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NEWFOUNDLAND REGION

by

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Abstract

A synopsis of Canadian research activity in the NAFO area in 1996 by researchers from Science Branch, Newfoundland Region of the Department of Fisheries and Oceans is presented.

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 estimates for 1996 in Div. 0B are approximately 3500 t, equal to the TAC, and, as in 1995, includes catches of both northern shrimp, *Pandalus borealis*, and striped shrimp, *P. montagui*. Fishing effort and CPUE were comparable to 1995. The status of the resource remains uncertain as CPUE is not considered a reliable index of stock conditions given the degree of difficulty in locating concentrations of shrimp. An increase in the TAC for the 1997-99 period could be possible provided that the effects of a greater level of exploitation be closely monitored.

A review of the Canadian fishery for northern shrimp from 1979-1996 (see SCR Doc. 96/106). was conducted Over the past sixteen years, the fishery has commenced in late June to early July and continues into November and has been restricted to the area between the international boundary to the east and the 500 m depth contour to the west. Beginning in 1988, effort has expanded north of 68°N. Catch, effort, and CPUE (both standardized and unstandardized) were derived from available vessel logs and vessel hails, length frequencies and age composition complied, and trends in shrimp discards reviewed. Analyses indicated that catch rate indices have declined since 1987 and, for the 1994-96 period, are at a lower level than observed from 1989-93, that the decline was associated with a gradual reduction in the catch rates of females, and suggested that the 1993 year class is strong.

A single integrated biomass index to track the development of the stock during the 1976-95 period was developed from five temporally and geographically fragmented biomass indices based on multiplicative modeling of CPUE data in the Canadian and Greenland fisheries (see SCR Doc. 96/111). The model linked catch rate to vessel fishing power, temporal and spatial availability of shrimp, and overall annual abundance. In four of the indices, temporal and spatial effects were modeled either as an interaction term or as an interaction in addition to the main effects. The series showed that during the 1976-88 period, stock biomass fluctuated dramatically at a level substantially higher than that observed from 1989-95 and a declining trend was evident within the latter period.

b) *Greenland Halibut*

Canadian catches for 1996 were approximately 1,457 t down marginally from 1,934 t in 1995. This total excludes catches taken by foreign vessels fishing Canadian quotas which amounted to almost 4,000 t in 1995. This fishery was one of the few active groundfish fisheries in the Canadian Zone in 1996. Recent scientific information on this stock remains limited as the last complete survey was conducted in 1986.

SUBAREA 2

A. Status of the Fisheries

Nominal landings from 1990 to 1996 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) *Atlantic salmon*

Total landings decreased to 48 t in 1996 from a TAC of 55 t

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 1996 achieved the TAC of 5200 t. Both standardized and unstandardized catch per unit effort (CPUE) analyses show an overall increase from 1989 to 1994 followed by a decrease in 1995 and 1996. Size composition consisted of females in two distinct size groups of 24 and 27 mm. The larger size is typical for the area while the smaller is characteristic of more southerly fishing areas. The continued occurrence of large female shrimp suggests maintenance of a health spawning biomass, however, the lower catch rates in 1995 and 1996 are of concern to fishermen.

Catches in Hopedale and Cartwright Channels (2H) acheived the TAC of 7,650 t. The 1996 standardized CPUE was the highest in the 1977 to 1996 period. No declining trends in the male-female components or catch rates of female shrimp has emerged in the 1994 to 1996 data and the resource remains healthy. Given the current positive view of the state of the resource and evidence of continued good recruitment in the next few years, an increase in the TAC appears justified.

Catches in Hawke Channel (southern Div. 2J) + 3K were approximately 11,000 t. 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 and a subtantial increase in TAC for the next three years is possible.

d) *Cod*

The northern cod moratorium has been in effect since July 1992 for cod from Div. 2J3KL. Additional information on the Div. 2J3KL stock is presented under Subarea 3.

e) *Redfish*

There was no directed fishery in 1996 for the Subarea 2 +3K stock. Reported landings totaled less than 2 t. Results from research vessel surveys suggested that population biomass indices remain at extremely low levels.

f) *Crab*

Landings declined to 3,090 t due to quota reductions from 1995 catches of 3178 t. Catch rates continued to decline from a high of 14.6 kg/trap haul in 1991 to 7.9 kg/trap haul in 1995 but increased to 10.2 kg/trap haul in 1996 due to an expansion of fishing effort to new grounds.

g) *Greenland halibut*

The only directed fishery for flatfish species in Subarea 2 was for Greenland halibut from the Subarea 2 + 3KLMNO. Catches increased to 1917 t in 1996 from approximately 1,400 t, in each of 1994 and 1995.

The status of Greenland halibut in the management areas of NAFO Subarea 2+3KLMNO from analyses of commercial fishery and research vessel survey data were conducted (see SCR Doc 96/73). Analyses of the fall 1995 and 1996 data are confounded by the adoption of the Campelen shrimp trawl to replace the

traditional Engel trawl as the standard research survey bottom trawl and the unavailability of the appropriate conversion indices. The cumulative biomass index for all three divisions has steadily declined from 200,000 t in 1984 to approximately 37,000 t in 1992 and appears to be stable since then. Age analyses show different trends for different cohorts. There appears to be a general increase in the abundance index from cohorts at ages 3-5, but cohorts at ages 6-9 have been declining rapidly since the mid 1980s and ages 10+ have been declining at least since the mid 1980s and maybe as early as the beginning of the survey series in 1978. In general terms, the data indicate that estimates of recruiting year classes at ages 2-4 exhibited an increasing trend since the early 1980s except for the 1987 and 1988 year classes. The 1990 and 1991 year classes appear to be at least better than average and early indications suggest that the 1992 and 1993 year-classes may also be better than average.

h) *Roundnose and Roughhead Grenadier*

Information on roundnose and roughhead grenadier in Subareas 2+3 from commercial fisheries and a number of research vessel surveys conducted by the European Union , Russia, and Canada were presented (see SCR Doc. 96/69). Canada has requested the Scientific Council to provide information on the resource inside the Canadian Zone, although the absence of any fishery makes this increasingly difficult. Given mixed reporting of roundnose and roughhead catches in the directed fishery for the former, there is a need to re-evaluate the status of both species.

i) *Witch Flounder*

By-catch of witch flounder in Div. 2J and 3KL in 1996 was approximately 6.2 t. A stock status update reviewing commercial fishery data and research vessel data was prepared (see SCR Doc. 96/105). The commercial fishery began in the early 1960s, peaked at a catch of 24,000 t in 1974, and declined since that year. Estimates of trawlable biomass for the early 1980s averaged about 40,000 t before declining to less than 1,000 t by 1994. The remaining resource, though low in abundance, appears to be concentrated in water depths of greater than 1,000 m near the border between 3K and 3L. This stock is at a dangerously low level and a directed commercial fishery is not advised.

B. Special Research Studies

1. Gear and Selectivity Studies

a) *Discarding of Cod*

A review of discarding of cod in directed northern shrimp and cod fisheries from fishery observer records from 1980 to 1994 in Divisions 2J, 3K, and 3L was conducted in response to concerns that discards were under-recorded in fishing logs and not accounted for in the landing statistics (see SCR Doc.96/46). It was found that discarding from the shrimp fishery was a considerably smaller component than from the cod fishery, accounting for an average of about 8% of the weight of total discards annually, peaking at 34% or 1,156 t in 1988. For both fisheries combined, total discards peaked in 1986 at 9,403 t but dropped to low levels by 1992 when directed cod fisheries were closed. Discards were found to decline substantially with the introduction of the Nordmore grate in 1993.

SUBAREA 3

A. Status of Fisheries

Nominal landings from 1990 to 1996 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) *Shrimp.*

The international fishery in Div. 3M which began in 1993 continued in 1996.

A review of the Canadian fishery from 1993-96 suggests that the 1997 fishery will be dependent on a single year class - the 1993 year class which first recruited to the fishery at age 2 (see SCR Doc. 96/93). A preliminary assessment of the status of shrimp on Flemish Cap summarizing and interpreting data from the fishery, research vessel surveys, and other biological studies show several changes related to the distribution, abundance, and demographic structure of the resource (see SCR Doc. 96/102). Catches have been maintained at high levels due to increasing effort and an expansion of the fishing grounds to target smaller shrimp in shallower waters. A sharp decline in catches of large female shrimp from 1993 to 1996 is considered to reflect the trend in the spawning biomass. The changes in fishing patterns and catch

composition since 1993 suggest that the resource is currently overexploited. Although it is not possible to quantify and compare the effects of fishing with natural events or establish the stock recruitment relationship, it is evident that the continuation of an intensive fishery directed towards young male shrimp is imprudent. The strong 1993 year class was produced b a healthy biomass before the fishery started. The current biomass is much weaker and may remain depressed if younger male ages continue to be heavily exploited before they have the opportunity to change sex and spawn at least once as females.

b) *Capelin*

Inshore capelin catches are usually taken during the inshore spawning migration. Female capelin are preferred to satisfy the Japanese roe market. The 1996 inshore catch (provisional) was approximately 24, 000 t. The 1993 and 1994 year classes are expected to be major contributors to the 1997 spawning stock.

c) *Cod*

Moratoria on directed cod fisheries remained in place in 1996 for Div. 2J3KL since July 1992 , for Subdiv. 3Ps since 1993, and for Div. 3NO beginning in 1995.

Catches for Div. 2J3KL were limited to a recreational fishery, bycatch, and the Sentinel Surveys and totaled approximately 349 t. The 1996 regional 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. An assessment of the stock at the NAFO Scientific Council meeting in June, 1996 indicated severe declines in recent years and confirmed the absence of any good indication of good recruitment although mean weights at age from both Sentinel and trawl surveys suggested that the downward trend has been reversed in the most recent years (see SCR Doc. 96/62). An estimate of biomass and age composition for the portion of the stock in the Regulatory Area from fall stratified random trawl surveys was updated (see SCR Doc. 96/65).

The inshore Sentinel Survey for cod in Div. 2J3KL continued in 1996 and results of the 1995 survey were presented (see SCR Doc. 96/52). The results indicated distributions of cod in shallower water than expected. Interpretation of catch rates remains difficult due to the absence of competitive fishing gear at Sentinel sites.

By-catch and Sentinel Survey catches of Div. 3Ps cod totaled approximately 576 t. Based on a Science Branch regional stock assessment stock status report and consultations held by the Fisheries Resource Conservation Council, the FRCC recommended a 10,000 t fishery for 1997. The Minister of Fisheries and Oceans announced a closely monitored fishery to commence in May.

By-catch of 3NO cod was limited to approximately 99 t. An assessment of Div. 3NO cod based on stratified-random research vessel surveys and a comparison of Canadian and Spanish surveys in the regulatory area were conducted (see SCR Doc. 96/80). However, due to a survey gear change in 1995 in the Canadian survey and the unavailability of appropriate conversion factors, the 1995 fall and 1996 spring survey estimates cannot be compared directly with preceding estimates. Biomass and abundance remain low and recruitment prospects depend upon the 1989 and 1990 cohorts, although the former thought to be relatively strong, is small compared to the strong year classes that sustained the fishery in the 1970s and early 1980s.

d) *Yellowtail Flounder*

A commercial fishing moratorium, established by the Fisheries Commission, has been in place for Div. 3LNO yellowtail flounder since 1994. Overall, the catches from this stock exceeded the TAC in each year from 1985-95 and considerable uncertainty regarding the precise catch levels from this stock in recent years remains as up to one-third of the catch is estimated from Canadian surveillance reports and estimates of the proportion of yellowtail flounder in catches of unspecified flounder by South Korea.

The status of Div. 3LNO yellowtail flounder based on Canadian spring/fall and juvenile, USSR/Russia spring, EU/Spain spring research vessel surveys was reviewed (see SCR Doc. 96/74). The total stock biomass up to 1995, shows a systematic decline since 1984, particularly in Div. 3L but the assessment of the resource status is optimistic compared to recent years. The stock size is still well below that observed for most of the 1970s and early to mid 1980s. With the exception of the spring surveys, the fall and juvenile survey indices, as well as the EU/Spain spring survey from 1995 and 1996, have shown improvement since the moratorium imposed in 1994. There are concerns that the distribution of the stock has contracted to the southern Grand Banks and the high catch rates may confound assessment and management of this stock. A joint industry-DFO survey of this stock is planned for 1997.

e) *American Plaice*

The Fisheries Commission has set a TAC at 0 since 1994. An assessment of the stock in Div. 3LNO based on spring and fall stratified –random bottom trawl surveys reviewed geographic distributions, age at maturity, female spawning stock biomass, stock-recruitment data, and catch to RV biomass data (see SCR Doc. 96/75). The stock has declined to a small fraction of its size in the early 1980s and is reflected in all three divisions. It is not clear if the decline has continued in the last few years – juvenile surveys show no trend while the indices from the spring and fall surveys have continued to decline. Although there has been an increase in the proportion mature at age, the index of spawning stock biomass continues to decline due to large declines in the abundance of older fish and there is no indication of better than average recruitment in recent years.

f) *Witch Flounder*

The commercial fishery has been closed since 1994. An update on distribution and trends in stock size of witch flounder in Div. 3NO based on annual stratified-random research surveys carried out by Canada during spring and fall was conducted (see SCR Doc. 96/70). Plots of geographic distribution from both surveys indicated that the witch flounder resource has been and continues to be mainly distributed in Div. 3O along the southwestern slope of the Grand Bank. In recent years, this distribution has been concentrated in the slope area of the shelf. Total biomass and abundance estimates from both spring and fall surveys were developed – although not directly comparable due to changes in fishing gear in 1995, estimates remain near the lowest observed and there has been no apparent improvement in the stock size since 1994. Recruitment prospects are not known due to the absence of any recent aging data.

g) *Redfish.*

Landings of Unit 2 redfish increased to 6,488 t in 1996 from approximately 4,300 t in 1995 but are substantially below the 18,500 t taken in 1994.

An assessment of redfish in Div. 3LN reviewed commercial catch and effort data and research vessel data from spring and fall Canadian surveys and Russian trawl surveys (see SCR Doc. 96/76). It was not possible to prepare an estimate of absolute size of the stock due to a change of survey gear in 1995 and the unavailability of conversion indices. Results from Canadian spring and fall surveys suggest that the biomass index has been low in Div. 3L since 1991 relative to the late 1970s to mid 1980s. The situation in Div. 3N is unclear due to large seasonal fluctuations in mean numbers and weights per tow possibly related to availability to the trawl gear rather than real changes, however, the survey biomass index has averaged 14,000 t from 1991 to 1995. Catch rate indices for Div. 3L and 3N show much variability but there are indications of decline from the mid 1980s to 1990 in all the derived indices. This corresponds to a period of some of the largest historical catches which likely generated high fishing mortalities. Redfish in Div. 3L continues to be very low with no sign of good recruitment. Div. 3N has declined from 1984 to 1991, but the status since then is uncertain – it contains a recruiting component of unknown abundance that is already recruiting to some fleet sectors. Despite this, there is no sign in the research surveys of any good year classes to follow.

h) *Crab*

Catches in Subarea 3 totaled 33, 893 t in 1996 from Divisions 3K, 3LNO, and 3Ps. Overall, commercial catch rates in 1996 remained high and the 1997 fishery should continue to perform well, but area specific inshore declines due to local variation in recruitment and exploitation levels may be expected.

Landings in Div. 3K increased to 14, 190 t in 1996. Catch rates have ranged from 12 to 15 kg/trap haul over the last several years.

Landings increased to 16,656 t in 1996 up from 13,790 t in 1995. 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 although rates have declined in some inshore areas.

Landings in Div. 3Ps increased in 1996 to 3,047 t from 1853 t from 1995. Overall catch rates increased to 16.6 kg/trap haul from 10.0 kg/trap haul in 1995.

i) *Iceland Scallops*

Expansion of this fishery continued in 1996 with removals totaling 9,454 t up from 6,501 t in 1995. Catch rates have generally remained stable with the exception of the northern areas of Div. 3LN, where CPUE declined.

B. Special Research Studies

1. Environmental Studies

a) *Environmental and Oceanographic Studies*

An overview of physical oceanographic/environmental conditions in the Northwest Atlantic in 1995 were presented using selected oceanographic and meteorological data sets (see SCR Doc. 96/41). Winter air temperatures and ocean temperatures were colder than normal although in the case of the later warmer relative to the extreme cold period of the early 1990s. The volume of the CIL declined significantly and its core temperatures generally rose with the exception of the northeastern shelf. Large areas of the continental shelf, particularly the Grand Banks contained warmer-than-normal bottom temperatures in the autumn.

Environmental conditions and oceanographic observations – temperatures, salinities, ice coverage - on the Newfoundland Shelf during spring 1996 and on Flemish Cap during the summer were compared to historical data (1961-1990) from the respective areas (see SCR Doc. 96/26 and 96/87).

Analyses of the Newfoundland Shelf data indicated that the moderate air temperatures experienced in Atlantic Canada during late fall of 1995 and winter of 1996 gave rise to below normal ice cover extent and concentration during winter and early spring along the east coast of Newfoundland and Labrador which led to early ice clearing along the Newfoundland coast. At Station 27, the warming trend that began during the fall of 1995 continued with temperatures 0.5°C above normal by March over the entire water column. Salinities were near normal. Temperatures on the Grand Bank and along the east coast of Newfoundland were up to 1.0 °C above normal over much of the water column consistent with the lack of spring ice cover. The cold-intermediate-layer (CIL) was below normal along Flemish Cap and Bonavista transects. In general, the meterological, ice, and oceanographic conditions during the spring of 1996 continue to show a moderating trend that started in 1994 compared to the anomalous conditions of the early 1990s.

The results on Flemish Cap indicated that the colder than normal water temperatures experienced since the late 1908s continued into 1996 with some improvements, particularly in the depth range of 50 m to the bottom. In the near surface layer, temperatures were up to 0.5 to 1.5 °C below normal in 1995 and slightly cooler at 0.5 to 2.5 °C below normal in 1996. Upper layer (top 50 m) salinities were above the long term mean in both 1995 and 1996. Chlorophyll measurements show higher summer values in the upper 50 m of the water column over the Cap compared to the Grand Bank where a weaker maximum was observed somewhat deep in the water column. Dissolved oxygen levels indicate a well oxygenated water column over the Cap in 1995 similar to values in 1993 and 1995. Additionally, current measurements using ADCPs continue to show the presence of a general anticyclonic circulation around the Cap.

2. Biological Studies

a) *Cod.*

A pelagic juvenile cod survey of 2J3KLNO was conducted with data on abundances, distributions, length frequencies, ages, and hatch dates collected (see SCR Doc. 96/43). Cod were distributed throughout the inshore areas sampled and observed nearshore off southern Labrador. There were few cod observed offshore on the Northeast Newfoundland Shelf and Grand Bank. Overall abundance in the inshore was similar to 1994 but offshore, the index value was lower in 1995 than 1994.

An inshore seine survey of demersal juvenile cod in the coastal zone of Div. 3K and 3L was conducted to test for enhanced density of first year juvenile cod resulting from a spawning aggregation located in Smith Sound, Trinity Bay in the spring of 1995 and to compare the abundance of juvenile cod between years in the entire survey area (see SCR Doc. 96/18). It was found that the density of 0+ fish did not exceed previous years densities and the abundance of 1+ and 2+ juveniles was lower than expected. Suggesting an apparent increase in mortality.

A cohort projection model was analyzed as a recruitment index to assess the relative abundance of pre-recruit demersal cod in Div. 3K and 3L (see SCR Doc. 96/19). An analysis to determine the homogeneity of catches across surveys, based on the interaction term in a two-way classification of catch, by year and by survey was conducted. The interaction F-ratios tended to be small, often less than unity. This homogeneity in year to year change across surveys means that a single composite index could be constructed by averaging across surveys within each year. However, a simple average will give undue weight to the series that has the largest mean value. In the absence of an acceptable weighting, and in light of the similarity in trends of the indices,

we constructed a narrative index that reports the evolution of each year class, as seen in the several surveys. This demonstrated that two cohorts - 1992 and 1993 - began weakly but became somewhat stronger at age 1 and 2 with strong offshore shifts in distribution. Two cohorts - 1994 and 1995 - began more strongly of which only the latter appears strong. Two cohorts - 1993 and 1994 - became substantially weaker in 1995 as age 2 and age 1 respectively.

The availability of suitable habitat and the use of such habitat by juvenile cod in Placentia Bay (Div. 3Ps) in conducting assessments of juvenile abundance was investigated (see SCR Doc. 96/23). Habitat availability was established by submersible and by a groundtruthed acoustic seabed classification system. Habitat use of age 1 to 4 year old cod was analyzed and habitat types characterized by depth, substrate particle size, bathymetric relief, and the presence or absence of macroalgae. Agreement between visual assessments of bottom type and those derived from acoustic signals were found to be good. Substrate selection by juvenile cod was age specific. Age 2-4 cod were found to be associated with areas of coarse substrate and high bathymetric relief. In contrast, age 1 cod were found primarily in areas with a gravel substrate an low relief. Juveniles did not select for substrates with macroalgae cover. By integrating information on the substrate associations with acoustically sampled bottom classification data over a broad area, it was determined that the amount of suitable habitat for juvenile cod was a small proportion of that available and the location of suitable habitat was age specific. Such information should refine the use of juvenile survey data and help determine survey designs.

Maturity of female cod in Div. 2J3KL from 1982 to 1996 was analyzed to extend the time series for estimates of proportion mature at age and present the observed proportion mature at age in each year for each division (see SCR Doc. 96/45). In recent years, there has been an increase in the proportion of mature fish at age in the 2J3KL stock as a whole, particularly since the early 1990s, and within each division, of which point estimates of age at maturity do not take into account. As a result of these increases, the estimated age at 50% maturity has decreased from over six to a low of 4.86 in the most recent 2 years. Given the potential for changes in age at maturity to be an indicator of stress in a population and that even small differences in age at maturity can have a significant impact on the estimation of potential yield of a fishery and of population growth rate, the best estimates of proportion mature at age should be incorporated into spawning stock biomass estimates.

A review of information regarding distribution and spawning of cod around headland shelves, within major bays, and within small fjord-like inlets in eastern Newfoundland prior to the 1990s was conducted to resolve uncertainty regarding the stock affinities of cod found in inshore waters in 1995-1996 (see SCR Doc. 96/59). Cod in Div. 2J3KL have historically migrated on a seasonal basis between an overwintering area near the shelf break and a summer-autumn feeding area in shallow water along the coast of southern Labrador and eastern Newfoundland. Some cod, however, remain near the coastal shelves in deep water below the cold-intermediate-layer (CIL) and some remain within the bays. Recent reports of large aggregations of cod in inshore areas and frequent observations of cod in unusually shallow water contrast with very low catches during fall research vessel bottom trawl surveys in offshore waters. Cod are known to have been present in each of these environments during the winter, spawning cod have been reported in each environment during the spring, and a fishery occurred in Trinity Bay and Bonavista Bay (Div. 3L), and possibly other bays, in the early spring before the arrival of cod from the offshore. despite these observations, and evidence that some of the cod found in the small inlets in the early 1990s were genetically distinct from cod sampled offshore at the same time, there is yet little evidence to support the hypothesis that each bay has one or more substocks which have historically contributed substantially to the fishery.

Cross-shelf distributions of cod in Div. 2J3KL in May and June 1995 were measured to determine the current population density and distributions of cod and other acoustically detectable species (capelin and Arctic cod) in Trinity and Bonavista Bays outward to the shelf edge (Div. 3KL) and Black Tickle, Labrador eastward across the Hawke Channel (Div. 2J) as part of longer term study on population structure and dynamics (see SCR Doc. 96/57). In the southern block, most of the cod were detected inshore in the NW part of Trinity Bay. Densities were high where cod occurred as a result of spawning behavior. Cod were also found in the inner sound areas of Bonavista Bay, but surveying was not possible. In the northern block, cod, at very low densities, were widely distributed in the Hawke Channel at depths of 350-450 m over an area spanning 50 nm and in an area of high shrimp density. These fish were mostly juveniles with a portion of spawning adults in spent condition. They did not exhibit any of the typical migratory behavior of this species. No fish were located inshore.

Bank scale migration patterns of northern cod were assessed using cod tagging data from experiments conducted over the last three decades in the Hamilton Bank and Belle Isle Bank regions and the North Cape region of Grand Bank to further refine cod stock structure understanding and a hypothesis regarding inshore and offshore aggregations of northern cod in recent years was proposed (see SCR Doc. 96/42). Genetic analyses suggests that differences may exist between northwestern (Hamilton, Funk, and Belle Isle Banks) and southeastern (Northern Grand bank) cod aggregations in the Div. 2J3KL stock (see SCR Doc. 96/21).

Conditions of cod in Div. 2J3KL were monitored by sampling catches during the fall research vessel surveys between 1978-1995 and the inshore Sentinel Surveys during summer-fall 1995 to assess changes in fitness as a factor in the decline of the stock in the early 1990s (see SCR Doc. 96/48). In the offshore, the somatic condition of cod in Div. 2J and 3K recovered from low levels in 1991-92 to moderate levels in 1993-95. Liver index, which had declined in Div. 2J, remained at a relatively low level. preliminary analyses revealed that sampling has varied spatially within Divisions over time, and that there is spatial heterogeneity in condition within Divisions. Thus, some of the variability observed in the time series of cod condition may be related to the sampling itself. When liver index data are aggregated into groups defined by aggregations of cod rather than Division boundaries, the contrast between patterns in the north an patterns in the south become more apparent; of considerable interest is an increase in liver index on the plateau of grand Bank at the time that liver index declined rapidly in Div. 2J. Condition of cod inshore in 1995 increased considerably over time at one site which was monitored during July-August. Condition at 14 other sites, each of which was monitored only 1-3 times in September-October, was highly variable, but generally good.

Biological characteristics – length, sex, maturity, and otoliths - of aggregations of cod in Smith Sound and Northwest Arm, Trinity Bay were collected in December, 1995 and April, 1996 (see SCR Doc. 96/20). Cod were generally large and ages ranged from 3 to 8 years with more than 50% five year olds. Prevalence of the parasitic copepod *Lernaeocera branchialis* suggested that these fish had resided in inshore waters throughout the fall and winter months. The gonads of females sampled in December suggested they would spawn in the spring of 1996 while those sampled in April appeared destined to spawn later in the spring of 1996.

Patterns in the annual weight increment for Div. 2J3KL cod were analyzed to evaluate the potential utility of a predictive relationship between environment and biological processes determining fish production (see SCR Doc. 96/47). A general linear model containing division and age effects was found to explain 36% of the variance in the logarithm of annual weight increment. The residuals from this model had a temporal pattern which could in part be explained by variability in the area of the cold-intermediate-layer (CIL). A predictive model based on this relationship could be developed, but its utility is questionable. Given the lag between the analysis (up to and including year *t-1*), the assessment (year *t*) and the projection (year *t+1*), the model would have to be able to make useful 2 year projections. To do this, the CIL has to be predicted in year *t* and year *t+1*, however, there is only a lag-1 autocorrelation in the CIL data. Further work to examine the cross-validated prediction sums of squares for a variety of different weight increment models is planned.

The population growth rate of cod at low abundance was examined for a number of cod stocks in terms of the variability of the intrinsic rate of natural increase (see SCR Doc. 96/40). The intrinsic rate of increase was found to be related to temperature, contrary to the expectation that it might increase as the high and low temperature limits of habitability for cod was approached. For the parameter regime considered, the intrinsic rate of natural increase was found to have a simple dependence on age at maturity and the number of replacements each spawner can produce at low population densities. Density was shown to be not temperature dependent, and thus the covariation of the intrinsic rate of natural increase and temperature arises from the influence of temperature on age at maturity. This rate was robust and may be of use in estimating the recovery time of depleted stocks.

b) *Yellowtail Flounder*

Tag returns of juvenile yellowtail flounder were analyzed to examine movement in the Southeast Shoal nursery area of the Div. 3LNO stock (see SCR Doc. 96/66). Juveniles are relatively sedentary moving an average of 29 nm in 384 free days. This implies that there are low transport rates out of the nursery area which is a major requirement to introducing year round closure as a technical measure to protect the juveniles from over-exploitation in an effort to conserve and rebuild the stock. Prior to the closure of this fishery, there was conflicting fishery taking place for juveniles in the Regulatory Area and adults inside the 200 mile limit.

c) *American Plaice*

Yield-per-recruit calculations for the American plaice stock in Div. 3LNO were presented and discussed in relation to optimal size of first capture (see SCR Doc. 96/60). Results indicated that an optimum size of first capture cannot be defined in terms of maximum yield per recruit with any of the observed exploitation patterns observed in the fishery. However, significant gains in spawning stock biomass per recruit can be achieved by changing the exploitation pattern or reducing the level of fishing mortality. The results also indicated that for this slow growing stock, significant increases in effective minimum mesh size for trawls is required to achieve a level of spawning stock biomass per recruit equivalent to that achieved with more selective gears at the same level of fishing mortality.

Preliminary results of two tagging experiments conducted in Div. 3LNO were presented in 1996 (see SCR Doc. 96/61). The objectives of the experiments were to examine movements of juvenile plaice released near the

tail of the Grand Bank and adults released near the top of the bank. Both adults and juveniles appeared to be rather sedentary with juvenile plaice moving an average of 33.8 nm in 400 days free and adult plaice moving 52 nm in 250 days free without any indications of any large scale migrations.

3. Gear and Selectivity Studies

a) *Shrimp Fishery*

Reviews of the Canadian fishery from 1993-96 and the Norwegian fishery in 1995-96 for P. borealis on Flemish Cap (Div. 3M) from 1993-96 were conducted (see SCR Doc. 96/93 and 96/104 respectively). Catch, bycatch and discards, effort, and CPUE data were analyzed from logbook data and biological data on length distributions and age composition were reviewed.

Analyses of the Canadian fishery showed substantially lower commercial catch rates from 1994-96 than those achieved in the virgin fishery. Major shifts in the distribution of the fishery occurred to the west and southwest in 1994 and to much shallower depths in 1995 and 1996 as the fishery along the eastern slope dissipated since 1993. High catch rates, which were common in the areas fished in 1993, occurred only sporadically in 1996. The review of the Norwegian fishery did not detect a trend in CPUE in recent years although effort was dispersed over a wider range in 1996 compared to 1995 and was concentrated in the north and along the eastern slope. Size and age composition also changed over time. In 1993, catches were dominated by females predominantly from the abundant 1988 year class. In 1995 and 1996, the Canadian and Norwegian catches were dominated by males recruited from the strong 1993 year class. Confounding the age analyses, is the substantial variation in the length and age at sex reversal observed in the relatively short time series of the Canadian data, the implications of which are not entirely clear.

A review of the level and composition of bycatch of small fish and invertebrates by Canadian and Norwegian fleets in the Div. 3M fishery was conducted (see SCR Doc. 96/64). Redfish was found to be dominant with lesser amounts of striped wolffish, Greenland halibut, skates, capelin, witch, plaice, and cod taken as well as about 95 other noncommercial species. Reductions in terms of catch by weight and numbers of fish have been observed in 1994 and 1995 due to the introduction of the Nordmore grate in 1994 and a reduction in grate size in 1995.

b) *3Ps Stratification*

The stratification scheme for Div. 3Ps was revised to correct a mistake in identifying the line dividing Div. 4V and Div. 3P (see SCR Doc. 96/55).

c) *Survey Gear and Comparative Fishing Trials*

In 1995, a Campelen 1800 shrimp trawl was adopted as the new survey trawl for stratified random bottom trawl surveys. The annual fall survey of Div. 2J3KLMNO was described (see SCR Doc. 96/27). Comparative fishing trials were developed for converting catches at length of cod, American plaice, Greenland halibut, witch flounder, and redfish obtained by the *Gadus Atlantica* using 30 minute tows with an Engel 145 High Lift otter trawl to *Teleost* equivalents - 15 minute tows with the Campelen 1800 shrimp trawl (see SCR Doc. 96/28 and SCR Doc. 96/77). Paired tows were employed and criteria developed for determining whether one vessel fished on an aggregation essentially missed by the other vessel; such pairs were omitted from the final analysis. Bootstrap distributions were used for estimating the precision of the conversions. Because the Campelen is more efficient at catching small fish than the Engel and because of the current scarcity of larger fish, extrapolation in either direction beyond the ranges indicated could not be justified.

d) *Gear Selectivity from Multiple Tagging Experiments*

A new method was introduced for estimating selectivity of fishing gears from tagging data in which data from many experiments are combined as a tool to improve stock assessments (see SCR Doc. 96/44). This method was applied to 126 tagging experiments on cod conducted from 1954 to 1990. It was demonstrated that the selectivity of otter trawls changed from the 1960s to the 1980s; during the earlier time period, maximum probability of capture occurred at 55 cm and declined for older fish whereas now the maximum probability is approximately 60 cm and remains constant for longer fish. Gillnet selectivity at length decreased from the 1960s to the 1990s; the peak gillnet maximum probability of capture declined from approximately 75 to 60 cm for gillnets.

e) *Canadian Groundfish Survey Trawls*

A description, history, and outline of standardization protocols of the bottom survey trawls and survey vessels

used at the Northwest Atlantic Fisheries Centre aimed at furthering understanding of measurement errors associated with trawl efficiency was presented (see SCR Doc. 96/50). The capabilities of the current survey trawl, the Campelen 1800 shrimp trawl, in catching a wide range of demersal fishes, pelagic fishes, and benthic invertebrates were also reviewed.

Performance of the Campelen on both offshore survey vessels during the 1995 fall surveys of Div. 2J3KLMNO was analysed using SCANMAR acoustic trawl monitoring sensors attached to the fishing gear to quantify trawl efficiency to decrease the variation around catchability (see SCR Doc. 96/51). Data on trawl geometry, towing speeds, bottom contact, tow duration, and trawl performance were collected from both the *Wilfred Templeman* and *Teleost*. Intepretations regarding fishing power of both trawls on these vessels was difficult, highlighting the need for comparative fishing trials.

f) *Restrictor Rope Contol of Bottom Trawl Geometry*

Experiments were carried out to investigate the use of a restrictor rope to physically control the door spread of the newly adopted Campelen 1800 bottom survey trawl to evaluate the effects on trawl performance and catchability of groundfish (see SCR Doc. 96/53). The alternate haul method was used to compare differences in trawl performance and geometry with the trawl doors unrestricted with a rope attached to each trawl warp ahead of the doors. Catches from these alternate hauls were used to evaluate the effect of the restrictor rope technique on catchability of groundfish species. The technique was found to be effective in minimizing trawl width variation at bottom depths ranging from 43 to 1244 m and had no obvious effect on the magnitude of catches and size composition.

4. Miscellaneous Studies

a) *Closed Areas as a Management Measure*

Data from the Canadian commercial fishery in Div. 3NO was examined and related to the distributions of groundfish observed in research vessel surveys to determine if one or more areas on Grand Bank can be defined where catches of juvenile flatfish and cod could be eliminated when commercial fisheries are reopened (see SCR Doc 96/63). Practical considerations and potential benefits of closed areas as a management tool were discussed as a precautionary measure against overexploitation and as a measure to increase the fishable resource somewhere outside the boundaries of the closed area.

b) *Resource User Interviews in Northern Cod Assessments*

Preliminary findings of interviews with inshore and longliner fishers in Div. 3K and 3L were presented (see SCR Doc 96/22). The potential contribution to cod stock assessments of fisher's knowledge regarding cod stock structure, changes in catchability, information on abundance in a closed fishery, and potential impacts of a re-opened capelin fishery on northern cod stock recruitment were reviewed.

SUBAREA 4

A. Status of the Fisheries

a) *Scallops*

The TAC of 1,200 t was caught in 1996. 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 and the operation of the fishery over areas that are also nursery grounds for recently settled scallops may further impair recruitment.

SUBAREAS 2 + 3 + 4

A. Special Research Studies

1. Biological Studies

a) *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 char stock complexes.

LIST OF 1996 CANADIAN (NEWFOUNDLAND REGION) RESEARCH DOCUMENTS (SCR)

SCR No.	Ser. No.	Author(s) and Title
96/19[a]	N2692	SCHNEIDER, D. C, E. L. DALLEY, and J. T. ANDERSON. A combined recruitment index for demersal juvenile cod (0, 1 and 2 group) NAFO Divisions 3K and 3L. (9 p.)
96/20[a]	N2693	BRATTEY, J. Biological characteristics of Atlantic cod (*Gadus morhua*) from three inshore areas of western Trinity Bay, Newfoundland. (18 p.)
96/21[a]	N2694	BENTZEN, P., C. T. TAGGART, D. E. RUZZANTE, and D. COOK. Microsatellite polymorphism and the population structure of Atlantic cod (*Gadus morhua*) in the Northwest Atlantic. (20 p.)
96/22[a]	N2695	NEIS, B., L. FELT, D. C. SCHNEIDER, R. HAEDRICH, J. HUTCHINGS, and J. FISCHER. Northern cod stock assessment: what can be learned from interviewing resource users? (22 p.)
96/23[a]	N2696	GREGORY, R. S., J. T. ANDERSON, and E. L. DALLEY. Use of habitat information in conducting assessments of juvenile cod abundance. (14 p.)
96/26[a]	N2699	COLBOURNE, E. Environmental conditions on the Newfoundland Shelf, spring 1996 with reference to the 1961-1990 normal. (14 p.)
96/27[a]	N2700	BRODIE, W. B. A description of the 1995 fall groundfish survey in Divisions 2J3KLNO. (7 p.)
96/28[a]	N2701	WARREN, W. G. Report on the comparative fishing trial between the *Gadus Atlantica* and *Teleost.* (16 p.)
96/40[a]	N2715	MYERS, R. A., G. MERTZ and P. S. FOWLOW. The population growth rate of Atlantic cod (*Gadus morhua*) at low abundance. (18 p.)
96/41[a]	N2716	DRINKWATER, K. F., E. COLBOURNE, and D. GILBERT. Overview of environmental conditions in the Northwest Atlantic in 1995. (65 p.)
96/42[a]	N2717	TAGGART, C. T. Bank-scale migration patterns in northern cod. (9 p.)
96/43[a]	N2718	ANDERSON, J. T., and E. L. DALLEY. Pelagic juvenile cod (*Gadus morhua*) in the Newfoundland Region (2J3KLNO), 1994 and 1995. (10 p.)
96/44[a]	N2719	MYERS, R. A., and J. M. HOENIG. Estimates of gear selectivity from multiple tagging experiments. (17 p.)
96/45[a]	N2720	MORGAN, M. J., and J. BRATTEY. Maturity of female cod in NAFO Divisions 2J3KL with a comparison of fish from western Trinity Bay with offshore 3L. (7 p.)
96/46[a]	N2721	KULKA, D. W. Discarding of cod (*Gadus morhua*) in the northern cod and northern shrimp directed fisheries from 1980-94. (12 p.)
96/47[a]	N2722	SHELTON, P. A., G. R. LILLY, and E. COLBOURNE. Patterns in the annual weight increment for 2J3KL cod and possible prediction for stock projection. (18 p.)
96/48[a]	N2723	LILLY, G. R. Condition of cod in Divisions 2J+3KL during the autumns of 1978-1995. (15 p.)

96/50[a] N2726 McCALLUM, B. R., and S. J. WALSH. Groundfish survey trawls used at the Northwest Atlantic Fisheries Centre, 1971-present. (18 p.)

96/51[a] N2727 WALSH, S. J., and B. R. McCALLUM. Performance of the Campelen 1800 shrimp trawl during the Northwest Atlantic Fisheries Centre 1995 fall groundfish surveys. (17 p.)

96/52[a] N2728 DAVIS, M. B. The 1995 inshore sentinel survey for cod in NAFO Divisions 2J3KL. (14 p.)

96/53[a] N2729 WALSH, S. J., and B. R. McCALLUM. Preliminary analysis of controlling the geometry of a bottom survey trawl using the restrictor rope technique: effect on trawl performance and catchability of groundfish. (15 p.)

96/55[a] N2731 MURPHY, E. F. Corrections to the stratification scheme in 3Ps. (11 p.)

96/57[a] N2733 ROSE, G. A. Cross-shelf distributions of cod in NAFO Divisions 2J3KL in May and June 1995: some preliminary findings of a longer term study. (12 p.)

96/59[a] N2735 LILLY, G. R. Observations on cod in the inshore environment of eastern Newfoundland. (10 p.)

96/60[a] N2736 CASEY, J., P. A. LARGE, and M. J. MORGAN. On addressing the optimal size of first capture for American plaice in Divisions 3LNO. (7 p.)

96/61[a] N2737 MORGAN, M. J. Preliminary results of tagging experiments on American plaice in NAFO Div. 3LNO. (13 p.)

96/62[a] N2738 SHELTON, P. A., D. E. STANSBURY, E. F. MURPHY, G. R. LILLY, and J. BRATTEY. An assessment of the cod stock in NAFO Divisions 2J+3KL. (56 p.)

96/63[a] N2739 BRODIE, W. B. Should closed areas be considered as a management measure in future fisheries for cod and flatfish on the southern Grand Bank. (40 p.)

96/64[a] N2740 KULKA, D. W. and D. POWER. By-catch in the NAFO Division 3M shrimp fishery, 1993-1995. (15 p.)

96/65[a] N2741 MURPHY, E. F. Cod in Divisions 2J+3KL - Estimates of biomass and age composition for the portion of the stock in the NAFO Regulatory Area from Canadian research vessel surveys. (11 p.)

96/66[a] N2742 MORGAN, M. J. and S. J. WALSH. Tracking movements of juvenile yellowtail flounder in the nursery area on the southern Grand Bank, NAFO Divisions 3LNO. (10 p.)

96/69[a] N2760 ATKINSON, D. B. Roundnose grenadier (*Coryphaenoides rupestris*) and roughhead grenadier (*Macrourus berglax*) in NAFO Subareas 2+3. (6 p.)

96/70[a] N2745 BOWERING, W. R., and D. ORR. Distribution and trends in stock size of witch flounder in NAFO Divisions 3NO. (15 p.)

96/73[a] N2748 BOWERING, W. R., W. B. BRODIE, M. J. MORGAN, D. POWER, and D. ORR. The status of the Greenland halibut resource in the management area of NAFO Subarea 2 and Divisions 3KLMNO. (34 p.)

96/74[a] N2749 WALSH, S. J., W. B. BRODIE, M. VEITCH, D. ORR, D. POWER, and J. MORGAN. The status of yellowtail flounder resource in the NAFO fisheries management area of Divisions 3LNO. (REVISED, 36 p.)

96/75[a] N2750 MORGAN, M. J., W. B. BRODIE, S. J. WALSH, D. POWER, and D. ORR. An assessment of the American plaice stock in Divisions 3LNO. (31 p.)

96/76[a] N2751 POWER, D. An assessment of redfish in Divisions 3LN. (33 p.)

96/77[a] N2752 STANSBURY, D. E. Conversion factors from comparative fishing trials for Engel 145 otter trawl on the FRV *Gadus Atlantica* and the Campelen 1800 shrimp trawl on the FRV *Teleost.* (15 p.)

96/80[a] N2755 DAVIS, M. B., E. F. MURPHY, D. STANSBURY, and P. A. SHELTON. An assessment of the cod stock in NAFO Divisions 3NO. (31 p.)

96/87[b] N2770 COLBOURNE, E. Oceanographic conditions on the Flemish Cap during the summer of 1996, with comparisons to the previous year and the 1961-1990 average. (16 p.)

96/93[b] N2776 PARSONS, D. G., and P. J. VEITCH. The Canadian fishery for northern shrimp (*Pandalus borealis*) on Flemish Cap (NAFO Division 3M), 1993 to 1996. (12 p.)

96/102[b] N2785 PARSONS, D. G. Assessment of shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap) - 1996. (9 p.)

96/104[b] N2787 GODØ, O. R., and D. G. PARSONS. Biological and catch and effort data from the Norwegian fishery for shrimp on Flemish Cap, 1995-1996. (5 p.)

96/105[b] N2788 BOWERING, W. R. Stock status update of witch flounder in NAFO Divisions 2J and 3KL. (13 p.)

96/106[c] N2803 PARSONS, D. G., and P. J. VEITCH. The Canadian fishery for northern shrimp (*Pandalus borealis*) in NAFO Division 0A and Subarea 1, 1979-1996. (13 p.)

96/111[c] N2808 HVINGEL, C., H. LASSEN, and D. G. PARSONS. A biomass index for northern shrimp (*Pandalus borealis*) in Davis Strait based on multiplicative modelling of commercial catch-per-unit-effort data (1976-1995). (19 p.)

Table 1: Summary of Preliminary Catches for Stocks within the DFO, Newfoundland Region

Subarea	Species	Division	Catch (t)						
			1996	1995	1994	1993	1992	1991	1990
0+1	Greenland	0	1453	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	3000	2,721	469	106	1,291	1,107	1,609
2	Cod		0	-	9	13	-	2,835	46,900
	Redfish		1	1	-	-	1	7	192
	Greenland		1917	1,400	1,444	1,119	1,800	3,200	3,800
	American plaice		1	0	-	-	<10	80	900
	Shrimp		12850	12,720	11,481	12,114	12,036	10,655	10,234
	Crab	2J	3090	3,178	2,978	2,275	1,529	989	645
3	Cod								
		3K	160	94	368	544	1,756	42,800	54,400
		3L	190	236	932	3,384	22,600	74,500	104,000
		3N	2	0	-	326	580	1,500	4,600
		3O	51	63	2	3,391	6,600	6,500	7,000
		3Pn	58	35	158	2,411	-	6,500	5,300
		3Ps	458	613	562	13,517	24,600	27,300	26,300
	Redfish		9581	4,255	10,735	17,481	22,200	16,100	14,900
	Greenland		3859	1,012	1,619	3,919	15,100	4,000	6,500
	American plaice		183	167	187	8,015	11,800	27,000	27,500
	Yellowtail		63	7	1	6,280	6,800	7,400	5,100
	Witch flounder		285	276	437	5,420	6,600	5,700	6,900
	Atlantic halibut		92	194	35	120	-	560	790
	Haddock		72	65	20	763	1,200	1,600	4,500
	Pollock		244	309	189	472	264	1,300	1,800
	Capelin								
		3L	16000	83	1,000	23,000	3,000	21,400	48,000
		3K	8000	57	100	13,000	18,000	20,400	51,900
	Shrimp	3K	11000	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	9454	6,501	3,941	817	22	-	-
	Crab	3K	14190	12,245	11,039	9,760	7,295	7,675	4,253
		3LNO	16656	13,790	12,237	8,979	6,652	6,394	5,211
		3Ps	3047	1,853	1,590	704	121	176	596
2+3	Capelin	2J3KL (offshore)	0	0	0	0	0	450	57,300
	Atlantic salmon	2J3KLPs		95	133	126	213	353	498
4	Iceland scallop	4R	1204	1,497	2,294	1,914	1,169	412	79
	Crab	4R	833	920	655	-	-	-	-