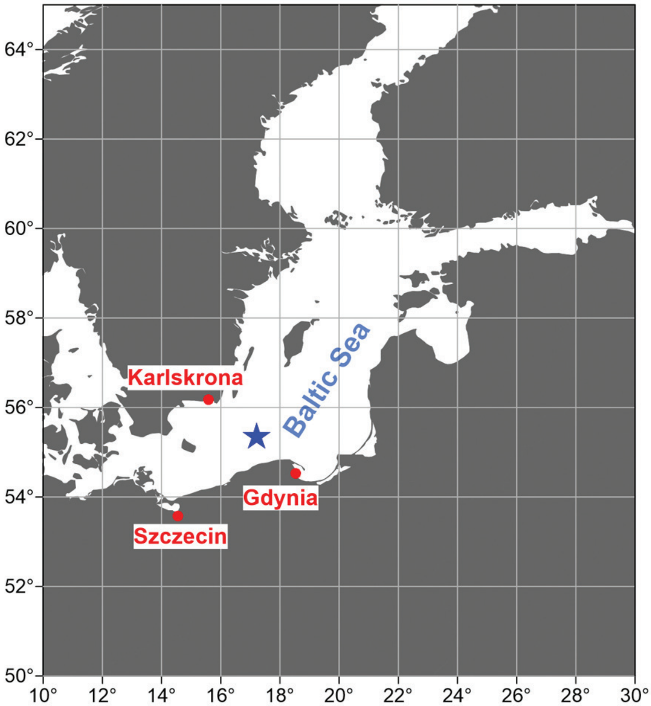

Fig. 7.34 The air sampling position at the BALTIC sampling site (blue star) installed on board the STENA BALTICA (map drawn by T. Wodzinowski, NMFRI)

7.5. Global warming – future projections, concerns, and proposed remedies

A changing climate has a range of potential ecological, physical and health impacts, including extreme weather events such as floods, droughts (resulting in wild fires), storms, and heat waves, sea-level rise, altered crop growth, and disrupted water systems. The most extensive source of analysis on the potential impacts of climatic change can be found in IPCC (2013, 2014, 2021) reports, and also in: Hoegh-Guldberg and Bruno (2010), Gruber (2011), Doney et al. (2012), Salinger (2013), Bolle et al. (2015), Viitasalo et al. (2015), Gutiérrez et al. (2016), Matishov et al. (2016), Stergiou et al. (2016), van der Lingen et al. (2016), Verheye et al. (2016), and Vivekanandan et al. (2016). Viitasalo et al. (2015) widely comment the impact of already observed and further projected climate change on Baltic Sea ecosystem functioning. The study is based on a very extensive bibliography and it covers the following specific issues: (i) community-level variations in the past, and the presented studies encompass: phytoplankton, zooplankton, open-sea benthic communities, shallow-water benthic communities, (ii) system-level variations in the past, and the presented studies encompass: regime shifts, cascading effect in the pelagic ecosystem, microbial food web, (iii) potential future system-level responses to climate change, and the presented studies encompass: pelagic dynamics, benthic dynamics, sea ice dynamics, regime shifts and cascading effects, food web efficiency, biodiversity, (iv) modeling climate change: what can be learnt from simulating future ecosystems?

Future projections of carbon dioxide and greenhouse emissions, measured in gigatonnes of carbon dioxide equivalents, have been visualized by Ritchie and Roser (2020) and Hausfather (2019). These authors present five scenarios:

- **No climate policies**: projected future emissions if no climate policies were implemented; this would result in an estimated 4.1-4.8°C warming by 2100 (relative to pre-industrial temperatures);
- **Current climate policies**: projected warming of 3.1-3.7°C by 2100 based on current implemented climate policies;
- **National pledges** (nationally determined contributions - NDC; https://www.carbonbrief.org/explainer-what-are-intended-nationally-determined-contributions): if all countries achieve their current targets/pledges set within the Paris climate agreement (https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement), it's estimated average warming by 2100 will be 2.6-3.2°C; this will go well beyond the overall target of the Paris Agreement to keep warming "well below 2°C";
- **1.5°C consistent**: there are a range of emissions pathways that would be compatible with limiting average warming to 1.5°C by 2100 (Fig. 7.35). However, all would require a very urgent and rapid reduction in global greenhouse gas emissions. If emissions had peaked and begun to decline after the year 2000, the 1.5°C target would have been much easier to achieve, only requiring reductions of around 3% per year. By contrast, limiting warming to below 1.5°C starting in 2019, without net-negative emissions, would require a 15% cut each year through to 2040. If emissions continue at current levels for another few years, then the only way to limit warming to below 1.5°C in the absence of net-negative emissions would be to immediately cut all global emissions to zero. Each year that passes without global emission reductions puts the 1.5°C target further out of reach (Fig. 7.35; https://www.carbonbrief.org/unep-1-5c-climate-target-slipping-out-of-reach);
- **2°C consistent**: there are a range of emissions pathways that would be compatible with limiting average warming to 2°C by 2100 (Fig. 7.36). This would require a significant increase in ambition of the current pledges within the Paris Agreement. While the below 2°C target is easier to achieve than 1.5°C, delays will make it

increasingly difficult, too. Fig. 7.36 shows the emission reductions needed, by peaking year, to meet the 2°C target without use of net-negative emissions. If global emissions had peaked in the year 2000, they would have had to decline at a gradual 1-2% per year to limit warming below 2°C by 2100. A more difficult, but still achievable, rate of around 4% to 5% per year would be needed if emissions peak and start to decline after 2019. However, if reductions are delayed for another decade, meeting the 2°C target becomes much more challenging, requiring emissions to fall by 7% per year (Fig. 7.36; https://www.carbonbrief.org/unep-1-5c-climate-target-slipping-out-of-reach).

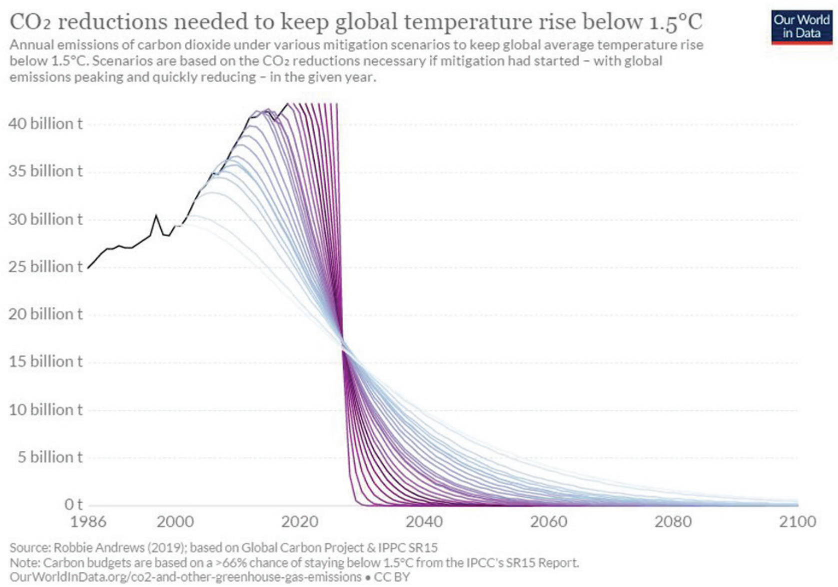

Fig. 7.35 Annual emissions of carbon dioxide under various mitigation scenarios to keep global average temperature rise below 1.5°C [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

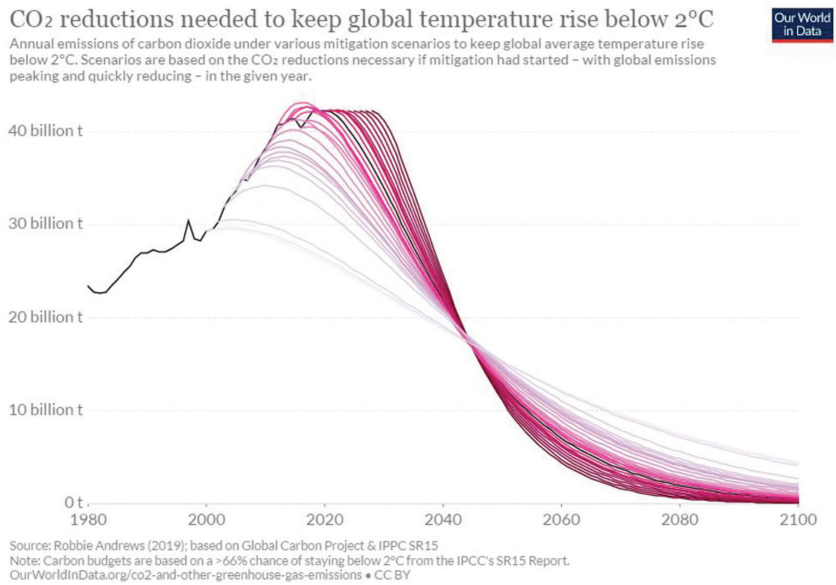

Fig. 7.36 Annual emissions of carbon dioxide under various mitigation scenarios to keep global average temperature rise below 2°C [source: Ritchie and Roser (2020) "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions'; sources of input data are visible within the field of graph]

Studies reviewed by Hoegh-Guldberg and Bruno (2010) indicate that rapidly rising greenhouse gas concentrations are driving ocean systems toward conditions not seen for millions of years, with an associated risk of fundamental and irreversible ecological transformation. In the opinion of the above mentioned authors there is considerable uncertainty about the spatial and temporal details but climate change is clearly and fundamentally altering ocean ecosystems. As these authors further state, the impacts of anthropogenic climate change so far include decreased ocean productivity, altered food web dynamics, reduced abundance of habitat-forming species, shifting species distributions, and a greater incidence of disease. Increases in the heat content of the ocean have driven thermal expansion of the oceans as well as increased melt water and discharged ice from terrestrial glaciers and ice sheets have increased ocean volume and hence sea level. Warmer oceans also drive more intense storm systems; the warming of the upper layers of the ocean drives greater stratification of the water column, reducing mixing in some parts of the ocean and consequently affecting nutrient availability and primary production. These changes have increased the size of the nutrient-poor "ocean deserts" of the Pacific and Atlantic by 15%, over the period 1998 to 2006 (Polovina et al., 2008; Hoegh-Guldberg and Bruno, 2010). Hoegh-Guldberg and Bruno (2010) also comment on consequences of decreasing oxygen content due to increase in sea water temperature and on decrease in salinity in surface layer in Polar Regions due to ice melt.

In marine ecosystems, rising atmospheric CO_2 and climate change are associated with concurrent shifts in temperature, circulation, stratification, nutrient input, oxygen content, and ocean acidification, with potentially wide-ranging biological effects. Direct effects of changes in ocean temperature and chemistry may alter the physiological functioning, behavior, and demographic traits (e.g., productivity) of organisms, leading to shifts in the size structure, spatial range, and seasonal abundance of populations. These shifts, in turn, lead to altered species interactions and trophic pathways as change cascades from primary producers to upper-trophic-level fish, seabirds, and marine mammals, with climate signals thereby propagating through ecosystems in both bottom-up and top-down directions. Changes in community structure and ecosystem function may result from disruptions in biological interactions. Therefore, investigating the responses of individual species to single forcing factors, although essential, provides an incomplete picture and stresses the need for more comprehensive, multispecies- to ecosystem-level analyses (Doney et al., 2012; Pastuszak et al., 2018).

Gruber (2011) is of the opinion that in the coming decades and centuries, the ocean's biogeochemical cycles and ecosystems will become increasingly stressed by at least three independent factors: rising temperatures, ocean acidification and ocean deoxygenation [i.e., the loss of dissolved oxygen (O_2) from the ocean, which is bound to occur in a warming and more stratified ocean]. These changes will tend to operate globally, although with distinct regional differences and will affect the ocean's biogeochemical cycles and ecosystems in ways that we are only beginning to fathom. Ocean warming will not only affect organisms and biogeochemical cycles directly, but will also increase upper ocean stratification. The changes in the oceans' carbonate chemistry induced by the uptake of anthropogenic carbon dioxide (CO_2) (i.e., ocean acidification) will probably affect many organisms and processes, although in ways that are currently not well understood. The impacts of ocean acidification tend to be strongest in the high latitudes, whereas the low-oxygen regions of the low latitudes are most vulnerable to ocean deoxygenation. Specific regions, such as the eastern boundary upwelling systems, will be strongly affected by all three stressors, making them potential hotspots for change. Of additional concern are synergistic effects, such as ocean acidification-induced changes in the type and magnitude of the organic matter exported to the ocean's interior, which then might cause substantial changes in the oxygen concentration there. Ocean warming, acidification and deoxygenation are essentially irreversible on centennial time scales, i.e., once these changes have occurred, it will take centuries for the ocean to recover. With the emission of CO_2 being the primary driver behind all three stressors, the primary mitigation strategy is to reduce these emissions. Gruber (2011) further states that substantial mitigation measures are required if the ocean is to be spared from this triple whammy. The primary objective must be to reduce emissions of CO_2, but it is important to limit the growth of all greenhouse gases, as all of them contribute to ocean warming and deoxygenation. The strategy should include not only the changes we are already committed to by past emissions, but also those that will occur in the future as it is difficult to foresee a future without a substantial additional increase in the atmospheric burdens of CO_2 and other greenhouse gases. How should the problem be tackled? Gruber (2011) suggests that dedicated research efforts are required to shed more light on the connected issues of acidification and deoxygenation. According to this author, the joint perspective, where the full and synergistic effect of all three stressors acting at the same time is investigated is missing and it requires a coordinated approach, which would span the range from detailed laboratory studies and *in situ* manipulation experiments to large-scale monitoring and modeling approaches.

Von Storch et al. (2015) provided an extensive summary and conclusions in the BACC II Author Team, Second Assessment of Climate Change for the Baltic Sea basin. Although some of their conclusions were drawn based on studies carried out in the Baltic basin, they are concerned with other Large Marine Ecosystems (see Chapter 1); therefore they are worth mentioning in this elaboration:

- changes in the hydrological cycle are expected to become obvious in the coming decades,
- regional warming is almost certain to have a variety of effects on terrestrial and marine ecosystems - some will be more predictable (such as the changes in phenology) than others,
- climate change is a compounding factor for major drivers of changes in freshwater biogeochemistry, but evidence is still often based on small-scale studies in time and space; the effect of climate change cannot yet be quantified on a basin-wide scale,
- scenario simulations suggest that the Baltic Sea water may become more acidic in the future; increased oxygen deficiency, increased temperature, changed salinity, and increased ocean acidification are expected to affect the marine ecosystem in various ways and may erode the resilience of the ecosystem,

- when addressing climate change impacts on, for example, forestry, agriculture, urban complexes, and the marine environment in the Baltic Sea basin, a broad perspective is needed which considers not only climate change but also other significant factors such as changes in emissions, demographic and economic changes, and changes in land use.

Today's anthropogenic climate change is largely driven by increasing greenhouse gases (GHGs) in the atmosphere, modified to some extent by the distribution of aerosols and aerosol properties. To understand the influence of changing atmospheric composition on climate change and minimize its eventual magnitude, society needs the best possible information on the trends, distributions, emissions and removals of greenhouse gases. It is necessary to develop a solid scientific understanding of their natural cycles, and how human management and the changing climate influence those cycles. Atmospheric measurements can also provide fully transparent and objective quantification of emissions, supporting national and regional emissions reduction policies and generating trust in international agreements (https://www.esrl.noaa.gov/gmd/about/theme2.html).

Jain (1993) is of the opinion that limitation and adaptation strategies need to be developed and implemented. Decreasing use of fossil fuels and increasing use of alternative sources of energy: solar, wind, hydro, biomass - coupled with energy conservation strategies are needed to reduce emissions of greenhouse gases. Reducing deforestation and embarking on reforestation programs is needed to increase the sinks of carbon dioxide. More research is needed to enable better understanding of climate processes and decrease uncertainties in climate predictions. Climate data, analyses and information need to be utilized in planning processes.

Leip et al. (2015) state that in Europe (European Union), the agricultural sector significantly contributes to global warming (12%) and to worsening of N water quality (59%). Therefore, the authors are of the opinion that significant progress in mitigating these environmental impacts in Europe will only be possible through a combination of technological measures reducing livestock emissions, improved food choices and reduced food waste of European citizens.

Reusch et al. (2018) argue that the Baltic Sea can serve as a time machine to study consequences and mitigation of future coastal perturbations, due to its unique combination of an early history of multi-stressor disturbance and ecosystem deterioration and early implementation of cross-border environmental management to address drastic changes driven by climate change and increasing anthropogenic pressures in coming decades. The authors further emphasize that the Baltic Sea also stands out in providing a strong scientific foundation and accessibility to long-term data series that provide a unique opportunity to assess the efficacy of management actions to address the breakdown of ecosystem functions.

7.6. References

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APPENDICES

LONGSTANDING POLISH-AMERICAN RESEARCH
OCEANS AND ATMOSPHERE

Marianna Pastuszak, Emil Kuzebski (Eds.)

APPENDICES

Marianna Pastuszak, Emil Kuzebski (Eds.)

Longstanding Polish-American research
Oceans and atmosphere

APPENDIX I
Ref. Chapter 1 - Environmental Hero Award - documents

Press release: Press release concerning Environmental Hero Award for Polish scientist and the crew members from the ferry boat "STENA BALTICA" involved in the project (source: private archives of M. Pastuszak)

MIR

A scientist from the Sea Fisheries Institute and the crew from STENA BALTICA receive the Environmental Hero Award **from NOAA**

Stena Line

A scientist from the Sea Fisheries Institute (SFI) in Gdynia Dr. Marianna Pastuszak and the following crew members from the *STENA BALTICA* ferry boat: captains - Krzysztof Romowicz, Adam Kędziora, Darek Grzybek, Marek Czapiewski, and mates – Włodzimierz Jarzyński, Andrzej Kalicki, Piotr Kamiński, Janusz Maślanka, Mieczysław Miakinko, Daniel Skrzypek, Konrad Soćko, Robert Żuk have been named **Environmental Heroes** by the National Oceanic and Atmospheric Administration (NOAA)**,** for over a decade long cooperation with NOAA Laboratories studying carbon cycle in natural environment and global climate change.

Polish Baltic sampling station is supervised by Dr. Marianna Pastuszak and it was incorporated in the global network of stations in August 1992. Since that moment the air samples are taken twice a week from onboard the ferry boat m/t *STENA BALTICA* owned by the STENA LINE. The ferry boat operates on a regular basis between Gdynia (Poland) and Karlskrone (Sweden). Four captains and eight mates are directly involved in the sampling at the sampling station whose geographical position is described by the coordinates. The collected samples are shipped to the American Embassy in Warsaw and then to Climate Monitoring and Diagnostic Laboratory in Boulder, Colorado (USA), where they are analyzed to determine concentrations of trace gases such as carbon dioxide, methane, carbon dioxide etc. responsible, among other factors, for the climatic changes taking place at present on the globe.

According to the statement expressed by the American coordinator of the project Dr. Thomas Conway the conduct of the project in this part of the globe would not be possible without cooperation with Dr. M. Pastuszak, the captains and the mates from the *STENA BALTICA*. "NOAA and the world are fortunate to have such dedicated people who volunteer so much of their time," said retired Navy Vice Adm. Conrad C. Lautenbacher, Ph.D., undersecretary of commerce for oceans and atmosphere and NOAA administrator. „They set a perfect example for others to follow in their communities. The world needs more environmental heroes like them". „On behalf of the 12,500 men and women working for the National Oceanic and Atmospheric Administration, I am pleased to present you with this 2003 Environmental Hero Award," Lautenbacher wrote in a letter to the recipients. „Your dedicated efforts and outstanding accomplishments greatly benefit the environment...".

The **Environmental Hero Award** was established in 1995 to commemorate the 25th anniversary of Earth Day, and it is presented to individuals and organizations that volunteer their time and energy to help NOAA carry out its mission. Previous 35 recipients include oceanographers Jean-Michel Cousteau and Sylvia Earle, and actor Ted Danson, head of the American Oceans Campaign.

A ceremonial handing of the awards to the recipients in the year 2003 will take place in the American Embassy in Warsaw on 17 June 2003.

After: **United States Department of Commerce NEWS**
National Oceanic and Atmospheric Administration (NOAA)
Washington, D.C. 20230

Message from Dr. Thomas Conway at the Environmental Hero Award Ceremony (source: private archives of M. Pastuszak)

Thank you, Ambassador Hill, for your hospitality and hosting this ceremony at the U.S. Embassy in Poland.

The National Oceanic and Atmospheric Administration operates a Cooperative Global Air Sampling Network to determine the trends and variations of atmospheric trace gases that potentially affect climate. From these measurements we know that the amount of carbon dioxide in the atmosphere is increasing due primarily to emissions from combustion of fossil fuels. Many scientists believe that increases in CO_2*, and other greenhouse gases, will change the earth's climate.*

However, we also know that about one half of the fossil fuel CO_2 *emitted each year remains in the atmosphere; the other half dissolves into the ocean, or is taken up by plants on land. We call these removal processes "carbon sinks." Without these carbon sinks, atmospheric* CO_2 *would be increasing about twice as fast as is currently observed.*

Because the CO_2 *sinks vary significantly over space and time, data from a global network are needed to constrain estimates of their magnitude and to understand the processes that cause them. Quantifying and understanding these carbon sinks is crucial for governments and society in general to make informed decisions on energy policy and climate change.*

Since 1992 air samples have been collected on ships sailing across the Baltic Sea between Gdynia, Poland and Karlskrona, Sweden. For the past several years samples have been collected on ferries operated by the Stena Line. The Stena Line and the ship Captains permit the installation of air sampling equipment, and the ship's officers collect the samples 3 times each week. The U.S. Embassy in Warsaw also participates in this project by facilitating the transport of the air samples between Gdynia and the NOAA laboratories in Boulder, Colorado, where the measurements are made. These samples provide an extremely valuable record of CO_2 *and other trace gases in regionally polluted European air.*

For their excellent cooperation, the U.S. National Oceanic and Atmospheric Administration thanks the Stena Line, and recognizes the Captains and Mates as Environmental Heroes. They are being presented today with a certificate and a letter from the NOAA Administrator, Vice Admiral Conrad Lautenbacher, who praises them for assisting NOAA in "providing the sound science and service essential to addressing our nation's and the world's environmental challenges."

It is also my pleasure to make specific mention of my scientific colleague in this endeavor, Dr. Marianna Pastuszak. Dr. Pastuszak, an oceanographer at the Sea Fisheries Institute in Gdynia, has made essential contributions in starting the measurement program and ensuring its continuity, moving the equipment to different ships, convincing the Captains and the Stena Line to allow this project, and training the Mates in the air sampling procedures. It is fair to say that without Dr. Pastuszak's contributions, this important 10 year measurement record would not exist.

When I talk to people about NOAA's Global Network, I like to say it is a network not of stations, but a network of people. In my 22 years of working with this network, Dr. Pastuszak is one of the most dedicated, and fun, people with whom I have had the pleasure of working. Dr. Pastuszak demands excellence of herself and those with whom she works.

So, on behalf of NOAA, I am pleased to recognize Dr. Marianna Pastuszak as an Environmental Hero, and offer my thanks and congratulations to Marianna and all the recipients. You have all made a valuable and enduring contribution to the study of the global carbon cycle and global climate change. Thank you very much!

Message from Dr. Marianna Pastuszak at the Environmental Hero Award Ceremony (source: private archives of M. Pastuszak)

Mr. Ambassador, distinguished guests!

All of us who received the ENVIRONMENTAL HERO AWARDS today feel very grateful to the Carbon Monitoring and Diagnostic Laboratory in Boulder, Colorado for nominating us for such a prestige Award; we feel very happy and proud that National Oceanic and Atmospheric Administration has selected us as HEROES of the year 2003.

We are proud not only because we are the first Poles presented with this Award; we are proud because from the very beginning of the ongoing project we were certain that we contributed to studies which were and are extremely important for all the nations all over the globe. Transport of air pollutants does not respect borders between countries, therefore any efforts aiming at environment protection should be and must be united. The role of scientists is to monitor parameters which constitute a potential threat to the environment and to call the decision makers' attention to the arising problems.

We were invited to join the "carbon cycle - global climate change"project, led by the scientists from the NOAA institution in Boulder, Colorado in 1992. The proposal came to the Sea Fisheries Institute in Gdynia because by that time my Institute and I personally had already been closely cooperating with the NOAA institutions for over 20 years. For the past 12 years we have been concentrating on studying changes taking place in the atmosphere, for the previous 20 years we had studied the world ocean. Both, the American partners and Poles were so determined to continue the cooperation that even the "martial law" or "the wind of change" over the last decade did not wipe us out from the field of studies. The crew members from the present STENA BALTICA were as determined as me and we managed to overcome all the inconveniences related to the transformation period.

Personally, I consider the Environmental Hero Award handed to me today as a recognition of my and my Institute's over 30-year-cooperation with the NOAA institutions. I am looking forward to continuing this inspiring cooperation!

Taking opportunity I would like to thank our American partners from the CMDL group, in particular its leader Dr. Pieter Tans, and present here Dr. Thomas Conway for their superb leadership. It has been my great pleasure to cooperate with such dedicated personnel as that from the CMDL in Boulder, Colorado.

I would like to thank my project partners - that is - all the captains and the mates from the STENA BALTICA owned by the STENA LINE. Their great interest in the project and enthusiasm are worth admiring. I would like to thank the STENA LINE for letting us continue the studies on the new ferry boat.

My words of appreciation also go to the employees of the American Embassy in Warsaw, in particular to Mrs. Ewa Kurhanowicz, for helping us with shipment of the samples.

And last but not least – I would like to thank the authorities of the American Embassy for organizing this very nice ceremony for us.

Thank you for your attention!

APPENDIX II
Ref. Chapter 2

Meetings of the Advisory Committee of the Plankton Sorting and Identification Center in 1975 - 2020

The First ACM Szczecin, Poland August 26-28, 1975	
Poland	**USA**
Dr. Kazimierz Siudziński, Representing the Director of Sea Fisheries Institute, Gdynia	Dr. Robert L. Edwards, NEFC Director, Woods Hole
Dr. Idzi Drzycimski, Head of the Center,	Mr. Kenneth Sherman, NEFSC Narragansett
Dr. Leonard Ejsymont, Deputy Head of the Center, Szczecin	Mr. Robert Marak, NEFSC Narragansett

The Second ACM Szczecin, Poland October 15-17, 1976	
Poland	**USA**
Dr. Jan Piechura, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Robert L. Edwards, NEFC Director, Woods Hole
Dr. Idzi Drzycimski, Head of the Center, Szczecin	Mr. Kenneth Sherman, NEFSC Narragansett
Dr. Leonard Ejsymont, Deputy Head of the Center, Szczecin	Mr. Robert Marak, NEFSC Narragansett
	Mr. Norman Pease, RFA Copenhagen (Observer)

The Third ACM Szczecin, Poland June 15-17, 1977	
Poland	**USA**
Dr. Jan Piechura, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Kenneth Sherman, NEFSC Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Robert Marak, NEFSC Narragansett
Dr. Leonard Ejsymont, Head of the Center	Mr. Wallace Smith, Sandy Hook Lab
	Dr. George Grice, (Observer)

The Fourth ACM Narragansett – Woods Hole, Massachusetts, USA September 11-14, 1978	
Poland	**USA**
Dr. Ryszard Maj, Director of Sea Fisheries Institute, Gdynia	Dr. Robert L. Edwards, NEFC Director, Woods Hole
Dr. Jan Piechura, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Kenneth Sherman, NEFSC Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Robert Marak, NEFSC Narragansett
Dr. Henryk Kurowski (Ministry of Science, Education and Technologies), Warsaw	Mr. Wallace Smith, Sandy Hook Lab

The Fifth ACM Gdynia – Szczecin, Poland May 15-18, 1979	
Poland	**USA**
Dr. Jan Piechura, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Kenneth Sherman, NEFSC Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Robert Marak, NEFSC Narragansett
Mr. Marek Baranowski, Deputy Head of the Center, Szczecin	Mr. Wallace Smith, Sandy Hook Lab
Dr Jerzy Płociak, Center Fisheries Board, Szczecin	
Mr. Stefan Grimm, SFI Gdynia (Observer)	

The Sixth ACM Narragansett, USA May 19-23, 1980	
Poland	**USA**
Dr. Andrzej Ropelewski, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Kenneth Sherman, NEFSC Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Robert Marak, NEFSC Narragansett
Dr Jerzy Płociak, Chief, Division for Scientific Reasearch Coordination and Development Fiheries Central Board, Szczecin	Mr. Wallace Smith, Sandy Hook Lab
Mr. Stefan Grimm, SFI Gdynia (Observer)	Dr. Reuben Lasker, NMFS, La Jolla, (Observer)
	Dr. Arthur Kendall, NMFS, Seattle, (Observer)
	Mr. Thomas Potthoff, NMFS, Miami, (Observer)

The Seventh ACM Gdynia, Poland July 7-8, 1981	
Poland	**USA**
Dr. Bohdan Draganik, Director of Sea Fisheries Institute, Gdynia	Mr. Kenneth Sherman, NMFS Narragansett
Dr. Andrzej Ropelewski, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Robert Marak, NEFSC Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Wallace Smith, Sandy Hook Lab
	Dr. Reuben Lasker, NMFS, La Jolla, (Observer)
	Dr. Arthur Kendall, NMFS, Seattle, (Observer)
	Mr. Thomas Potthoff, NMFS, Miami, (Observer)

The Eight ACM Narragansett, USA March 30 – April 1, 1982	
Poland	**USA**
Dr. Andrzej Ropelewski, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Robert Marak, NMFS, Narragansett
Ms. Hanna Fidelus-Ferlas, SFI Sczecin	Mr Wallace Smith, NMFS, Sandy Hook
	Mr. Martin Newman, NMFS, Oxford
	Ms. Sharon MacLean, NMFS, Oxford

The Ninth ACM Narragansett, USA June 6-8, 1983	
Poland	**USA**
Dr. Andrzej Ropelewski, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Robert Marak, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr Wallace Smith, NMFS, Sandy Hook
	Mr. Martin Newman, NMFS, Oxford
	Ms. Ann Matarese, NMFS, Seattle
	Mr. Thomas Potthoff, NMFS, Miami

The Tenth ACM Szczecin, Poland June 20-22, 1984	
Poland	**USA**
Dr. Bohdan Draganik, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Robert Marak, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr Wallace Smith, NMFS, Sandy Hook
Mr. Vagn Hansen, Danish Institute for Fisheries and Marine Research, (Observer)	Mr. Thomas Potthoff, NMFS, Miami
	Ms. Jean Dunn, NMFS, Seattle

The Eleventh ACM Narragansett, USA June 18-19, 1985	
Poland	**USA**
Dr. Andrzej Ropelewski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Mr Wallace Smith, NMFS, Sandy Hook
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. William Richards, NMFS, Miami
	Dr. Arthur Kendall, NMFS, Seattle
	Mr. Kenneth Stuck, GCRL, Mississippi

The Twelfth ACM Szczecin, Poland July 9-11, 1986	
Poland	**USA**
Dr. Andrzej Ropelewski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Kenneth Stuck, GCRL, Mississippi
Dr. Leonard Ejsymont, Head of the Center, Szczecin	

The Thirteenth ACM Narragansett, USA June 24-26, 1987	
Poland	**USA**
Dr. Andrzej Ropelewski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Wallace Smith, NMFS, Sandy Hook
	Dr. William Richards, NMFS, Miami

The Fourteenth ACM Narragansett, USA June 24-26, 1988	
Poland	**USA**
Dr. Daniel Dutkiewicz, Acting Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. Wallace Smith, NMFS, Sandy Hook
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. Jack Jossi, NMFS, Narragansett
	Dr. Arthur Kendal, NMFS, Seattle
	Dr. Donald Hoss, NMFS, Beaufort

The Fifteenth ACM Szczecin, Poland October 3-6, 1989	
Poland	**USA**
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Donald Hoss, NMFS, Beaufort
Dr. Leonard Ejsymont, Head of the Center, Szczecin	

The Sixteenth ACM Szczecin, Poland 9-12 June, 1990	
Poland	**USA**
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Jerzy Janson, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Donald Hoss, NMFS, Beaufort
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Mr. John Green, NMFS, Narragansett
	Dr. Arthur Kendall, NMFS, Seattle
	Mr. Wallace Smith, NMFS, Sandy Hook

The Seventeenth ACM Szczecin, Poland 18-21 June, 1991	
Poland	**USA**
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Borys Kisler, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Donald Hoss, NMFS, Beaufort
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Arthur Kendall, NMFS, Seattle
Mr. Vagn Hansen, Danish Institute for Fisheries and Marine Research, (Observer)	Dr. Jeff Napp, NMFS, Seattle

The Eighteenth ACM Narragansett, USA 15-17 June, 1992	
Poland	**USA**
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
	Mr. John Green, NMFS, Narragansett
	Dr. Arthur Kendall, NMFS, Seattle
	Mr. Wallace Smith, NMFS, Sandy Hook
	Dr. Jeff Napp, NMFS, Seattle
	Mr. Wallace Smith, NMFS, Sandy Hook
	Mr. Jack Jossi, NMFS, Narragansett
	Ms. Donna Busch, NMFS, Narragansett

The Nineteenth ACM Szczecin / Gdynia, Poland 14-19 June, 1993	
Poland	**USA**
Dr. Zbigniew Karnicki, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Donald Hoss, NMFS, Beaufort
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Arthur Kendall, NMFS, Seattle
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Mr. Rene Eppi, NOAA, Rockville
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Mr. Robert Marak, NMFS, Narragansett
Mr. Vagn Hansen, Danish Institute for Fisheries and Marine Research, (Observer)	Mr. Robert Williams, NERC, Plymouth, UK, (Observer)

The Twentyth ACM Seattle, USA 14-16 June, 1994	
Poland	**USA**
Dr. Zygmunt Polański, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Arthur Kendal, NMFS, Seattle
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
Mr. Mirosław Ciupiński, Head of the Administrative Section of the Center	Dr. Jeff Napp, NMFS, Seattle
	Dr. Ann Matarese, NMFS, Seattle
	Mr. Jack Green, NMFS, Narragansett

The Twenty-first ACM Szczecin, Poland 19-22 June, 1995	
Poland	**USA**
Dr. Zygmunt Polański, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Arthur Kendal, NMFS, Seattle
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
Mr. Mirosław Ciupiński, Head of the Administrative Section of the Center	Dr. Jeff Napp, NMFS, Seattle
	Dr. Ann Matarese, NMFS, Seattle

The Twenty-second ACM Beaufort, USA 3-6 June, 1996	
Poland	**USA**
Dr. Zygmunt Polański, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Arthur Kendal, NMFS, Seattle
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
	Dr. Jeff Napp, NMFS, Seattle
	Dr. John Govoni, NMFS, Beaufort
	Mr. John Green, NMFS, Narragansett
	Dr. Roger Robins, NMFS, Beaufort
	Dr. Allyn Powell, NMFS, Beaufort
	Ms. Donna Busch, NMFS, Narragansett

The Twenty-third ACM Szczecin, Poland 14-18 July, 1997	
Poland	**USA**
Dr. Zygmunt Polański, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Arthur Kendal, NMFS, Seattle
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
Mr. Mirosław Ciupiński, Head of the Administrative Section of the Center	Dr. Jeff Napp, NMFS, Seattle
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Mr. Robert Marak, NMFS, Narragansett
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	

The Twenty-fourth ACM Narragansett, USA 22-25 June, 1998	
Poland	**USA**
Dr. Zygmunt Polański, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. John Green, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Ms. Carolyn Griswold, NMFS, Narragansett
	Ms. Julien Goulet, Jr., NMFS,
	Mr. Alonzo Hamilton, Jr, NMFS, Pascagoula
	Dr. Jonathan Hare, NMFS, Beaufort
	Dr. Arthur Kendal, NMFS, Seattle
	Ms. Sharon MacLean, NMFS, Narragansett
	Mr. Robert Marak, NMFS, Narragansett
	Dr. David Mountain, NMFS, Woods Hole

The Twenty Fifth ACM Szczecin, Poland 7-9, 1999	
Poland	**USA**
Dr. Daniel Dutkiewicz, Acting Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Tomasz Linkowski, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Arthur Kendal, NMFS, Seattle
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Mr. Robert Marak, NMFS, Narragansett
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Ms. Ann Matarese, NMFS, Seattle
Mr. Mirosław Ciupiński, Head of the Administrative Section of the Center	Mr. Thomas Azarovitz, NMFS, Woods Hole

The Twenty Sixth ACM Seattle, USA 5-9 June, 2000	
Poland	**USA**
Dr. Tomasz Linkowski, Acting Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Ms. Donna Busch, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Ms. Sharon MacLean, NMFS, Narragansett
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Gulf Springs
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Bruce Wing, NMFS, Auke Bay
	Ms. Ann Matarese, NMFS, Seattle
	Dr. Arthur Kendal, NMFS, Seattle
	Dr. Jeff Napp, NMFS, Seattle

The Twenty Seventh ACM Gdynia, Poland 25-27 June, 2001	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Daniel Dutkiewicz, Deputy Director of Sea Fisheries Institute, Gdynia	Ms. Sharon MacLean, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
Dr. Andrzej Jaworski, SFISzczecin	Dr. Jonathan Hare, NMFS, Beaufort

The Twenty Eight ACM Beaufort, USA 4-6 June, 2002	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Ms. Sharon MacLean, NMFS, Narragansett
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
	Dr. Donald Hoss, NMFS, Beaufort
	Dr. Jonathan Hare, NMFS, Beaufort
	Dr. Ann Matarese, NMFS, Seattle

The Twenty Ninth ACM Szczecin, Poland 10-12 June, 2003	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Zbigniew Karnicki, Deputy Director of Sea Fisheries Institute, Gdynia	Ms. Donna Busch, NMFS, Narragansett
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Ann Matarese, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	

The Thirtieth ACM Narragansett, USA 7-10 June, 2004	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Ms. Donna Busch, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy	Dr. Ann Matarese, NMFS, Seattle
Section of the Center, Szczecin	
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	Dr. Donald Hoss, NMFS, Beaufort
	Dr. Bruce Wing, NMFS, Auke Bay
	Dr. Jon Hare, NMFS, Beaufort
	Mr. John Green, NMFS, Narragansett
	Ms. Carolyn Griswold, NMFS, Narragansett
	Mr. Jack Jossi, NMFS, Narragansett

The Thirty First ACM Szczecin, Poland 24-27 May, 2005	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Ann Matarese, NMFS, Seattle
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	Dr. Frank Hernandez, Dauphin Island Sea Lab.

The Thirty Second ACM Seattle, USA 23-26 May, 2006	
Poland	**USA**
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
	Dr. Jeff Napp, NMFS, Seattle
	Dr. Ann Matarese, NMFS, Seattle
	Dr. Elizabeth Clarke, NMFS, Seattle
	Dr. Frank Hernandez, Dauphin Island Sea Lab.

The Thirty Third ACM Szczecin, Poland 19-21 June, 2007	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Mr. John Green, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Ann Matarese, NMFS, Seattle
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	Dr. Frank Hernandez, Dauphin Island Sea Lab.

The Thirty Fourth ACM Pascagoula, USA 28-30 April, 2008	
Poland	**USA**
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Dr. Dariusz Fey, SFI Gdynia	Dr. Ann Matarese, NMFS, Seattle
	Dr. Frank Hernandez, Dauphin Island Sea Lab.

The Thirty Fifth ACM Gdynia, Poland 21-23 April, 2009	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NMFS, Narragansett
Dr. Leonard Ejsymont, Head of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Wanda Kalandyk, Deputy Head of the Center, Szczecin	Dr. Ann Matarese, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Frank Hernandez, Dauphin Island Sea Lab.
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	
Dr. Dariusz Fey, SFI Gdynia	

The Thirty Sixth ACM Narragansett, USA 12-14 April, 2010	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
	Dr. Ann Matarese, NMFS, Seattle
	Dr. Frank Hernandez, Dauphin Island Sea Lab.
	Dr. Jeff Napp, NMFS, Seattle

The Thirty Seventh ACM Gdynia, Poland 12-16 September, 2011	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
	Dr. Ann Matarese, NMFS, Seattle
	Dr. Frank Hernandez, Dauphin Island Sea Lab.
	Dr. Jeff Napp, NMFS, Seattle

The Thirty Eighth ACM Seattle, USA 12-16 September, 2012	
Poland	**USA**
Dr. Dariusz Fey, SFI Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
	Dr. Ann Matarese, NMFS, Seattle
	Dr. Jeff Napp, NMFS, Seattle

The Thirty Ninth ACM Szczecin, Poland 22-26 April, 2013	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS, Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	

The Fortieth ACM Pascagoula, USA 7-10 April, 2014	
Poland	**USA**
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Joanne Lyczkowski Schultz, NMFS, Pascagoula
	Dr. Jeff Napp, NMFS, Seattle
	Dr. Ann Matarese, NMFS, Seattle

The Forty-first ACM Szczecin, Poland 20-25 April, 2015	
Poland	**USA**
Dr. Tomasz Linkowski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS Narragansett
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NMFS, Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Mr. Glenn Zapfe, NMFS, Pascagoula
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Dr. Jeff Napp, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Ann Matarese, NMFS, Seattle
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	

The Forty-second ACM Narragansett, USA 25-28 April, 2016	
Poland	**USA**
Dr. Emil Kuzebski, Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NMFS Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Jon Hare, NMFS, Narragansett
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Mr. Glenn Zapfe, NMFS, Pascagoula
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Jeff Napp, NMFS, Seattle
	Dr. Ann Matarese, NMFS, Seattle
	Dr. David Kimmel, NMFS, Seattle
	Ms. Pamela Bond, NMFS, Pascagoula
	Ms. Christina Schobernd, NMFS, Beaufort
	Ms. Katey Marancik, NMFS, Narragansett
	Mr. Mike Jones, NMFS, Woods Hole
	Mr. Jerry Prezioso, NMFS, Narragansett
	Dr. David Richardson, NMFS, Narragansett
	Ms. Paula Fratantoni, NMFS, Woods Hole
	Mr. Harvey Walsh, NMFS, Woods Hole

The Forty-third ACM Szczecin, Poland 24-28 April, 2017	
Poland	**USA**
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NMFS, Narragansett
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Mr. Glenn Zapfe, NMFS, Pascagoula
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Dr. Jeff Napp, NMFS, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Ann Matarese, NMFS, Seattle
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	Dr. David Kimmel, NMFS, Seattle
	Ms. Christina Schobernd, NMFS, Beaufort
	Ms. Katey Marancik, NMFS, Narragansett
	Dr. Alison Deary, NMFS, Seattle
	Mr. Jesse Lamb, NMFS, Seattle

The Forty-fourth ACM Seattle, USA 23-27 April, 2018	
Poland	**USA**
Dr. Emil Kuzebski, Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NOAA Fisheries, Woods Hole
Mr. Rafał Geremek, Deputy Director of Sea Fisheries Institute, Gdynia	Dr. Kenneth Sherman, NOAA Fisheries, Science & Technology
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. David Kimmel, NOAA Fisheries, Seattle
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Dr. Alison Deary, NOAA Fisheries, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Mr. Glenn Zapfe, NOAA Fisheries, Pascagoula
	Ms. Katey Marancik, NOAA Fisheries, Narragansett
	Dr. David Richardson, NOAA Fisheries, Narragansett
	Mr. Alex Andrews, NOAA Fisheries, Juneau

The Forty-fifth ACM Gdynia, Poland 6-10 May, 2019	
Poland	**USA**
Dr. Piotr Margoński, Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NOAA Fisheries, Woods Hole
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. Kenneth Sherman, NOAA Fisheries, Science & Technology
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Dr. David Kimmel, NOAA Fisheries, Seattle
Ms. Małgorzata Konieczna, Head of Fish Taxonomy Section of the Center, Szczecin	Dr. Alison Deary, NOAA Fisheries, Seattle
Ms. Hanna Skólska, Head of Plankton Sorting Section of the Center, Szczecin	Mr. Glenn Zapfe, NOAA Fisheries, Pascagoula
	Ms. Katey Marancik, NOAA Fisheries, Narragansett
	Dr. David Richardson, NOAA Fisheries, Narragansett

The Forty-sixth ACM, Poland - USA 21-22 April, 2020	
Poland	**USA**
Dr. Piotr Margoński, Director of Sea Fisheries Institute, Gdynia	Dr. Jon Hare, NOAA Fisheries, Woods Hole
Ms. Wanda Kalandyk, Head of the Center, Szczecin	Dr. David Kimmel, NOAA Fisheries, Seattle
Mr. Paweł Kaźmierczak, Deputy Head of the Center	Dr. Alison Deary, NOAA Fisheries, Seattle
	Mr. Glenn Zapfe, NOAA Fisheries, Pascagoula
	Ms. Katey Marancik, NOAA Fisheries, Narragansett
	Mr. Alex Andrews, NOAA Fisheries, Juneau
	Dr. David Richardson, NOAA Fisheries, Narragansett
	Ms. Christina Schobernd, NOAA Fisheries, Beaufort
	Dr. Kym Jacobson, NOAA Fisheries, Newport

APPENDIX III
Ref. Chapter 3

Informal meetings in the U.S. and Poland - photos

Fig. App. III. 1 Picture taken in apartment of Thomas Morris - standing on the left (NMFS, Woods Hole), Roman Pactwa (MIR→NMFRI), sitting in the middle - Marianna Pastuszak, Krzysztof Supeł (MIR→NMFRI) (source: private archives of M. Pastuszak)

Fig. App. III. 2 Thanksgiving party in 1980 in L. Despres's house - sitting on the left, Daniel Patanjo's parents and his sister; standing, cutting the turkey - D. Patanjo (NMFS, Woods Hole), sitting on the right - Marianna Pastuszak (MIR→NMFRI), Linda Despres (NMFS, Woods Hole) (source: private archives of M. Pastuszak)

Fig. App. III. 3 Visits of Marianna Pastuszak (MIR→NMFRI) to Narragansett laboratory - here in company of Jeromie Prezioso (NMFS, Narragansett) (source: private archives of M. Pastuszak)

Fig. App. III. 4 Picture taken in the 1980s at L. Despres's house; in the centre - Thomas Morris (NMFS, Woods Hole), Wojciech Sztajnduchert (MIR→NMFRI), Linda Despres (NMFS, Woods Hole) Marianna Pastuszak (MIR→NMFRI), Kathy Bush (NMFS) (source: private archives of M. Pastuszak)

Fig. App. III. 5 Picture taken in the 1980s at L. Despres's house; from the left: Dr. Redwood Wright, Dr. David Mountain, Dr. William Overholtz (NMFS), Dr. Thomas Azarovitz (NMFS, Woods Hole) (source: private archives of M. Pastuszak)

Fig. App. III. 6 Picture taken in the 1980s at L. Despres's house; from the left: Dr. D. Mountain (NEFS, Woods Hole), A. Mann (Woods Hole), Dr. R. Wright (NMFS, Woods Hole), M. Pastuszak (MIR→NMFRI) (source: private archives of M. Pastuszak)

Fig. App. III. 7 Picture taken in the 1980s at L. Despres's house; from the left: Dr. M. Grosslein, Dr. T. Azarovitz, Dr. E. Anderson, (NMFS, Woods Hole), wife of Dr. E. Anderson (Geraldine - in blue dress), son of A. Mann, Dr. R. Wright, Dr. D. Mountain (NMFS, Woods Hole), A. Mann (Woods Hole) (source: private archives of M. Pastuszak)

Fig. App. III. 8 Picture taken in the 1980s at L. Despres's house: sitting from the left; Stefan Szmulta (electrician from R/V WIECZNO), Julian Knurowski, Borys Kisler (researchers, R/V WIECZNO), Jan Chołyst (captain of R/V WIECZNO), Wojciech Gołaszewski (fisherman, R/V WIECZNO), Linda Despres (NMFS, Woods Hole) (source: private archives of M. Pastuszak)

Fig. App. III. 9 Picture taken in the 1980s at L. Despres's house: sitting from the left: Dr. Ronald Schlitz (NMFS, Woods Hole), Marianna Pastuszak (MIR→NMFRI), Jan Chołyst (captain of R/V WIECZNO), and Linda Despres (NMFS, Woods Hole) (source: private archives of M. Pastuszak)

Fig. App. III. 10 Picture taken in the 1980s at L. Despres's house: Linda Despres (NMFS, Woods Hole) and Marianna Pastuszak (MIR→NMFRI) (source: private archives of M. Pastuszak)

Fig. App. III. 11 Linda Despres's (NMFS, Woods Hole) trip to Zakopane in Poland in the 1970s; trip organized by M. Pastuszak and J. Bielecki (MIR→NMFRI); they stayed in the house of Bolesław Karpiel-Bułecka (in the picture), Polish folk artist and musician (source: private archives of M. Pastuszak)

Fig. App. III. 12 Linda Despres's (NMFS, Woods Hole) visit to apartment of Bronisław Bogdanowicz, captain of R/V WIECZNO, and his wife in the 1990s (source: private archives of M. Pastuszak)

Fig. App. III. 13 Visit of Loretta Sullivan (NMFS, Narragansett) in Poland in the 1970s (in the middle); she is in company of Marianna Pastuszak and Franciszek Król (MIR→NMFRI) (source: private archives of M. Pastuszak)

Fig. App. III. 14 Linda Despres (NMFS, Woods Hole) with her Polish friend Marianna Pastuszak (MIR→NMFRI); in Poland - visit to Jurata SPA on Hel Peninsula in the 2000s (source: private archives of M. Pastuszak)

Fig. App. III. 15 Linda Despres (NMFS, Woods Hole) in apartment of her friend Marianna Pastuszak in Poland in the 2000s (source: private archives of M. Pastuszak)

APPENDIX IV
Ref. all Chapters

ABBREVIATIONS AND ACRONYMS

AAAS	American Association for the Advancement of Science
AD	Anno Domini
AFS	American Fisheries Society
AFSC	Alaska Fisheries Science Center
AHL	Allowable Harvest Level
AMLR	Antarctic Marine Living Resources
BCF	Bureau of Commercial Fisheries
BIOMASS	Biological Investigations of Marine Antarctic System and Stocks
BIPM	Bureau International des Poids et Mesures
BSI	Baltic Sea Index
CBSPC	Central Bering Sea Pollock Convention
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCGG	Carbon Cycle Greenhouse Gases
CCL	Central Calibration Lab.
CE	Common Era
CMDL	Carbon Monitoring and Diagnostic Laboratory
CSTP	Cooperative Shark Tagging Program
CPR	Continuous Plankton Recorder
DNA	deoxyribonucleic acid
ECD	Electron Capture Detector
EEZ	Exclusive Economic Zone
EFARO	European Fisheries and Aquaculture Research Organization
ELH	Early Life History
EU	European Union
FAO	Food and Agriculture Organization
FCMA	Fishery Conservation and Management Act
FRG	Federal Republic of Germany
GDR	German Democratic Republic
GHG	Green House Gases
GLOBEC	Global Ocean Ecosystems Dynamics
GMD	Global Monitoring Division

GML	Global Monitoring Laboratory
GSP	Groundfish Survey Project
GWP	Global Warming Potential
IATTC	Inter-American Tropical Tuna Commission
ICES	International Council for the Exploration of the Sea
ICNAF	International Commission for the Northwest Atlantic Fishery
IPCC	The Intergovernmental Panel on Climate Change
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IWC	International Whaling Commission
LME	Large Marine Ecosystems
MABL	The marine atmospheric boundary layer
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MIR	Morski Instytut Rybacki
MIT	Massachusetts Institute of Technology
MLO	The Mauna Loa Observatory
MOCNESS	Multiple Opening/Closing *Net* and Environmental Sensing *System*
MONERIS	Modeling Nutrient Emissions in River Systems
MSFCMA	Magnuson–Stevens Fishery Conservation and Management Act
NAFO	Northwest Atlantic Fisheries Organization
NAO	North Atlantic Oscillation
NAOI	North Atlantic Oscillation Index
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NEFC	Northeast Fisheries Center
NEFSC	Northeast Fisheries Science Center
NESDIS	National Environmental Satellite, Data and Information Service
NDC	Nationally Determined Contributions
NDIR	Non-Dispersive Infrared analyzer
NESDIS	National Environmental Satellite, Data and Information Service
Nm	Nautical mile
NMFRI	National Marine Fisheries Research Institute
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Science
NWAFC	Northwest and Alaska Fisheries Center
NWFSC	Northwest Fisheries Science Center

NWFC	Northwest Fisheries Center
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
OISST	Optimum Interpolation Sea Surface Temperature
OMAO	Office of Marine & Aviation Operations
PAN	Polska Akademia Nauk (Polish Academy of Sciences)
PBS	Pacific Biological Station
PPI	Office of Program Planning and Integration
PSU	Practical Salinity Units
RF	Radiative Forcing
SABRE	South Atlantic Bight Recruitment Experiment
SD	standard deviation
SEAMAP	Southeast Area Monitoring and Assessment *Program*
SEBSCC	Southeast Bering Sea Carrying Capacity
SEFC	Southeast Fisheries Center
SEFSC	Southeast Fisheries Science Center
SFI	Sea Fisheries Institute
SGSCA	Seattle-Gdynia Sister City Association
SMO	Samoa Observatory
SWFC	Southwest Fisheries Center
SWFSC	Southwest Fisheries Science Center
TAC	Total Allowable Catch
UG	Uniwersytet Gdański (Gdańsk University)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UK	United Kingdom
USA	United States of America
USSR	Union of Soviet Socialist Republics
W	Watt
WHO	World Health Organization
WMO	World Meteorological Organization
WOC	Washington-Oregon-California area
XBT	Expendable Bathythermograph

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