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by

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PART I. MARITIMES REGION by M. Sinclair

Herring

In the Gulf of St. Lawrence industry is interested in fat content in different locations and times of the year. As part of the port sampling and survey programs, samples have been taken to determine the relationship between fat content, location, season, size, and maturity stage. To improve flow of information to the fishing industry and management, weekly updates are provided on catch, catch composition in terms of spawning group, length-frequencies, and fat content. The 1995 patterns were compared to 1994. Acoustic surveys were conducted in the fall from Chaleur Bay to 4Vn. Also, the annual spawning bed survey was conducted on Fisherman's Bank.

Given the low abundance level of the 4WX herring stock and the uncertainty associated with the estimates, 1995 was a year of intensive collaborative work by DFO and industry. An "in season" management process was initiated. A table of biological characteristics based on current fishery data was developed to orient discussion of stock status. Sampling of the catch was enhanced and a series of spawning area surveys conducted using commercial purse seiners. The Bay of Fundy and Georges Bank herring larval surveys were conducted in the autumn as an indice of spawning stock abundance. Through the co-operative efforts of DFO, UNB, Simrad and FEMTO an acoustic survey was undertaken from the J.L. Hart in Scotts Bay to investigate the capturing of acoustic data using both a traditional dual-beam system and a scanning sonar. A tagging strategy for the 4WX area was developed and several small tagging initiatives undertaken to establish protocols of working with industry.

Tunas and Swordfish

The swordfish tagging study continued with 77 fish being tagged in 1995. A standardized CPUE indice for Bluefin tuna in the Canadian fishery from 1984 to 1995 is being developed.

Sharks and Skates

An enhanced program has been established in 1995. The aim is to provide a scientific basis for rational harvesting of the expanding shark and skate fisheries (Blue, Porbeagle, and Mako sharks, as well as dogfish and skates). Catch and effort data is being collected on a more comprehensive manner and a co-operative tagging program set up with recreational fishers for sharks (about 250 sharks were tagged). Standards are being developed for hook and release sports fishing. The survival rate of undersize skates discarded by the fishery are being evaluated.

Groundfish

Cod condition in the southern Gulf of St. Lawrence has been shown to exhibit a marked seasonal and interannual variation. Samples were collected for the estimation of condition through port sampling, sentinel fisheries and research vessel surveys, and condition indices from commercial samples from 1983-1995 calculated. Considerable efforts were directed towards the development of a sentinel fishery for 4T cod in order to improve estimates of stock status during the cod fishery closure. A survey was conducted in January 1995 in the Cabot Strait, an area where many groundfish species from the Gulf of St. Lawrence are thought to overwinter. The aim of this work was to study groundfish distribution in relation to oceanographic conditions in the area. The sixth annual July survey was conducted for estimates of cod recruitment. In addition, the "core" September groundfish research vessel survey was conducted. Special biological collections were made for a number of projects including studies on cod energetics, stock identification, cod/plaice feeding ecology and interactions, and herring. Extensive plaice collections were completed for the Sealworm Index Survey.

An enhanced effort has been directed towards assessing the stock status of white hake in 4T. Age determinations have been made for the September surveys and the commercial landings and commercial by-catch distribution determined by area, gear and month. By-catch of juvenile hake in the smelt fisheries were monitored. A manuscript on morphological differences between Northumberland Strait and Laurentian Channel white hake has been prepared.

Analyses have been completed on changes in distribution of cod and plaice in the 4T area as a function of changes in environmental conditions and population sizes. Effects of variation in cod temperature distribution on catchability to the annual bottom-trawl survey were examined.

Cluster analysis has been carried out on the groundfish data from 1971 to 1994 in four-year blocks in order to examine temporal variation in groundfish species assemblages.

A method has been developed to estimate trends in natural mortality of juvenile cod using the groundfish research vessel survey data. The project was stimulated by model predictions that predation by seals on cod has been increasing during the past decade. The method has been applied to a number of cod management units.

Fishing effort trends in 4T have been compared to estimates of fishing mortality on 4TVn cod. There is a strong relationship which indicates that for this management unit expected days fishing can be provided along with quotas at different harvesting levels.

American plaice is the only flatfish species in 4T for which age-based analyses are conducted. Age determination was made on 6200 samples of plaice obtained from research surveys and port sampling in 1995. Research was submitted or published on plaice distribution and depth-temperature preferences in relation to changes in density. Analyses of gonadal development of 4T plaice continued in order to determine the maturity cycle in this stock. The management unit for witch flounder was extended from 4RS to 4RST in 1995 and research is underway to combine survey data for an index of 4RST witch abundance. Winter flounder in 4T will come under quota management for the first time in 1996. Effort was made to improve the information on flatfish landings in 4T, particularly the species identification and reporting of plaice and winter flounder catches.

For Georges Bank haddock a distribution and migration study has been completed.

For cod in 4X the effect of age on gamete quality, spawning time and spawning success is being investigated. Data acquisition was completed in 1995. In addition, the reliability of assessing maturity stages of cod is being evaluated by histological analyses. Differences in growth patterns from cod in the Bay of Fundy and the outer part of 4X have been compared. A tagging study has been initiated on cod caught in lobster traps.

For Georges Bank cod the major research emphasis during 1995 has been on the analysis of tag returns from previous tagging activities. Survey data on maturity were analyzed in

order to identify time of spawning and to estimate maturity ogives for the estimation of spawning stock biomass. Samples were collected and analyzed for cod food habits.

For pollock in 4VWX and 5 an analysis of stock structure was initiated. The historical tagging data has been updated and analyzed. Also, the distribution of pollock spawning sites has been inferred from the accumulated information on egg and larval surveys. Analyses of growth rate indicate substantial geographic differences with the western portion of the management unit growing faster than the eastern component.

For cod in Sydney Bight a fifth annual survey was conducted to provide information on juvenile cod as well as morphological difference between inshore and offshore cod. A comparative hook size study was carried out for longlines in the 4Vn area.

For redfish on the Scotian Shelf and in the Gulf of Maine area, the regular 1995 summer groundfish survey was extended to 400 fathoms by adding 3 new strata. The historical redfish distributions from the survey data set were analyzed in relation to environmental conditions.

An industry tagging project for winter flounder in 4X and Scotian Shelf halibut continued in 1995.

Participants in directed monkfish fishery conducted a survey in co-operation with Science.

As part of a National Sea Products/DFO deep-sea fishing project a second survey was conducted by NSP's Cape Chidley.

A digest of longline catches and their size compositions, in comparison with those of other gears, was prepared. Also, a longliner size selectivity experiment was conducted successfully aboard a chartered commercial fishing vessel. Two sizes each of 'J' and 'circle' hooks, and two bait sizes were tested. By-catches of cod, haddock, and pollock by the Cuban silver hake fleet were monitored in May/June to assess the effectiveness of management changes recommended to reduce incidental catch of these species.

Efforts continued on the integration of spatial information into stock assessments. A model incorporating spatial segregation of the 4X haddock stock was used in 1995. Also a model with these interacting spawning populations within a management unit being fished by two gear types was developed in order to illustrate the potential role of closed areas in protecting spawning component.

A study was initiated to provide an historical estimation of discarding practices in 4VW. The initial stage involved interviewing fishermen from different gear sectors in order to evaluate the methodology to be used.

Due to ageing problems with haddock on the Scotian Shelf, a special study has been initiated to establish ageing protocols, establish a reference collection and to validate the ageing procedure by radiochemical methods. The first two parts of the study were completed and the third initiated.

As part of the wrapping up part of OPEN, studies were completed on the growth of cod from the Scotian Shelf and adjacent areas, as estimated from mark-recapture data. Also, the study on the changes on the lipid class composition and survival of a cohort of cod larvae was completed.

Studies demonstrating the reliability of otolith elemental fingerprints for use in stock identification studies were carried out. These included using whole otolith elemental fingerprints to identify cod stock structure in the Northwest Atlantic, using elemental fingerprints to track migrating Gulf of St. Lawrence cod onto the Scotian Shelf, and an assessment of the stability of elemental fingerprints through time at a single site in 4Vs. The spatial patterns in cod growth were documented and a temperature-based predictive model developed. Also, the relationship between early life history growth of Georges Bank cod to year-class strength was evaluated. Growth during these early stages will be used to predict year-class strengths.

A joint study with NOAA (USA), Environment Canada, and other Atlantic regions of DFO was initiated to describe groundfish assemblages from Cape Hatteras to Cape Chidley between 1975 and 1994. The aim of the study is to evaluate the degree to which environmental variability and fishing effort have influenced changes in distributional patterns at the species and community level. The groundfish and environmental data have been put on a GIS for ease of analysis.

The sampling component of a study of the organochlorine concentration, in blubber samples from grey and harbour seals was completed. The recent concentration levels will be compared to measurements taken in the 1980s in order to evaluate trends. Dioxins and furans were also sampled.

A three year project entitled Identification of Mixed Cod Stocks in the Gulf of St. Lawrence, was initiated in 1995 using funds under the DFO High Priority Funding initiative. The goal of this study is to identify unambiguously the cod stocks of the Gulf and its approaches, and through use of elemental, genetic, and meristic markers, determine the stock composition and geographic extent of the winter mixing zones.

Under the same funding source, a study to evaluate the effectiveness of a contraceptive for female grey and harp seals is being continued. The study involves Dalhousie University and the three Atlantic Zone DFO regions. It is multidisciplinary involving molecular biology/pharmacology, modeling of seal-fish interactions, seal distributional studies and the monitoring of grey seal diets on Sable Island.

The annual groundfish surveys (4VWX July, 4T September, 4VW March, and 5Z March) were carried out again in 1995. These were complimented by joint surveys with industry in a number of areas ("sentinel" surveys in 4T, 4Vn and 4VWX; fixed gear and mobile gear surveys in 4X and 5).

PART II. NEWFOUNDLAND REGION by G. N. Perry

SUBAREAS 0 AND 1

A. Status of the Fisheries

Nominal landings from 1990 to 1995 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

- a) **Shrimp.** Catches for 1995 increased to 3510 t from 476 t in 1994. The 1995 catch estimate includes catches of both northern shrimp, *Pandalus borealis*, and striped shrimp, *P. montagui*. Catches of *P. montagui* from the area east of Resolution Island possibly exceeded 2500 t due to an apparent eastward shift in distribution from Hudson Strait. Areas fished in 1995 reflected targeting of *P. montagui* and a return to grounds north of 65°N. Catches were composed of large females (average carapace length of 23-24 mm) whereas the 1994 catches comprised both large males and females. The 1995 CPUE was the highest of those of the previous six years. Catches and catch rates have been variable since the northern shrimp fishery began in 1988. The status of the resource remains uncertain as the fluctuations in catches and catch rates are more likely a reflection of the difficulty in locating concentrations of shrimp than indicators of significant changes in abundance.
- b) **Greenland Halibut.** Catches for 1995 were approximately 5,852 t which includes 3,918 t taken by foreign vessels fishing Canadian quotas. This fishery was one of the few active groundfish fisheries in the Canadian Zone in 1995. Recent scientific information on this stock is limited as the last complete survey was conducted in 1986.

B. Special Research Studies

Biological Studies

- a) **Atlantic salmon.** Commercial sampling of the west Greenland fishery was conducted in 1995 with 2,045 samples collected. Analyses of sampling data indicated that 65% of the catches were of North American origin representing a significant increase from 1992, the last year of commercial sampling, in which 54% of the catches were of North American origin.

Research was also conducted to forecast the abundance of the two-sea winter component of the North American stock complex prior to fisheries in Greenland and North America. These estimates provided the basis for fishery catch allocation in North America and Greenland and two-sea winter escapement in Canada.

- b) **Shrimp.** Sampling of commercial shrimp catches by the Canadian Observer Program continued in 1995. Data from 1987-1995 were used to estimate by-catch of groundfish in northern shrimp fisheries (Subareas 0 + 1 + 2). The analysis suggested that the introduction of the Nordmore grate coupled with a decline in abundance of most groundfish stocks resulted in a decrease in the level of by-catch in recent years in all areas except Davis Strait. Redfish by-catch remains a significant problem in the north where the grate is not an effective excluder of small (10 to 20 cm) fish.

SUBAREA 2

A. Status of the Fisheries

Nominal landings from 1990 to 1995 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

- a) *Atlantic salmon*. Total landings of salmon (56 t) decreased by 40% from 1994. The recreational harvest totalled 7.1 t.
- b) *Arctic charr*. Landings of Arctic charr in northern Labrador declined marginally to 30 t in 1995. Declines in catches were primarily attributable to a concomitant decline in effort in 1995 which represented the lowest level of effort recorded since 1974.
- c) *Shrimp*. The shrimp fishery in Subarea 2 is divided into three management areas - 2G, Hopedale and Cartwright Channels (2H), and Hawke Channel (2J) + 3K. Catches in 2G for 1995 increased to 5104 t from 3982 t as a consequence of a planned increase in the TAC to 5200 t in 1995 from 4000 t in 1994. Both standardized and unstandardized catch per unit effort (CPUE) analyses show an overall increase from 1989 to 1994 followed by a decrease in 1995. Size distribution remained variable with strong female components in both 1994 and 1995. The continued occurrence of large female shrimp suggests maintenance of a health spawning biomass, however, the lower catch rate and the relatively low proportion of male shrimp in 1995 could result in some reduction in recruitment to the female component in the short term.

Catches in Hopedale and Cartwright Channels (2H) increased marginally to 7616 t in 1995 from 7499 t in 1994. CPUE increased 83% from 757 kg/hr in 1994 to 1385 kg/hr in 1995 and the standardized 1995 catch rate was the highest in the time series (1977 - 1995). No declining trends in the male-female components or catch rates of female shrimp has emerged in the 1994 or 1995 data and the resource remains healthy.

Catches in Hawke Channel (southern Div. 2J) + 3K declined marginally in 1995 to 10,914 t from 10,978 t in 1994. Both standardized and unstandardized CPUE's suggested approximately the same overall increasing trend. Catch rates and male-female components suggest an increase in abundance in recent years and continued good recruitment.
- d) *Capelin*. In 1995, the fishery did not open. In 1994 and 1995, the average size of female capelin was below the management plan criterion of 50 count/kg.
- e) *Cod*. The northern cod moratorium has been in effect since July 1992 for cod from Div. 2J3KL. The 1995 assessment, based on the research vessel bottom trawl surveys and Sentinel surveys, suggested that the population remains at a very low level with no significant sign of good recruitment.
- f) *Redfish*. There was no directed fishery in 1995 for the Subarea 2 + 3K stock. Results from research vessel surveys suggested that population biomass indices in both areas are at extremely low levels. In early 1995, National Sea Products Ltd. conducted a short experimental fishery on traditional redfish grounds. Although the number of sets were limited, no fish were caught and no marks were encountered on the sounder while steaming.
- g) *Crab*. Landings and effort continued to increase in 1995 and catches reached 3178 t up from 2978 t in 1994. Catch rates continued to decline from a high of 14.6 kg/trap haul in 1991 to 7.9 kg/trap haul in 1995. Catches were maintained due to expansions northward and eastward in the management areas.
- h) *Flatfish*. The only directed fishery for flatfish species in Subarea 2 was for Greenland halibut. Preliminary catches were approximately 1,400 t, equal to catches in 1994.

B. Special Research Studies

1. Environmental Studies

- a) *Hydrographic studies*. Field surveys and field sheet production were conducted for inshore areas of southern Labrador (southern 2J) by the Canadian Hydrographic Service.
- b) *Oceanographic studies*. Temperature profiles were taken at each fishing station occupied in the subarea. CTD profiles were collected along the standard NAFO transect line across Hamilton Bank (Seal Island Line) and several other stations on the Labrador Shelf. Oceanographic observations were presented and referenced to the long term (1961-1990) mean. The 1995 cold-intermediate layer (CIL) was 32 % below normal on the Seal Island transect while minimum CIL core temperatures were above normal.

2. Biological Studies

- a) *Cod*. Biological and oceanographic data from multi-species research vessel surveys were collected from Div. 2J to conduct distribution and abundance studies; detailed biological sampling was performed. A portion of Div. 2J was covered during a cod acoustic research trip in June. Stomachs were collected from the Div. 2J autumn survey.
- b) *Arctic charr*. Samples were obtained for food and feeding and age, sex, and length distributions from commercial landings from 12 northern Labrador fishing areas. Analyses of sampling data demonstrated a decline in mean weight of charr, particularly for the Nain and Voisey stock units (a decline of 30g per year since 1980). These observations are consistent with growth overfishing and it was hypothesized that the trend is attributable to the long term selective pressure of the Labrador commercial gill net fishery for Arctic charr. An experimental in-river fishery was continued in Saglek Fiord for 1995.
- c) *Shrimp*. Sampling of commercial shrimp catches by the Canadian Observer Program continued in 1995. Data on distribution and abundance of shrimp were collected during research surveys of Div. 2J in 1995.
- d) *Flatfish*. Data on distribution and abundance of American plaice, Greenland halibut and witch flounder were collected during groundfish surveys of Div. 2J in 1995.

SUBAREA 3

A. Status of Fisheries

Nominal landings from 1990 to 1995 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

- a) *Squid*. The 1995 total catch of squid was approximately 48 t down from 1954 t in 1994. The poor fishery, for the thirteenth consecutive year, was due to a natural low abundance of squid in commercial fishing areas.
- b) *Atlantic salmon*. A five year moratorium on the commercial fishery has been in place since 1992. The recreational harvest was 32 t, a marginal decrease from 34 t in 1994.
- c) *Shrimp*. The international fishery in Div. 3M which began in 1993 continued in 1995. Canadian vessels caught 970 t compared to 3724 t in 1993 and 1041 t in 1994.
- d) *Iceland scallop*. Although subject to TAC (2,800 t round), nominal catch was only 300 t, landed by Canadian vessels. France did not fish for Iceland scallops in 1995.
- e) *Clams*. The Grand Bank fishery (Div. 3N, Unit Area 319) for the Arctic (Stimpson's) surf clam on the Grand Bank continued in 1995. Total removals are estimated at 14,100 t (total allowable catch - 20,000 t) down 30% from 1994.
- f) *Capelin*. Inshore capelin catches are usually taken during the inshore spawning migration. Female capelin are preferred to satisfy the Japanese roe market. The 1995 inshore TAC was 36,000 t but catches were only 100 t. The fishery did not open because test fishing indicated that female capelin were too small to meet the size criteria established in the management plan.
- g) *Herring*. There are five herring stock complexes distributed along the east and southeast coasts of Newfoundland: White Bay - Notre Dame Bay (Div. 3K), Bonavista Bay - Trinity Bay (Div. 3L), Conception Bay - Southern Shore (Div. 3L), St Mary's Bay - Placentia Bay (3LPs), and Fortune Bay (Div. 3Ps). Landings in 1995 were approximately 5,000 t, 80% of which was taken from White Bay, Notre Dame Bay, Bonavista Bay and Trinity Bay.
- h) *Cod*. Moratoria on directed cod fisheries remained in place in 1995 for Div. 2J3KL (since July 1992), for Subdiv. 3Ps (since 1993), and for Div. 3NO (beginning in 1995). Total by-catch for all Divisions totalled approximately 640 t. An additional 400 t were taken during Sentinel Surveys in Div. 3KLPs.
- i) *Flatfish*. The only directed fisheries in Subarea 3 were Div. 3LNOP Atlantic Halibut, Div. 3KL Greenland halibut and Div. 3Ps witch flounder. Catches of Atlantic Halibut were 194 t in 1995 up significantly from 35 t in 1994. Preliminary estimates of Greenland halibut landings totalled 1014 t. Witch flounder landings totalled 276 t in 1995. The 1995 catches in both the Greenland halibut and witch flounder fisheries are down approximately 37% from 1994. All other flatfish fisheries were subject to by-catch fisheries only.
- j) *Redfish*. Landings in 1995 declined to approximately 4,300 t, most of which was taken in Div. 3P from 18,500 t in 1994. The reduction from 1994 to 1995 was primarily attributable to fishery closures and TAC reductions.
- k) *Crab*. Catches in Subarea 3 totalled 27,888 t in 1995 from Divisions 3K, 3LNO, and 3Ps. Landings in Div. 3K increased to 12,245 t in 1995 from 11,039 t in 1994. Catch rates declined to 11.5 kg/trap haul in 1995 from 14.5 kg/trap haul in 1993. These declines were attributable to lower catch rates in the inshore areas.

Landings increased to 13,790 t in 1995 up from 12,237 t in 1994. Ninety percent of the catches came from Div. 3L. Overall catch rates remained high, especially in newly exploited fishing grounds near the 200 mile limit, and have increased steadily from 7.8 kg/trap haul in 1990 to 17.0 kg/trap haul in 1995.

Landings in Div. 3Ps increased in 1995 to 1853 t from 1590 t in 1994. Overall catch rates declined to 10.0 kg/trap haul in 1995 from 15.2 kg/trap haul in 1994, representing an approximate doubling in fishing effort.
- l) *Scallops*. Expansion of this fishery continued in 1995. Commercial vessels (fifty-seven under 65 ft. L.O.A.) harvested about 4,500 t (round) of Iceland scallops from the Grand Bank (Div. 3LNO).

B. Special Research Studies

1. Environmental Studies

- a) *Hydrographic Studies*. Field surveys and field sheet production were conducted for berths in St. John's harbour. Additional electronic navigational chart verification surveys were conducted for major ports on the island of Newfoundland (Subareas 3+4). Digital and paper sailing directions were published, including cartographic production, for Ferryland Head to Port aux Basques (3LP) and Ferryland Head to Cape Bonavista including Placentia Bay (3LP). Quality control and procedures for rasterized products distributed for Canadian Hydrographic Service by Nautical Data International were developed.
- b) *Plankton studies*. Ichthyoplankton studies were conducted in Conception Bay (Div. 3L) to analyze patterns of dispersal and community diversity and to study the influence of wind-induced turbulence on feeding, growth, and condition. Biological sampling of zooplankton, nutrients, and chlorophyll, using ships of opportunity, at Station 27 (Div. 3L) was continued for studies on zooplankton dynamics on the Newfoundland Shelf and Grand Banks.
- c) *Benthic Studies*. Spatial and temporal mapping of benthos on the Grand Bank and Northeast Newfoundland continental shelf through grab sampling of macrofauna, meiofauna, organic carbon, and sediment for grain size analyses during spring groundfish surveys continued in 1995. The program will be expanded in 1996 to include invertebrate by-catch sampling from Campellan trawls during the fall groundfish surveys (Div. 2J3KL) to define spatial and temporal patterns of abundance of epibenthic invertebrates.

An impact of trawling on benthos project was continued and a physical model of trawl - seabed interaction

developed. The third year of experimental otter trawling was carried out in an area of the Grand Bank north of the Hibernia site which has been closed to all other fishing. Analyses to date suggest a trend of declining invertebrate by-catch in the three trawl corridors. A novel acoustics technology has been developed to detect how trawling affects the structural fabric of surficial sandy sediment using a fractal model in which biogenic structure is seen to be imposed upon the background fabric of the sediment.

- d) **Oceanographic studies.** Oceanographic observations from St. Pierre Bank (Div. 3Ps), Grand Bank (Div. 3LMNO), Northeast Newfoundland shelf (3K), and Southern Labrador Shelf during 1995 were presented and referenced to the long term (1961-1990) mean. At Station 27 (Div. 3L) water temperatures were normal during the winter months but cooled to 0.5 to 1.0 °C below normal during the spring and early summer of 1995. By the fall, temperatures were near normal over most of the water column. Salinities were near normal during early winter over the entire water column and from January to July near the bottom, but up to 1.0 psu fresher than normal in the upper water column during spring and summer. The cold-intermediate-layer (CIL) on the Newfoundland Shelf was 28% above normal along the Flemish Cap transect (Grand Bank) and 28% below normal along the Bonavista transect. The cross-sectional area of sub-zero water, except for the Grand Bank on the Newfoundland Shelf, was the lowest in about ten years. Minimum CIL core temperatures were about normal along the Bonavista transect but remained slightly below normal on the Grand Bank. Bottom temperatures on the shelf during the fall period increased significantly over previous years and were up to 0.5°C above normal, except on St. Pierre Bank where significant negative temperature anomalies still exist. In general, the cold trends of the early 1990s have moderated during 1994 and 1995, however, negative temperature and salinity anomalies were still present in the upper layers during the summer on the Newfoundland Shelf and during the spring on St. Pierre Bank.
- e) **Marine Protected Areas.** Data from selected Canadian vessels fishing for flatfish and cod on the Southern Grand Bank (Div. 3NO) from 1985-93 were tabulated on a set-by-set basis. The data will be compared to results from research vessel surveys in the same area with the objective of defining locations to be considered as possible marine protected areas.

2. Biological Studies

- a) **Cod.** Modelling research on the distribution and drift of cod eggs and larvae on the Northeast Newfoundland Shelf continued in 1995. The objective is to develop field sampling protocols and analyses that could address issues related to the link between egg and larval survival and recruitment variability.

Multi-species, multi-disciplinary pelagic juvenile fish (cod and capelin) and demersal juvenile cod surveys were conducted to index distributions and abundances of pre-recruit pelagic and demersal cod.

Sampling of the landings from the commercial fisheries, both inshore and offshore, were continued in 1995. Biological and oceanographic data were collected on multi-species research vessel surveys in Div. 3Ps (Spring), Div. 3LNO (Spring), Div. 3LMNO (fall), and Div. 2J3K (fall) to provide abundance and biomass estimates, continue food and feeding analyses, and continue population dynamics studies.

Tagging studies continued in 1995 with 2500 fish tagged in Trinity Bay (Div. 3L) to continue stock structure and migration studies. Analyses of the historic tagging database to date have revealed separate substocks within the Div. 2J3KL stock complex.

Parasitological investigations on the parasitic copepod *Lernaeocera branchialis* were conducted to evaluate spatial and temporal patterns of infestation and the effects of parasite infestations on mortality and population dynamics.

Combined trawl and acoustic research was undertaken to determine distributions of cod in Div. 2J3KL during the shoreward migration in June and inshore surveys of Trinity Bay (Div. 3L) and Placentia Bay (Div. 3Ps) were conducted as a component of ecological studies of cod spawning and distribution relative to oceanographic and biotic conditions.

- b) **Scallops.** A random survey was completed over a scallop aggregation straddling Div. 3L and 3N northeast of Lilly Canyon-Carson Canyon. A review of the practices of shell-stocking scallops for land based processing versus shucking at sea was conducted to demonstrate the influence of shell debris on larval settlement and survival.
- c) **Atlantic salmon.** The fourth year of a five year program to conduct enhanced assessment of salmonid stocks continued to provide for sustainable development of these resources. Projects are designed to evaluate the effects of the moratorium in the commercial salmon fisheries on insular Newfoundland and the retirement of 50% of the commercial licenses in Labrador and to identify stocks that appear to require additional restorative measures.

Factors affecting marine survival of smolts were investigated by the evaluation of the impact of sodium + potassium + ATPase on osmoregulation and the impact of infestations of the cestode *Eubothrium* on navigational ability and salinity tolerance.

Long-term research studies continued to develop a model which could be used to estimate salmon production capacities of streams, optimal egg deposition and stock and recruitment relationships.

- d) **Seals.** Analyses of the 1994 harp seal (*Phoca groenlandica*) aerial and visual pup production survey and catch at age data were completed to produce estimates of pup production (702,900) and total population size (4.8 million) in the Northwest Atlantic.

Investigations on the diet of harp seals, estimated by reconstruction of wet weight of prey ingested based on hard parts recovered from stomachs and intestines, showed considerable annual, geographic, and seasonal variation. Comparisons of diets between 1982, 1986, and 1990-93 indicated that the major prey consumed changed from capelin to Arctic cod in nearshore areas while capelin remained the major prey item of seals sampled from offshore areas. The data set will be re-analyzed to provide finer resolution of variation and estimates of variation in the proportion of each prey species in the diet.

Seasonal distribution and diving behaviour was investigated through twelve satellite linked time-depth recorders deployed on newly moulted seals during May and June 1995. Data on movements, dive depths, and dive durations were obtained during their northward migration in the spring/summer and their fall return. Preliminary analysis suggests that offshore areas are of greater importance than previously assumed and that individuals move between Newfoundland and the Arctic more than once in a year. Additional animals will be tagged in 1996.

A consumption of major prey by species model was developed incorporating estimates of energy requirements, population size, seasonal distribution, and diets. Preliminary estimates of total prey consumption including temporal, interannual, and spatial variation were developed. Based on an average diet, harp seals consumed an estimated 1.2 million tonnes of Arctic cod, 620,000 t of capelin, and 88,000 t of Atlantic cod in 1994 in the Northwest Atlantic. Uncertainty in the consumption estimates of these prey species were estimated using Monte Carlo methods by varying the population estimates, energy requirements of individuals, distribution or residency in the study area, and diet parameters of the model.

Reproductive rates, mean age of sexual maturity, and age and body condition were studied in 1995. Trends for the 1990's indicated that late term pregnancy rates declined steadily, mean age of sexual maturity increased, growth rates of female seals (one to four years of age) was lower, and that older seals, regardless of sex were in poorer condition. Given the dynamics of the seal population, these variations in reproductive parameters, growth rates, and body condition are consistent with a density-dependent response although the impact of changes in availability of prey coinciding with the increased abundance of seals in recent years may have also influenced these changes in observations of fertility, growth, and condition.

- e) **Capelin.** Studies to determine factors governing capelin survival during egg development and larval emergence from beach sediments continued at two beach sites in 1995. A multi-disciplinary pelagic juvenile fish survey on the Southern Labrador Shelf (Div. 2J+3K), the Northeast Newfoundland Shelf (Div. 3K), and the Grand Bank (3LNO) was conducted to provide pre-recruit indices for ages 0, 1, and 2 year old capelin. Resource status estimates were provided using seven different indicators: aerial survey index, purse seine catch rate index, trap catch rate index, groundfish 3L fall by-catch, groundfish 2J3K fall by-catch, Russian 2J3K fall commercial catch rate index, and egg deposition index.

A new survey was developed for implementation in 1996 to test hypotheses regarding possible poor acoustic detectability and unusual geographic distributions to explain the divergence between inshore indices and offshore acoustic surveys in recent years.

Information on distribution and relative abundance of capelin, as inferred from by-catches during spring and autumn bottom trawl surveys and the contents of stomachs of cod caught during the autumn surveys was analyzed and presented at the regional assessment of capelin.

- f) **Herring.** Two series of abundance indices were utilised to calibrate an extended survivor analysis to provide stock size estimates. The research gill net catch rates index, maintained by fishermen, was continued for the sixteenth year and two acoustic biomass estimation surveys were conducted in Bonavista Bay - Trinity Bay (Div. 3L) and St Mary's - Placentia Bay (Div. 3LPs). A stock status classification system, developed in 1994 through consultations with fishers and industry, was used for east and southeast Newfoundland herring which links exploitation rates to recruitment estimates at given stock levels.
- g) **Flatfish.** Multi-species research vessel surveys were conducted to understand the biology and population dynamics of five flatfish species (Greenland halibut, American plaice, yellowtail flounder, witch flounder, and Atlantic halibut) in subareas 2 and 3. Data collected and analyses included estimates of biomass and abundance, otolith samples for ageing, meristic and morphometric analyses, ovaries for fecundity studies, stomachs for food and feeding analyses, as well as data on length, sex, maturity, weights, condition factors, and disease. A separate stratified random survey for Greenland halibut was conducted in Div. 3LMN in March, 1995 to investigate abundance and biomass and to collect data on population dynamics and stock structure.
- h) **Shrimp.** Data on distribution and abundance of shrimp were collected during research surveys in Div. 3KLNO in 1995.
- i) **Redfish.** A redfish fishery closure in Management Unit 1 (4RST and 3Pn4Vn [June to December]) for 1995 prompted the establishment of a multi-disciplinary research program on redfish. The objective of the program is to examine aspects of the biology and fisheries of redfish to develop a better understanding of these species and ensure long term viability and sustainability of the fishery. The joint program will have input from the Department of Fisheries & Oceans, the fishing industry, and other non-government institutions and will concentrate on four components: species identification and stock structure; improved stock assessment and management approaches; distribution in relation to environmental conditions; and recruitment studies. In addition, a Sentinel fishery will be established, primarily in Unit 1.
- j) **Crab.** Research surveys in Div. 3K and Div. 3L were conducted in 1995. Survey catch rates of legal-sized crabs were inputted into a model to provide an indication of commercial catch rates in the following year and catch rates of sub-legal sized males were also monitored as index of future recruitment. The adoption of the new bottom survey trawl in 1995 provided data on snow crab distribution in Div. 2J3KL. Analyses of catch rates by sex, size, and morphometry during the annual fall groundfish survey will be conducted towards developing an independent index of abundance of pre-recruit crabs.

3. Gear and Selectivity Studies

A number of gear and selectivity studies were conducted in 1995:

- a) **Shrimp Size Selectivity.** Investigations were conducted on two, 20 metre vessels equipped with trawls with trouser codends to evaluate the effectiveness of mesh size and shape and sorting grate bar spacing as means to reduce the catch of small shrimp. The first experiment compared 55 mm diamond mesh and 45 mm square mesh to the standard 43 mm mesh. The second vessel evaluated the effectiveness of a shrimp size sorting grate with 7 mm bar spacing installed into the trawl behind the standard nordmore grate. Comparative fishing trials were subsequently conducted by thirty 13 to 20 metre vessels to compare the effectiveness of the size sorting grates with bar spacings of 8 to 10 mm. An underwater camera was used to observe the behaviour of shrimp to the grate. For additional information contact: Gerald Brothers, Section Head, Conservation Technology, Industry Development Division, Fisheries Management Branch, Department of Fisheries & Oceans, P.O. Box 5667, St. John's, Newfoundland, Canada, A1C 5X1, Telephone: 709+772-4438, Fax: 709+772-2110.

- b) **Salmonid By-catch in Capelin Traps.** The effectiveness of a salmon deflector, consisting of a 37 m long and 1.8 m deep net extended from the trap leader to the front corners of the trap, to reduce the by-catch of Atlantic salmon in fixed gear capelin fisheries was evaluated. For additional information contact: Gerald Brothers, Section Head, Conservation Technology, Industry Development Division, Fisheries Management Branch, Department of Fisheries & Oceans, P.O. Box 5667, St. John's, Newfoundland, Canada, A1C 5X1, Telephone: 1 + 709 + 772-4438, Fax: 1 + 709 + 772-2110.
- c) **Groundfish By-catch in Scallop Rakes.** Cooperative research with the offshore scallop industry was initiated to identify how fish, particularly cod and haddock, enter scallop rakes in order to reduce by-catch of commercial groundfish species. Experiments have been conducted to compare square mesh ropebacks, windows in the ropebacks, and tickler chains in modified scallop rakes with standard gear configurations. For additional information contact: C.G. Cooper, Senior Advisor, Technological Development, Department of Fisheries & Oceans, 1505 Barrington Street, 17 North, P.O. Box 550, Halifax, Nova Scotia, B3J 2S7.
- d) **Scope Ratio Project.** Development of scope ratios for Campellan 1800 survey trawls to fish depths of 40 to 1500 m was completed in 1995. Warp angle of incidence (WAI) was developed to achieve optimum trawl door performance and bottom contact. Warp angle and trawl door attitude were measured using SCANMAR sensors and depth and speed modified to measure angles. New ratios were determined by targeting the required WAI on each tow at stations from 40 to 1500 m.
- e) **New Bottom Survey Trawl Project.** Comparative fishing between the Campellan 1800 (adopted as the standard bottom survey trawl in 1995) and the Engel 145 was conducted to derive conversion factors for all commercial groundfish species focussing on cod, American plaice, redfish, yellowtail flounder, thorny skate, Greenland halibut, and witch flounder. Conversion factors were developed from parallel tows using two vessels with a tow duration of 30 minutes (3.5 knots) for the Engel and 15 minutes (3.0 knots) for the Campellan trawl. For additional information, contact Stephen J. Walsh or William Brodie, Department of Fisheries & Oceans, P.O. Box 5667, St. John's, Newfoundland, Canada, A1C 5X1, Telephone: 1 + 709 + 772-5478, Fax: 1 + 709 + 772-4188.
- f) **Crab Selectivity Project.** The use of a plastic collar placed around the top of commercial crab pots to reduce the by-catch of undersized crab was investigated. For additional information, contact Brian Johnson, Department of Fisheries and Aquaculture, P.O. Box 8700, St. John's, Newfoundland, Canada, A1B 4J6, Telephone: 1 + 709 + 729-3766, Fax: 1 + 709 + 729-6082.
- g) **Exploratory Hagfish Trials.** Experimental fishing trials were undertaken to determine the ability to harvest and market hagfish from the Newfoundland Shelf. For additional information, contact Brian Johnson, Department of Fisheries and Aquaculture, P.O. Box 8700, St. John's, Newfoundland, Canada, A1B 4J6, Telephone: 1 + 709 + 729-3766, Fax: 1 + 709 + 729-6082.
- h) **Onboard Shrimp Handling Project.** The use of plastic storage boxes to determine if the quality of shrimp harvested on 13 to 20 m vessels could be better maintained than traditional storage methods was evaluated. For additional information, contact Brian Johnson, Department of Fisheries and Aquaculture, P.O. Box 8700, St. John's, Newfoundland, Canada, A1B 4J6, Telephone: 1 + 709 + 729-3766, Fax: 1 + 709 + 729-6082.
- i) **Comparative Fishing.** During February and March, 284 paired tows were made by the research vessels GADUS ATLANTICA and TELEOST. The data from these comparisons will be used to convert the results of groundfish surveys on the Gadus (1977-940) into a form comparable with the Teleost.

SUBAREA 4

Status of the Fisheries

- a) **Crab.** Development of the 4R fishery continued in 1995 with additional coastal licences (limited to 8 miles from the coast) issued. Landings totalled 920 t up from 655 t in 1994.
- b) **Scallops.** Landings declined 35% to 1,352 t in 1995 from 2105 t in 1994. Nominal fishing effort declined 50% from 80 to 40 vessels and overall catch rates declined from 70 lb/tow to 57 lb/tow between 1994 and 1995. Concerns were also expressed by the industry regarding an increased abundance of starfish and starfish predation and a high gear induced non-yield mortality in the Strait of Belle Isle fishery (Div. 4R). A research survey was conducted in 1995, combining acoustics and dredge haul sampling. Scarcity of juveniles and low catch rates throughout the area surveyed suggested that prospects for recruitment in the short to medium term are poor.

SUBAREAS 2 + 3 + 4

Special Research Studies

1. Biological Studies

Assessments. Assessments and stock status updates were provided for some 24 groundfish stocks - five cod stocks (2GH, 2J3KL, 3M, 3NO, and 3Ps), five redfish stocks (Subarea 2 + 3K, 3LN, 3M, 3O, and Unit 2), four American plaice stocks (Subarea 2 + 3K, 3LNO, 3M, and 3Ps), three witch flounder stocks (2J3KL, 3NO, and 3Ps), two Greenland halibut areas (Subarea 0 + 1 and Subarea 2 + 3KLMN), two haddock stocks (3LNO and 3Ps), one yellowtail flounder stock (3LNO), and 1 pollock stock (3Ps) as well as a portion of the 3NOPs4VWX Atlantic halibut stock. In addition, scientific advice was provided for lumpfish and relatively new fisheries for monkfish and skate, which came under quota management for the first time in 1995. NAFO.

Further assessments were conducted of 17 pelagic-shellfish-marine mammal stocks, the marine phase of mixed Atlantic salmon stocks originating from Newfoundland, Labrador, Quebec and Maritime rivers, and two Arctic charr stock complexes.

2. Sentinel Surveys

The Sentinel Surveys, initiated in October, 1994, were continued in 1995 and data collected tabled at the regional stock assessment. Fifty-eight sites (6 in 2J, 23 in 3K, and 29 in 3L) were sampled by inshore fish harvesters using traditional fishing gears based on historic fishing patterns. The objectives of the program are: to develop a reliable inshore catch rate, length frequencies, sex, maturity, and otolith series for use in resource assessment; to incorporate the knowledge of inshore fish harvesters in the process of resource assessment, to describe temporal and spatial inshore distributions; to establish a long-term physical oceanographic and environmental monitoring program of the inshore area; and to provide a source of biological material for other researchers for genetic, physiological, food and feeding, and toxicological analyses.

3. Northern Cod Science Program

The Northern Cod Science Program concluded on March 31, 1995. The five year research program was developed to address the science recommendations of the Independent Review of the State of Northern Cod. The program sponsored enhanced investigations of the physical and biological environments, cod biology, ecosystem dynamics, and gear and hydroacoustics technology.

Physical environment research focussed on current modelling and water quality analyses (temperature, salinity, oxygen) on the Grand Bank, Northeast Newfoundland Shelf, and Labrador Shelf to understand the impact and influence of the physical environment on growth, mortality, and behaviour. Perhaps its most significant accomplishment is the continued regular collaboration between fisheries scientists and oceanographers. Biological investigations focussed on ocean productivity, the role of capelin, and cod food and feeding. Cod biology projects examined reproduction and growth, juvenile cod dynamics, and cod migration between the inshore and offshore. Ecosystems dynamics studies investigated cod stock structure through tagging and genetic studies, predator-prey relationships through research on harp and hooded seals, the effects of trawling and fishing on benthic communities and cod spawning. Hydroacoustics and gear technology projects lead to the development of new tools for acoustics research and rigorous protocols for survey gear standardization.

Although analysis of data collected under the Northern Cod Science Program is continuing, it has, to 1995, produced some 250 publications.

4. Inter-regional and Multi-disciplinary Research

Several multi-year, multi-disciplinary, and inter-regional research initiatives commenced in 1995 with the objective of strategically focussing research in areas of concern for the entire Atlantic Zone (Div. 2 + 3 + 4).

- a) *Partitioning the Total Mortality of Cod Stocks.* A multi-component project designed to ascertain the degree of variability in total mortality of Atlantic cod stocks through the evaluation of alternative hypotheses concerning the potential interactions between the fishery, environmental conditions, and the physiological condition of cod populations.

The fishery mortality component includes projects that analyze both fishing mortality and non-catch fishery mortality. Analyses will be conducted on: tag returns to obtain an independent estimate of fishing mortality, potential errors in landings information and catch grading through fishers surveys; the magnitude of at-sea losses taking into consideration stock distribution from observer and surveillance information; catch rates of various fleet components to estimate trends in abundance; stock size using hydroacoustic surveys; regional seafood production to contrast with reported landings; and catch at age data from research vessels.

The environmental conditions component will focus on seal-fish interactions, distribution and dynamics of pre-recruit cod, comparative ecosystems dynamics, and on the inter-regional comparison of natural and fishery related influences on cod population dynamics.

The impact of seals and modelling of predator-prey dynamics will be evaluated. Studies will focus on quantifying: the geographic variation in the diet of harp seals in the Gulf of St. Lawrence and on the northern Newfoundland Shelf, the prey selection pattern of harp seals using simultaneous observations of the distribution and abundance of prey items from pelagic and demersal fish surveys, and estimates of the potential consumption of fish by seals through the development of a bioenergetics model.

The comparative ecosystem dynamics component will evaluate changes in fish community structure in the Northwest Atlantic. Studies will focus on quantitative analyses of: changes in abundance of stocks and species that co-exist with cod stocks; changes in abundance of cod stocks in Div. 4T and Div. 4VnW for comparison with changes in abundance of Div. 2J3KL and Div. 4RS; and fishing pressure in relation to non-catch fishing mortality and changes in natural mortality. A comparative analysis of the patterns of abundance, growth in relation to environmental conditions of cod stocks across the Atlantic, particularly the stocks of Iceland, Greenland, and Norway, will also be conducted.

The physiological condition of cod component will focus on metabolic pathways. Individual projects will focus on: laboratory analyses of the influence of environmental and feeding regimes on various measures of fish condition; studies of egg and larval quality to assess reproductive potential in relation to condition; evaluations of feeding and condition at the onset of winter as measures of physiological stress; spatial and temporal analyses of physiological condition; and evaluation of the correspondence between feeding conditions and changes in fish condition.

- b) *Aquaculture.* A local broodstock for the Newfoundland Atlantic salmon aquaculture industry is currently not available and the importation of broodstock poses significant risk for wild populations. Last year was the first year of evaluation of the marine growth performance of a Newfoundland stock for widespread use in the aquaculture industry. Experiments on the Grand Codroy River stock (Div. 4R) have demonstrated potential for this stock to be used as broodstock for the industry. One year performance was significantly better than the industry standard strain. Maturation, growth, and potential zero genetic variability in the strain will be evaluated in 1996.

- c) **Lobster.** A multi-year strategic approach to lobster research and conservation was developed in 1995. The focus will be on five initiatives - defining lobster production units and the appropriate scales for applying lobster conservation measures; investigating processes that determine variation in productivity; developing tools to predict abundance and landings up to ten years in advance; identifying biological reference points to evaluate stock status and its uncertainty in relation to these reference points; and assessing alternative management strategies or conservation measures.

5. Fisheries Resource Conservation Council

The Fisheries Resource Conservation Council (FRCC) produced two reports in 1995. It conducted its usual review of stock assessments and public hearings on the state of Atlantic groundfish stocks, including stocks within the NAFO divisions. It recommended conservation requirements and basic directions with respect to Science priorities, including use of information from fishermen and commercial fisheries in stock assessments, collection of commercial fishery data through test fisheries, involvement of fishermen in scientific research; research initiatives including an ecological approach to develop understanding of complex process, improve quantitative fish counting technology, predator-prey relationships, in particular capelin and groundfish relationship and predators of groundfish (seals).

In addition, it produced a conservation framework document for Atlantic lobster. Through consultations with fishers, fisheries scientists, and oceanographers it recommended a definition of lobster conservation principles and strategies. Recommended measures included tool kits for increasing egg production, reducing exploitation rates and effective fishing effort, improving understanding of stock structure, and minimizing waste.

Table 1: Summary of preliminary catches for stocks within the DFO, Newfoundland Region, 1990-1995

Subarea	Species	Division	Catch (t)					
			1995	1994	1993	1992	1991	1990
0+1	Greenland halibut	0	5,852	3,723	2,561	8,200	5,945	6,194
	Shrimp	0A	2,361	4,727	5,501	7,493	6,788	6,177
		0B	2,721	469	106	1,291	1,107	1,609
2	Cod		-	9	13	-	2,835	46,900
	Redfish		1	-	-	1	7	192
	Greenland halibut		1,400	1,444	1,119	1,800	3,200	3,800
	American plaice		0	-	-	<10	80	900
	Other groundfish		-	3	-	100	467	403
	Arctic charr		30	31	38	74	70	100
	Shrimp		12,720	11,481	12,114	12,036	10,655	10,234
	Crab	2J	3,178	2,978	2,275	1,529	989	645
3	Cod	3K	94	368	544	1,756	42,800	54,400
		3L	236	932	3,384	22,600	74,500	104,000
		3N	0	-	326	580	1,500	4,600
		3O	63	2	3,391	6,600	6,500	7,000
		3Pn	35	158	2,411	-	6,500	5,300
		3Ps	613	562	13,517	24,600	27,300	26,300
	Redfish		4,255	10,735	17,481	22,200	16,100	14,900
	Greenland halibut		1,012	1,619	3,919	15,100	4,000	6,500
	American plaice		167	187	8,015	11,800	27,000	27,500
	Yellowtail		7	1	6,280	6,800	7,400	5,100
	Witch flounder		276	437	5,420	6,600	5,700	6,900
	Atlantic halibut		194	35	120	-	560	790
	Haddock		65	20	763	1,200	1,600	4,500
			309	189	472	264	1,300	1,800
			626	442	-	-	-	-
			836	1,404	-	-	-	-
			27	25	-	-	-	-
			170	504	-	-	-	-
	Capelin	3L	83	1,000	23,000	3,000	21,400	48,000
		3K	57	100	13,000	18,000	20,400	51,900
		3Ps	-	300	2,000	50	80	1,200
	Herring		5,000	5,000	6,100	7,000	18,200	8,500
	Mackerel				5,100	1,300	800	1,200
	Squid		48	1,954	98	924	1,723	4,440
	Shrimp	3K	10,900	10,937	4,363	3,594	3,524	3,669
	Sea scallop	3Ps	564	1,299	1,438	676	1,279	1,559
	Iceland scallop	3LNO	6,678	4,571	459	19	-	-
		3Ps	-	440	667	5,967	755	507
	Clams	3N	-	20,000	20,000	11,254	7,200	10,000
	Crab	3K	4,253	7,675	7,295	9,760	11,039	12,245
		3LNO	5,211	6,394	6,652	8,979	12,237	13,790
		3Ps	596	176	121	704	1,590	1,853
2+3	Capelin	2J3KL (offshore)	0	0	0	0	450	57,300
	Atlantic salmon	2J3KLPS	95	133	126	213	353	498
4	Iceland scallop	4R	1,364	2,105	1,914	1,169	412	79
	Crab	4R	920	655	-	-	-	-