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Canadian Research Report for 2006

Part A. Newfoundland and Labrador Region[1]
Part 2. Central and Arctic Region[2]

Submitted by

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PART A.

SUBAREAS 0 AND 1

A. Status of Fisheries

Nominal landings from 1992 to 2006 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) *Greenland Halibut* – Subarea 0 + 1 (except Div. 1A inshore)

The Greenland halibut resource within Subarea 0+1 is considered to be part of a common stock distributed in Davis Strait and south to Subarea 3. The resource within the area, with the exception of Div. 1A inshore, is managed jointly by Canada and Denmark (Greenland), with the TAC being split equally. Since 2000, NAFO Scientific Council has provided separate TAC advice for offshore areas of Div. 0A+1A based on the unresolved relationship with the remaining areas and in 2003, Div. 1B has been included in the management area with Div. 0A and Div. 1A. In 2005, Scientific Council advised for 2006 a TAC of 13,000 t for Greenland halibut in Div. 0A+1AB and 11,000 t for Div. 0B and 1C-1F. Canadian catches in offshore 0+1 have been at the TAC levels since 2000. Canada (NL) catches from 2003 to 2006 were approximately 4000 t, fully utilizing it's allocation of the quota. In 2006, about 1,900 t were taken by otter trawls, 2,000 t taken with gillnets and 200 t taken by longline. Length compositions in the catches have been stable in recent years.

SUBAREA 2

A. Status of Fisheries

Nominal landings from 1992 to 2006 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) *Atlantic salmon* – Subarea 2

The commercial fishery remains closed since 1998. Approximately 6,227 salmon were retained or hooked and released in the recreational fishery. Preliminary information on subsistence fishery catches indicated that about 30 t of salmon were harvested in 2006.

b) *Arctic charr* – Subarea 2

Commercial landings of arctic charr from north Labrador in 2006 were approximately 40 t, an increase of 80% over 2005. Commercial catch rates have remained moderately high in recent years, but only two of three stock complexes were fished in 2006. Over the past 33 years (1974 – 2006), more than 2,800 t of charr have been harvested from a limited section of the north Labrador coast, and attests to the capacity of this area to produce fish. Preliminary information on the amount of charr harvested for subsistence (food) purposes in 2003, 2004, and 2005 are: 9.6 t, 13.7 t, and 17.2 t, respectively and are believed to be underestimates of the full extent of subsistence harvesting. Data for 2006 are presently unavailable.

c) *Cod* – Div. 2GH, Div. 2J3KL

The cod stock in Div. 2GH has been under a moratorium with respect to directed fishing since 1996. Landings (directed or by-catch) by Canada (NL) have been extremely low (<1 t) since 1992.

The northern (Div. 2J+3KL) cod stock was closed to directed commercial fishing in 1992. A small directed commercial fishery was reopened in the inshore only during 1998-2002. Over this time catches ranged from 4,200 to 8,500 t. In April 2003 the whole stock area was closed indefinitely to directed commercial and recreational fishing. Monitoring by means of limited fishing by a small number of fish harvesters at specific sites (sentinel surveys) continues. Most of the catch from 2003-2005, which ranged from about 600 t to 1,300 t, was by-catch from the gillnet fishery for winter flounder in shallow inshore waters (<25 fathoms).

During 2006, a pilot-scale inshore fishery using vessels <35 ft was reopened and fishers were each permitted to harvest 3,000 lb of cod. The landings in 2006 totaled 2,679 t, including 380 t in the recreational fishery, 159 t in the sentinel surveys, and 45 t of by-catch.

The 2J3KL cod stock was assessed in March-April 2007. The stock as a whole remains at a very low level. In the offshore, the 2006 research bottom-trawl surveys during both spring (3L only) and autumn indicate that the biomass remains at <4% of the levels in the 1980s. Prospects for recovery in the offshore remain very poor because of very low recruitment (related at least in part to low spawner biomass) and extremely high mortality. In the inshore, the biomass of populations in the central area (Trinity Bay to Notre Dame Bay), as determined by sequential population analysis, increased from the start of the series in 1995 to a peak in 1997 (4+ biomass) or 1998 (SSB), but declined by more than 50% by 2003 as a result of fishing mortality, high natural mortality on adults, and weak recruitment. The biomass increased during 2003-2005 as a result of slightly improved recruitment and reduced fishing mortality. However, more recent recruitment is weaker. The biomass declined by 6% during 2006 and is currently (1 January 2007) about mid-way between the peak in 1997-1998 and the low in 2003.

d) *American plaice* – Subarea 2 + Div. 3K

This stock has been under moratorium since 1994. This stock has not been assessed since 2003 but research vessel surveys indicate that the stock of American plaice in Subarea 2 + Div. 3K remains at a very low level. By-catch has increased from an average of 13 t during 1994-1999 to an average of 100 t per year from 2000 to 2002, due mainly to by-catch in the Greenland halibut fishery. From 2003-2005 by-catch averaged 26 t but increased to 60 t in 2006. The composition of the American plaice by-catch in this fishery is composed mainly of sexually mature females.

e) *Redfish* – Subarea 2 + Div. 3K

This stock has been under moratorium to directed fishing in the Canadian EEZ since 1997. Prior to this, there had not been a persistent directed effort on this stock since 1990, when 2,400 t was landed. Landings declined to less than 19 t in each year from 1992-1997 and were between 120-190 t for the period 1998-2000. Catch increased rapidly from

1,800 t in 2001, to 5,400 t in 2003 then declined to about 5,000 t in 2004 and 2005. A provisional estimate for 2006 suggests catch declined to 1,800t. The increases beginning in 2001 were from non-Canadian directed fisheries occurring in the NAFO Regulatory area (NRA) utilizing large midwater trawls. It is assumed these catches were from the pelagic stock of redfish that resides primarily in the Irminger Sea between Greenland and Iceland. Canadian (NL) landings since the moratorium are by-catch from Greenland halibut fisheries and had been less than 40 t annually from 1997 to 2003. Landings increased to 169 t in 2004 and have been between 135 t to 220 t to 2006. Based on observer data, estimates of redfish by-catch discarded from shrimp fisheries in the Div. 2G to Div. 3K area since 1980 have ranged from 14 t in 1983 to 665 t in 1990. In recent years, discard estimates have increased from 60 t in 2000 to 252 t in 2004. Results from research vessel surveys in Div. 2J and 3K suggest the resource was at a historically low level in 1994. The survey biomass index increased by a factor of six from 1994 to 1998, averaged about 34,000 t to 2003, and subsequently increased to 85,000 t in 2005. The 2006 survey suggests a doubling of the index to 165,000 t but 50% of the estimate was the result of a large set in a stratum that represents 3% of the survey area. The average of the index from 2002-2006 was about 13% of the index averaged from 1981-1990, a period over which the index began to decline. There has been an improvement in recruitment, particularly from the 1997, 1998 and 2000 year classes (fish less than 23 cm), although these are considered poor in comparison to year classes of the early 1970's. Although the stock continues to improve it is predominantly comprised of juvenile fish (<23 cm, 70% by number) which should begin to recruit to the adult population in the near future.

f) *Witch flounder* - Div 2J3KL

There has been no directed fishing on this stock since 1994. In 2006, by-catch in other fisheries from the Newfoundland region amounted to 53 t. Canadian fall surveys since the late 1970s indicated that witch flounder were widely distributed throughout the shelf area in deeper channels around the fishing banks primarily in Div. 3K. By the mid 1980s, they were rapidly disappearing and by the early 1990s had virtually disappeared from the area entirely except for some very small catches along the slope in Division 3L. The fall 1998-2006 surveys indicate no change in this distribution pattern. For the three divisions combined, the biomass index declined from about 65,000 t in 1984 to 1,100 t in 1995, the lowest in the time series. Mean weight per tow decreased from a maximum of near 6 kg/tow in 1984 to a low of 0.23 kg/tow in 1995. The small increase in biomass index and mean weight per tow observed between 1995 and 1996 was almost exclusively a result of inclusion of the deeper strata surveyed in Division 3L. The estimates have remained the same since then. The stock size remains extremely low.

g) *Greenland halibut* - Subarea 2 + Div. 3KLMNO

The Canadian (NL) catch of Greenland halibut in 2006 in Subarea 2 and Div. 3KLMNO was approximately 6,300 t, a reduction of 300 t from 2005, but higher than the 4,800 t taken in 2004. In 2005 and again in 2006, the total catch taken by gillnets (depths <400 fathoms) increased considerably compared to 2004, which may be partially attributed to decreases in the minimum allowable mesh size in that zone. In 2006, the majority of the catch was in equal proportions amongst bottom trawl, gillnet <400 fathoms and gillnet >400 fathoms. The catch at age in 2005 was dominated by the 1998 and 1997 year-classes (seven and eight year olds, respectively), which combined accounted for 70% of the catch numbers and 58% of the catch weight.

TACs in 2002 and 2003 were above scientific advice and appear not to have been reached. In September 2003 at its annual meeting, the Fisheries Commission implemented a fifteen year rebuilding plan for this stock. It established TACs of 20,000, 19,000, 18,500 and 16,000 t, respectively for the years 2004 to 2007. Subsequent TACs will be decided upon depending on the response of the resource to the reduced TACs. The total agreed catches for 2004 and 2005 have exceeded the rebuilding plan TAC by 27% and 22%, respectively.

The exploitable biomass (age 5+) was reduced to low levels in 1995-97 due to very high catches and high fishing mortality. It increased during 1998-2000 due to greatly reduced catches, much lower fishing mortality and improved recruitment. However, increasingly higher catches and fishing mortality since then accompanied by poorer recruitment has caused a subsequent decline. The current estimates are the lowest in the series. Recent recruitment has been below average, and fishing mortality has increased substantially in recent years.

h) *Shrimp* – Subarea 2 + Div. 3K

The shrimp fishery in Subarea 2 and the northern portion of Subarea 3 is divided into three management areas – 2G, Hopedale and Cartwright Channels (2HJ), and Hawke Channel (2J) + 3K.

Between 1998 and 2002, annual catches of approximately 8,000 t were taken in 2G from 8,320 t TACs. The 2003 TAC was increased to 10,320 t and included a 1,125 t allocation for northern shrimp research. In 2003, the Canadian shrimp fishing industry requested and was granted a change in season, from a calendar year (January 1 – December 31) to a fiscal year (April 1 – March 31). An additional interim quota of 2,802 t was set for the January 1 – March 31, 2004 period. Thus the 2003-2004 fishing season was 15 months long and had a 13,122 t TAC. The 2003-2004 (April 1 – March 31) TAC (10,320 t) was maintained for the 2004-2005 and 2005-2006 seasons. Approximately 13,500 t of northern shrimp were taken during the 2003 calendar year while approximately 10,000 t were taken in each year over the 2004 – 2007 period.

Historically, the fishery has been concentrated north of 60^{o}N in an area noted for producing high catch rates of large, high-quality shrimp. During 1998, a separate quota was created for the area south of 60^{o}N to reflect the existence of high concentrations of shrimp along the shelf slope. The new quota resulted in a southward shift in fishing effort. Standardized catch per unit effort declined since 2001 to the long-term average in 2002. Large vessels had model CPUE indices of 1.900 kg/hr during 2004 and 2005. Current status appears positive from fishery data, but future prospects are uncertain as the assessment is based solely upon fishery data.

Autumn 1999 was the last time that the Canadian Government conducted a bottom trawl research survey in 2G. However, during the summer of 2005, the Northern Shrimp Research Foundation and the Government of Canada (DFO) began a series of at least five (5) collaborative annual research bottom trawl surveys in 2G. These surveys make use of a research Campelen 1800 shrimp trawl with a 12.7 mm codend liner and fish at depths between 100 and 750 m. These surveys focus upon gathering data necessary for shrimp stock assessments. Once there is a sufficient time series, this survey may be used to assess the status of the shrimp resource in this area.

TACs in Hopedale and Cartwright Channels (2HJ) doubled from 7,650 t during 1994 - 1996 to 15,300 t over the 1997-2002 period. TACs have been taken in most years. In 2003, the TAC increased to 23,300 t and included a 2,500 t allocation for northern shrimp science research. In 2003 the fishing season changed to April 1 – March 31, and an additional interim quota of 9,787 t was set for the period January 1 – March 31, 2004. Thus the 2003-2004 fishing season was 15 months long and had a 33,087 t TAC. The 2003-2004 fiscal year TAC (23,300 t) was maintained for the 2004-2007 seasons. Approximately 23,400 t of shrimp were caught during the 2005 calendar year while preliminary data indicate that 24,600 t were taken in the 2006 calendar year. Standardized catch rates within Hopedale and Cartwright Channels increased from 1992 (750 kg/hr) through to 2002 (2,010 kg/hr) and have since remained high with an average catch rate of 1,800 kg/hr. Most model catch rates between 1997 and 2004 were statistically similar ($P>0.05$) to 2005 (1,700 kg/hr) while indices previous to 1997 were generally lower than the 2005 index ($P < 0.05$). High CPUEs are being maintained over a relatively broad area indicating that the stock is healthy.

Only the 2J portion of SFA 5 (Cartwright Channel) was surveyed over the history of the autumn multi-species surveys. Trends in indices and biological characteristics from SFA 5 and Cartwright Channel were broadly consistent; therefore, indices from Cartwright Channel are used as proxies for the entire of SFA 5. These analyses indicate that biomass and abundance have increased since 1998. Recruitment in the short-term remains, but appears average. Longer-term prospects are unknown. The resource continues to be distributed over a broad area and exploitation indices have remained low.

The fishery in Hawke Channel (southern Div. 2J) + 3K began in 1987 with landings of approximately 1,800 t. Catches increased to more than 7,800 t in 1988 and ranged between 5,500 and 8,000 t throughout 1989-1993. The first multi-year management plan for 1994-1996 set the annual TAC at 11,050 t for the Hawke Channel, St. Anthony Basin, east St. Anthony, Funk Island Deep and three exploratory areas on the seaward slope of the shelf. Catches increased to 11,000 t in each of these years. TACs were increased to 23,100 t in 1997 as a first step toward increasing the exploitation of an abundant resource within the 1997-1999 Management Plan. Most of the increase was reserved for development of the small vessel fleet (<65 ft vessels). TACs more than doubled between 1997 and 1999, increased slightly to 2002 and further increased to 77,932 t in 2003. An additional interim quota of 7,653 t

was set for the period January 1 – March 31, 2004 to facilitate an industry requested change in fishing season from January 1 – December 31 to April 1 – March 31. Thus the 2003-2004 fishing season was 15 months long and had an 85,585 t TAC. TACs remained at the 77,932 t level for the 2004-2007 fishing seasons. TACs have been reached in most years; however, due to market constraints, small vessels have not always taken their entire allocations. Between 72,000 t and 77,600 t were taken in each of the calendar years between 2004 and 2006.

Large vessel catch rates within Hawke Channel + 3K increased throughout 1990-1997 and have since fluctuated above the long-term average while the small vessel CPUE index increased significantly in 2004. The 2005 model CPUE indices for the large and small vessel fleets were 1,482 and 495 kg/ hr respectively.

Autumn research surveys have been conducted since 1995 and indices of biomass/ abundance have been increasing since 1997. The lower 95% confidence intervals for the biomass indices averaged 538,000 t (about 129 billion animals) during the 1999-2005 period. The resource in this area remains healthy with high biomass/ abundance of male and female components. Most of the 2005 biomass was attributed to female shrimp. The female spawning stock biomass index increased from an estimated 182,000 t (22 billion animals) in 1997 to 404,000 t (55 billion) in 2005. Males within 11.5 mm – 16 mm carapace length, primarily age 2, are used as a recruitment index. The latest recruitment index suggests that the 2003 year class is weaker than average; however, strong residual female biomass is expected to maintain the fishery in the short-term. Medium term recruitment appears positive from the presence of a stronger than average 2004 year class.

Exploitation rate indices (ratio of nominal catch/lower 95% confidence interval of biomass index) have remained below 16% over the past 6 years and the fishery continues to cover a broad area. Therefore, fishery related impacts could not be detected from the logbook, observer or research data. The fact that catch per unit effort for large and small vessel fleets has been maintained at a high level, or is increasing, and that fleets are able to take their quotas over broad geographic areas throughout the year further suggest that the stock is healthy.

The mandatory use of sorting grates, low groundfish abundance, and avoidance of problem locations have minimized by-catch. Recent studies estimated that low numbers of redfish and Greenland halibut have been caught by shrimp fishing fleets.

i) *Snow crab* – Div. 2J3KLNO

Landings increased by 9% from about 39,900 t in 2005 to 43,400 t 49,400 t in 2006, due primarily to increases in Div. 3K and 3L. Fishery performance is monitored through analyses of commercial logbook data and observer program data. Div. 2J CPUE from logbook data doubled from a record low level in 2004 to about the long-term average in 2006. Both offshore and inshore Div. 3K CPUE increased in 2006 to their long-term averages. CPUE increased inshore in Div. 3L in 2006 approaching the long-term average. Offshore, in Div. 3LNO CPUE has changed little over the past 3 years and remains high relative to other areas. The exploitable biomass index, which is estimated from the fall multi-species bottom trawl survey**,** declined between 1998 and 2003. This index agrees with CPUE in indicating that biomass has increased in the north (Div. 2J3KL) in 2006 but continued to decline in the south (Div. 3LNO). The pre-recruit index for greater than 75 mm new-shelled adolescent males also declined during 1996-2002, and remained low until it increased in 2006. Recruitment has increased since 2004 in Div. 2J and since 2005 in Div. 3K and prospects remain promising for 2007. However recruitment is expected to remain relatively low in the short term in Div. 3LNO. Longer-term recruitment prospects are unknown.

j) *Iceland scallop* – Div. 2HJ

Inshore aggregations were again fished in 2006, with nominal catches estimated at 684 t, round. The fishery is prosecuted by inshore vessels, typically under 45 ft (14 m), L.O.A. Except for exploratory surveys for presence/absence, there have been no directed scientific missions into scallop aggregations along the Labrador coast.

B. Special Research Studies

1. Biological Studies

a) Arctic charr

Samples were obtained for food and feeding, age, sex and length distributions from commercial landings from two north Labrador stock complex areas. Following long term declines in mean weight of charr harvested in north Labrador, recent data show that mean weight and mean-weight-at-age has increased, or generally stabilized in recent years. Besides the long term effects of fishing on stock characteristics, analyses have identified a possible environmental component contributing to some of the variation in stock characteristics. In addition, analyses of food and feeding patterns have demonstrated major diet shifts occurring over an 18-year interval and have also been related, in part, to changes in the size of charr in some areas. Diet studies continued in 2005 and 2006, with samples obtained from various subareas. Additionally, an analysis of latitudinal variation in fecundity has been published, along with several multi-authored contributions associated with the potential effects of climate change on charr in general with a specific case study focused on north Labrador Arctic charr.

b) Groundfish and Shellfish

Biological and oceanographic data from fall multi-species research vessel surveys were collected from Div. 2GHJ to conduct distribution and abundance studies and detailed biological sampling.

Analysis of sexual maturity data is conducted regularly on American plaice and cod.

c) Shrimp

In 2005, the first of a series of trawl surveys was conducted by the Northern Shrimp Research Foundation in partnership with DFO in Div. 2G. Biological and oceanographic data were collected to assess the distribution and abundance of the shrimp population in this division. Once there is a sufficient time series of data, it will be possible to make use of this data to assess the status of the shrimp resource in 2G.

SUBAREA 3

A. Status of Fisheries

Nominal landings from 1992 to 2006 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) Atlantic salmon - Subarea 3

A moratorium on the Canadian commercial fishery has been in place since 1992. The 2006 recreational harvest, including both retained and hooked-and-released, was 18,160 fish.

b) Capelin – Subarea 2 + Div. 3KL

Inshore capelin catches in Subarea 2 + Div. 3KL are taken during the inshore spawning migration. Catches increased from 27,700 t in 2005 to 29,800 t in 2006. Resource status has not been determined since 2000.

c) Cod – 3NO and 3Ps

The cod stock in Div. 3NO has been under moratorium to directed fishing since February 1994. Total catch since 1994 has increased from 170 t in 1995 to 4,900 t in 2003. Canadian catches over this time period increased from 60 t in 1995 to 800 t in 2003. Total Canadian landings in 2004 were about 480 t, with 440 t of this amount being caught by Canada (NL). In the last assessment of this stock (2003), fishing mortality averaged over 2000 to 2002 for ages 4 to 6 is 0.32. This level of fishing mortality is comparable to that in earlier time periods during which substantial fisheries existed. Estimates of recent year-class size indicate that recruitment has been very low since the

1990 year-class. Low spawner biomass, low recruitment and high fishing mortality point to poor prospects for this stock in the future. Recovery will require a number of relatively strong year-classes that survive to maturity, rebuilding the spawner biomass. Recent Canadian spring and fall research bottom trawl surveys confirm that the stock size remains at an extremely low level.

The cod stock in Subdiv. 3Ps was placed under moratorium in August 1993. Stock assessments estimated a growing spawner biomass and the fishery reopened in 1997 with a TAC of 10,000 t, which was increased to 20,000 t in 1998 and to 30,000 t in 1999. From 2000 onwards the TAC has covered the period 1 April to 31 March. Although the 2000/2001 TAC was reduced to 20,000 t based on stock assessment results which indicated that spawner biomass was declining, the transition in the TAC year resulted in a calendar year catch of 25,100 t in 2000. The TAC remained constant at 15,000 t for the 2001/2002 –2005/2006 fishing seasons, but was reduced to 13,000 t for the 2006/07 season. The Canada (NL) share of the TAC is 84.5%, the remainder is allocated to France (SPM). A preliminary estimate of Canada (NL) catch in 2006 10, 500 t. The most recent assessment (October 2006) indicated considerable uncertainty in the absolute size of the stock. The outlook about the short-term productivity is not optimistic, as relatively poor year classes enter the fishery. Concern continues regarding the low age at maturity in this stock and the high exploitation rates in a portion of the stock area (Placentia Bay).

d) American plaice - 3Ps

The last assessment of this stock was carried out in October 2005. This stock has been under moratorium since September 1993. From 1994 to 1998 the catch was 400 t or less. Catch since that time has increased substantially. During 2001 to 2003 the catch was greater than 1,000 t in each year. Catch declined somewhat in 2004 to just over 800 t. Catch in 2006 was 485 t by NL. Catch has been mainly as by-catch in the cod and witch flounder directed fisheries.

The Canadian survey in spring 2006 was incomplete and data on abundance and biomass could not be updated.

e) Witch flounder - 3Ps

Landings from this stock over the last 20 years have fluctuated between 300 t and 1,000 t annually. In 2006 the catch from the Newfoundland region was 182 t. The main directed fishery is prosecuted by offshore otter trawlers complemented by a nearshore Danish seine fishery. However, in recent years it appears to be a mixed American plaice and witch flounder fishery by otter trawlers. Although survey stock size indices since 1983 have been highly variable, the survey biomass index during recent years suggests that the biomass is on average about 75% of the 1983-90 average when catches were around 800 t. The age and size structure observed in this stock since the early 1980s also appeared to have remained stable with little change in growth pattern. Aging has not been conducted on witch flounder in this region since the mid-90s. Geographic distribution has not changed appreciably since 1983 except during the early to mid 1990s when fish disappeared from the 51-100 fathom depth zone, coincident with extremely cold sea bottom water temperatures. In recent years the distribution appears to be returning to a more normal pattern. No measurable change in recruitment has been observed over the past 20 years.

f) Yellowtail flounder – 3LNO

Since the fishery for this stock reopened in 1998, stock size has continued to increase and the TACs recommended for 2007 and 2008 were 15,500 t in each year. Annual spring and fall multi-species bottom trawl surveys have been conducted since 1971 and 1990 respectively. Evidence from the commercial fishery and various surveys indicates that the range of this stock has increased along with stock size since the mid-1990s. Fishing mortality is estimated to be relatively low and the stock biomass relatively high. In 2006, the majority of the Canadian directed fishery for yellowtail flounder did not take place due to a dispute in the industry. In 2007 NAFO Scientific Council will be carrying out an interim assessment of the resource.

g) American plaice – 3LNO

The last full assessment for American plaice in Div. 3LNO was in 2005. In 2006, an interim monitoring report presented at NAFO indicated that biomass and abundance levels remained similar to recent years. Catch in 2005 was 4,110 t, mainly taken in the Regulatory Area and as by-catch in the Canadian yellowtail flounder fishery. In

2005 the assessment concluded that SSB declined to the lowest observed levels in 1994 and 1995 and remains very low at just over 23,000 t. Considering the stock is under moratorium, average F is high. Based on overall indices for 2006, there is nothing to indicate a change in the status of this stock.

h) *Redfish* – Unit 2 (3Ps4Vs, 3Pn4Vn-June to December, 4Wfgi) and 3O

Redfish in the Canadian Atlantic within Div. 3P4RSTVWX were redefined into three management units in 1993. Redfish in UNIT2 were last reviewed in November 2001 and updated in 2004.

Total Canadian catches have declined steadily from 27,000 t in 1993 to 8,000 t in 2002, matching reductions in TACs. From 2002-2005 the TAC has been stable at 8,000 t but catches have declined from about 7,500 t in 2003 to 5,500 t in 2006. About 1,400 t of the 2006 catch was taken by Canada (NL) fisheries. Current management regulations include a closure related to peak spawning in May and June, and a minimum size restriction at 22 cm. The most recent DFO surveys (conducted from 1994-1997, 2000 and 2002) indicate relative stability over the time period to 2002. A corresponding survey index conducted by industry (from 1998-2001, 2003 and 2005) is variable but indicates a decline between 2001 and 2003 to the lowest in the time series followed by a large increase in 2005. Another industry survey is planned in 2007. The 2006 fishery was again dominated by exploitable year-classes born after 1980, most notably the 1988 year-class. Current information suggests the 1988 year-class is not as strong as the 1980 which has already produced about 17 years of yield. There appears to be improved recruitment to the stock from the 1994, 1998, 2003 and 2006 year-classes but their absolute size is unknown. Biological characteristics suggest that the above average year-classes since 1988 are predominantly *S. fasciatus*, a shallower water species, whereas the strong 1980 year class is predominantly *S. mentella,* a deeper water species. The strength of year-classes of *S. mentella* since the 1980 year-class are apparently very weak, yet it continues to be a significant portion of the fishery.

Canada has had limited interest in a fishery in Div. 3O because of small sizes of redfish encountered in areas suitable for trawling. Canadian landings were less than 200 t annually from 1983-1991 but increased in the early 1990s. Between 1996 and 2000 Canadian catches have alternated between levels of about 8,000 t and 2,500 t based on market acceptability for redfish near the Canadian 22 cm size limit. From 2001-2004, the Canadian catch averaged about 3,400 t, increased to 5,400 t in 2005 but declined to about 3,600 t in 2006. Canada (NL) has accounted for more than 95% of the catch since 2001. From 1974-2004, Div. 3O was under TAC regulation set by Canada within its jurisdiction, while catches were unrestricted in the NAFO Regulatory area of Div. 3O. In 2004, NAFO Fisheries Commission adopted TAC regulation for Div. 3O redfish at 20,000 t for 2005, 2006 and 2007. Assessment of this stock has been primarily based on research data due to variable commercial indices and fleets prosecuting different areas of the stock. It is difficult to reconcile year to year changes in the indices, but generally, the Canadian spring survey biomass index suggests the stock may have increased since the early 1990s, fluctuated over 100,000 t from 1994 to 1999 and declined to 2002. The index shows an increase in 2003 and a large increase in 2004 followed by a decline to about 60,000 t in 2005. The 2004 index at 85,000 t was influenced by one large set in a stratum that represented 40% of the biomass index. The survey in 2006 did not adequately sample redfish depths. The Canadian autumn surveys, while more stable in the early 1990s, generally supports the pattern of the spring survey index to 2003 with an increase to 2006. RV surveys do not adequately sample fish greater than 25 cm which, up to 1997, have generally comprised the main portion of the fishery, which makes it difficult to interpret survey estimates in relation to what is happening to the stock as a whole. The fishery since 1998 appeared to target the relatively strong 1988 year class that has grown sufficiently to exceed the small fish protocol of 22 cm. There is concern that there has been little sign in recent surveys of size groups smaller than 17 cm despite using a shrimp trawl, which is very effective at catching small fish.

i) *Witch flounder* – Div. 3NO

There has been no directed fishing on this stock since 1994. By-catch in 2006 (NL region) was 94 t. The data for Div. 3NO combined suggest an overall declining trend in stock size with the estimates for the spring 1998 survey at the lowest level observed since 1984. Since then, all indices have generally increased but remain variable. It was not possible to derive estimates from the 2006 spring RV survey due to incomplete coverage.

j) *White hake* – Div. 3NOPs (Div. 3NO in NRA)

The initial (2003) Fisheries Commission (FC) request for advice on white hake was specific for Div. 3N and 3O to the exclusion of NAFO Subdiv. 3Ps, formerly included in the stock management area for the Canadian assessment. In 2004, the FC subsequently requested scientific advice for the management of white hake in Div. 3NO. FC, by specifying advice for Div. 3NO implicitly set the stock management unit as 3NO. However evidence was presented in 1995 indicating that the stock encompasses 3NOPs. Since then the sock has been assessed within 3NOPs.

Prior to 1995, white hake was taken as by-catch in other demersal fisheries on the Grand Banks. Average estimated catch during 1985-1990 was approximately 5000 t. Annual catches in a new directed (Canadian) fishery on the Grand Banks, starting in 1995 and encompassing Divs. 3NO and Subdiv. 3Ps, averaged 460 t. However, in 2001 and 2002, a > 10-fold increase in the catch of white hake Div. 3NO was attributable to EU-Spain, EU–Portugal and Russia in the NAFO Regulatory Area. Given this large increase in catches in 2003, the FC of NAFO requested specific information on fishing mortality, abundance and distribution, reference points and conservation measures, size of fish and delineation of fishery areas with respect to white hake. That advice, to the extent of the available data was summarized in Kulka et al. (2004, 2005 and 2006). Most the increase in catch was attributable to a very large 1999 year class. For the past 7 years, the stock has been declining sharply due to an increase in fishing pressure and low recruitment. Only about 2% of that year class remains and the stock is at or near a historic low.

k) *Thorny skate* – Div. 3LNOPs

Before the mid-1980s, non-Canadian fleets landed several thousand metric tonnes (t) of skate (mainly thorny) annually. An average of about 5,000 t was discarded annually by the Canadian fleet during the 1980s and early 1990s, while only a few hundred tonnes per year were recorded in Canada's landings statistics during that period. Although often kept by non-Canadian fleets, skates were taken only as bycatch until the mid-1980s. In 1985, EU-Spain targeted skate in a non-regulated fishery in the NRA. Bycatches of thorny skate in other fisheries outside 200 miles (primarily Greenland halibut, *Reinhardtius hippoglossoides*) have also contributed significantly to skate catches. In 1993 and 1994, experimental fishing resulted in the first significant directed skate landings appearing in Canadian statistics. In 1995, Canada established a regulated skate fishery inside its 200-mile-limit with gear and by-catch policies, a licensing system, and TAC. The Canadian fishery includes otter trawl, gillnet and longline gear while the non-Canadian catches are taken by otter trawl. In 2000, Russia commenced a directed fishery for thorny skate. Catches have averaged about 11,000 t, all countries combined over the last 8 years.

Thorny skate underwent a decline in the late 1980s to early 1990s followed by a slight increase in the late 1990s. Since then, abundance has remained relatively constant near the lowest historic level. An average exploitation rate of 10% (equivalent to an average catch of 11,000 t) over the past 8 years has resulted in a flat biomass trajectory. Although stable in recent years, skate continues to be near a historic low population size. Average index of biomass over that 8 year period was 110,000 t. The current TAC for skates in 3LNOPs presently amounts to 14,550 t (13,500 t in 3LNO and 1,050 t in 3Ps) which considerably exceeds the current 11,100 t average catch. The results of the production model from 2005 suggest that a catch < 12,000 t would be required to allow rebuilding of the stock.

l) *Shrimp* – Div. 3LMNO

Subarea 3 has been divided into two shrimp management areas – Div. 3LNO and 3M. The 3LNO shrimp stock is distributed along the edge of the Grand Banks mainly in Div. 3L. The fishery began in 1993 and catches were approximately 1,800 t. Exploratory fishing from 1996-1999 resulted in catches ranging from 179 to 795 t. In 2000, the NAFO Fisheries Commission implemented a TAC of 6,000 t, and fishing was restricted to Div. 3L. The catch in 2000 increased to 4,900 t, 4,300 t of which was caught by Canada. The remainder of the catch was taken by vessels from 7 other countries.

STACFIS estimated that the 2001 fishery took approximately 10,600 t, with Canada taking just over 5,100 t. However, reliable catch reports were not available for all countries in 2001. Similarly, estimates of catch in 2002 were not available for all countries. However, STACFIS noted that the total catch in 2002 was likely lower than that estimated for 2001, but that there was considerable uncertainty with estimates of catch in both years. Canadian vessels caught 5,400 t of shrimp in 3L during 2002.

During November 2002, Scientific Council (SC) noted that there had been a significant increase in biomass and recruitment in Div. 3LNO shrimp since 1999. Applying a 15% exploitation rate to the lower 95% confidence interval of biomass estimates, averaged over the autumn 2000-2001 and spring 2001-2002 surveys, resulted in a catch of approximately 13,000 t. Accordingly, SC recommended that the TAC for shrimp in Div. 3LNO in 2003 and 2004 should not exceed 13,000 t. Over the period 2000-2003, catches were 4,900, 10,600, 7,000 and 12,000 t respectively. Preliminary data indicate that ~13,000 t of shrimp were taken in 3L each year during 2004 and 2005.

In 2004, SC advice of 22,000 t for 2006 was based upon 12% of the inverse variance weighted average fishable biomass from the most recent surveys. SC did not update this calculation due to the incomplete survey in autumn 2004.

Large (>500 t) and small (<65 ft) shrimp fishing vessel catches are taken from a broad area extending from the northeastern border with 3K south east along the 200-500 m contours to the NRA border. Large and small vessel catch rates were modeled in order to describe fishing activities.

The fishery for northern shrimp at Flemish Cap began in the spring of 1993 and has since continued with annual catches (as estimated by STACFIS) fluctuating between 25,000 and 54,000 t between 1993 and 2002. The 2003 catch was 62,000 t, the highest in the series. Preliminary NAFO catch statistics indicate, 43,000 t of shrimp were caught in 3M during 2004 while catches dropped to 12,000 t and 5,000 t during 2005 and 2006 respectively.

The use of a sorting grid to reduce by-catches of fish is mandatory for all fleets in the 3LNO and 3M fisheries. By-catch of groundfish has been quantified, and consists primarily of redfish and Greenland halibut.

m) *Iceland Scallop* – Div. 3LNOPs

The 3LN Iceland scallop fishery commenced in 1992. Aggregations over the eastern Grand Bank (3L) were first commercialized. In 1994, the fishery expanded into the Lilly and Carson Canyons (LCC) and subsequently (1995) into the northeast of LCC between 45°30' N and 46°30' N. In 1996 a new aggregation was located and rapidly fished down. Nominal landings have declined throughout, partially because of effort diversion into shrimp and crab.

A total of 339 t were removed from the LCC box in 2006. Elsewhere, over the Grand Bank (Div. 3LNO), there were 9 t removed.

The Iceland scallop fishery on 3Ps commenced in 1989. It encompasses the trans-boundary stock, along the northern edge of St. Pierre Bank, co-managed by France (70% of annual TAC) and Canada (30% of TAC), and the remainder of 3Ps remains entirely under Canadian jurisdiction.

Total removals from the Canadian zone have decreased from 5,367 t, (round) in 1997 to 38 t in 2004. In 2006, 102 t of a total 3,500 t TAC were removed, a decline from 2005. There has been no directed effort for Iceland scallops in the trans-boundary area since 1998; however, the resource status of this area was updated based on a joint Canada-France survey in September 2005.

n) *Sea scallop* – Subdiv. 3LPs

The sea scallop fishery on St Pierre Bank commenced soon after its discovery in 1953. The area has been fished by both Newfoundland inshore vessels and larger Maritimes (Nova Scotia) based offshore vessels. Occurring as they do towards the northern extreme of its distribution, sea scallops here have not been able to withstand continued heavy exploitation. The fishery is typically characterized by a disproportionate dependence on sporadic recruitment of a single or a few intermittent and sometimes, well-spaced year-classes. Figures shown in Table 1 represent only landings in Newfoundland ports and do not include removals from the area but landed in Nova Scotia.

There had been very little effort by offshore vessels from 1997 to 2003 with most of the landings coming from inshore beds. In 2003 there was sign of a large recruited year-class, with 647 t (round) removed. In the following two years, there was a significant increase in effort and landings by both inshore and offshore fleets. In 2006 there was a decrease in effort and landings from the previous year. A total of 516 t (round) was landed in Newfoundland, while an additional 43 t was removed but landed in Nova Scotian ports.

A small amount, 12 t, was removed by inshore vessels in Div. 3L.

o) *Squid* – Subarea 3

Following a peak catch in 1979 of about 88,800 t, the Subarea 3 catch declined regularly to 5 t in 1983. Catches remained lower than 5,000 t during the thirteen-year period 1983 to 1995. They increased since 1995 to about 12,700 t in 1997 before declining sharply to about 800 t in 1998 and about 20 t in 1999. They remained low, at about 300 t, in 2000, decreased to only about 20 t in 2001 and increased to about 600 t in 2003. Catches increased further in 2004 to approximately 2,000 t, but decreased to about 500 t in 2005. Catches increased to about 6,800 t in 2006. High catches in 1996-1997 and 2006 were associated with environmental warming and increase in squid abundance at the northern extreme of their range.

p) *Snow crab* – Subdiv. 3Ps

Landings in 3Ps declined by 59% (7600 t - 3100 t) during 2002-2006. Inshore CPUE declined from 2001-2005 by 70%, whereas offshore CPUE declined by 75% from 1999 to its historical low in 2005 due to an apparent reduction in the abundance of commercial-sized males. Offshore and inshore CPUE increased slightly in 2006 from record low levels in 2005. No exploitable biomass index is available as there are insufficient fishery- independent data from this area. Recruitment appears to have been stable in recent years and is expected to increase over the next 3 years. Longer-term prospects are unknown.

B. Special Research Studies

1. Environmental Studies

Physical oceanographic observations are routinely collected during fish assessment and research surveys in the Newfoundland and Labrador Region. The Atlantic Zonal monitoring program (AZMP) initiated in 1998 continued during 2006 with three physical and biological oceanographic offshore surveys carried out along several cross-shelf NAFO and AZMP sections from the Southeast Grand Bank to Hamilton Bank on the southern Labrador Shelf. The first was conducted on the CCGS Teleost from April 21 to May 3, the second on CCGS Templeman from July 24 to August 7 and the last on CCGS Hudson from November 18 to December 4. This program was established to include biological and chemical oceanographic sampling at a fixed coastal site (Station 27) at biweekly intervals and along offshore sections at seasonal time scales. The main objectives are to establish the seasonal temporal and spatial distribution and abundance of plant pigments, nutrients, microzooplankton and mesozooplankton in relation to the physical environment. Physical, biological and chemical variables being monitored include temperature, salinity, dissolved oxygen, ocean currents as well as measures of primary and secondary production and biomass, species composition of phytoplankton and zooplankton and nutrients. The oceanographic monitoring program currently conducted on the Newfoundland and Labrador Shelf should allow an understanding of changes in ecosystem productivity and changes in ecosystem structure over time. Data from this effort are used to produce annual physical, chemical and biological state of the ocean reports and in studies relating environmental conditions to marine resources.

a) *Plankton studies*

Overall, the seasonality of chemical and biological variables at Station 27 and along the major AZMP sections in 2006 was similar to previous years (1999-2005). The timing of events on the Newfoundland Shelf (south of Seal Island) was once again similar to conditions observed in the early part of the program but in contrast to 2001 when the onset of the spring phytoplankton bloom was delayed. However, satellite information indicates the onset of the spring bloom, at least since 2002, has become gradually earlier throughout the region of the Newfoundland Shelf and Labrador Sea.

There were a few notable trends in the observations from Station 27 and the oceanographic transects. At Station 27, the integrated seasonally-adjusted chlorophyll inventory along with many zooplankton species (*C. glacialis, C. hyperboreus, Oithona* spp., and larvaceans) were at low levels relative to the overall time series of observations. Exceptions to this trend were *C. finmarchicus*, *Metridia* spp. and euphausids, which all showed substantial increases in

abundance relative to 2005. Few of these trends were statistically significant, largely as a result of the considerable sampling variability. The deep (0-150 m) inventories of nitrate and silicate were similar to 2005 but levels are still low relative to 2000. However, the trends observed at Station 27 were in marked contrast with those observed along the oceanographic transects. With the exception of a general decline in the seasonally-adjusted deep (50-150 m) silicate inventory along the most transects, few of the standard oceanographic variables showed significant trends during the period 2000-2006. Values in 2006 were generally near the overall mean since the inception of AZMP. In addition, most of the seven major copepod taxa along the Flemish Cap, Bonvasita Bay and Seal Island transects were either at or near their maximum seasonally-adjusted means, in contrast to patterns at Station 27. Zooplankton abundance along the Southeast Grand Banks showed few significant trends, but there was indication that many species were at their lowest levels since 2000.

Discrepancies between the patterns of seasonally-adjusted means for oceanographic variables and major zooplankton taxa between Station 27 and the oceanographic transects is in marked contrast with the relatively large decorrelation scales found in temperature and salinity (Mathieu et al. 2003). One possible explanation is that the decorrelation scale is relatively small (10s of kms) for chemical and biological variables collected by the AZMP because local coastal processes are highly dynamic in contrast to broad oceanographic bio-physical interactions that govern the patterns of abundance further on the shelf. An analysis of the correlation between observations at Station 27 and transect stations taken during oceanographic surveys shows that the average correlation, based on the seven dominant copepod taxa, is highest for the nearshore stations along the Bonavista Bay and Flemish Cap transects, after which it drops rapidly as one moves offshore. There is no correlation with conditions at the deep water offshore stations, and a nearly inverse relationship with conditions along the Seal Island transect. The high concentration of copepods in offshore waters may therefore have a strong influence on the mean abundance estimated from the GLM analysis.

Aliasing of sampling and the onset of the spring phytoplankton bloom are likely to prevent an estimation of the annual mean phytoplankton standing stock from the oceanographic surveys. Estimates of annual mean phytoplankton standing stock or surface nutrient inventories along oceanographic transects based on GLM analysis are highly influenced by the magnitude of the spring phytoplankton bloom observed during our surveys. However, attempts to derive average annual values were strongly influenced by the stage of the spring phytoplankton bloom, as determined from the relative abundance of nutrients and phytoplankton. In some years (e.g., 2003), phytoplankton standing stock was low during the spring oceanographic surveys whereas the surface nitrate inventory was high, while the opposite was true in 2000. The two-week composite estimates of surface chlorophyll do assist in the interpretation of these patterns but a more temporally-resolved estimate of the seasonal variations in surface chlorophyll throughout the entire Atlantic Zone would assist in determining the degree of inter-annual variation in both the magnitude and duration of the spring phytoplankton bloom. Combining the data from the oceanographic surveys with satellite observations could enable us to obtain a three-dimensional view of the progression of phytoplankton dynamics throughout the Zone and thus provide a more accurate estimate of changes in standing stock.

The most notable advance in 2004 was in our ability to provide quantitative analysis of inter-annual differences in the abundance of dominant zooplankton taxa at Station 27 and along the key oceanographic transects (Pepin et al. 2005). The analytical approach is somewhat simplistic and does not take into consideration of major shifts in the spatial distribution of species (this appears as part of the error). However, the approach has revealed significant inter-annual variations in the abundance of zooplankton on the Shelf. The approach based on general linear models to determine the inter-annual variations in abundance of taxa from AZMP collections did raise some questions about the programs overall ability to accurately monitor zooplankton abundance and species composition. Data from Station 27 revealed that only 12 taxa were sufficiently abundant and frequent to allow appropriate inter-annual comparison in abundance patterns, which included copepods, gastropods, larvaceans and euphausiids. In contrast, only 7 to 8 species of copepods were sufficiently abundant and frequent on the shelf to allow effective and reliable intercomparison throughout the AZMP implementation period. Other groups, such as bivalves, gastropods, euphausiids and larvaceans were highly patchy in their distribution, making statistical intercomparisons unfeasible at this time. Longer time series of observations may be required before we can detect significant inter-annual variations in abundance based on the AZMP survey design and collection methods. We did investigate the potential to simply contrast seasonal and inter-annual variations in abundance without taking into consideration the spatial distribution of each species. This did allow a greater number of species to be included in the analysis but the complexity of the results requires further investigation at this time before we feel that we can comment on the overall trends.

b) Oceanographic studies - Subareas 2 and 3

Physical oceanographic studies were conducted on the Newfoundland and Labrador Shelf during 2006 in NAFO Divs. 2J and 3KLNO. These studies were based on observations from the southern Labrador Shelf to the Southern Grand Bank on the Newfoundland Shelf. The North Atlantic Oscillation winter index for 2006 was slightly below normal, while the sea-level pressure difference between Greenland and Newfoundland was significantly below normal. As a result, arctic outflow to the Northwest Atlantic was weaker-than-normal resulting in record high annual air temperatures in some locations and above normal values throughout the Northwest Atlantic from West Greenland to Baffin Island to Labrador and Newfoundland. Sea-ice extent and duration on the Newfoundland and Labrador Shelf remained below average for the 12th consecutive year. Consequently, water temperatures on the Newfoundland and Labrador Shelf remained well above normal in 2006, continuing the warm trend experienced since the mid-to-late 1990s. At Station 27 off St. John's, the depth-averaged annual water temperature increased over 2005 setting a new record high of nearly 1°C above normal. Annual surface temperatures at Station 27 were also the highest in 61 years at 1.7°C above normal. Bottom temperatures were also above normal by 0.8°C, the 3rd highest in the 61-year record. Annual surface temperatures on Hamilton Bank were 1°C above normal, the 10th highest on record; on the Flemish Cap they were 2.5°C above normal, the 3rd highest in 57 years. Upper-layer salinities at Station 27 were above normal for the 5th consecutive year. The area of the cold-immediate-layer (CIL) water mass on the eastern Newfoundland Shelf during 2006 was below normal for the 12th consecutive year and the 3rd lowest since 1948. The near-bottom thermal habitat on the Newfoundland and Labrador Shelf continued warmer than normal in 2006, with bottom temperatures remaining at >2°C, about 0.5°C above normal on Hamilton Bank off southern Labrador during the fall. Bottom temperatures during the fall however decreased substantially from 2005, particularly in northern areas. The area of bottom habitat on the Grand Banks covered by sub-zero water has decreased from >50% during the first half of the 1990s to near 15% during the past 2 years, ranking the 3rd lowest in 2006. In general, except for late fall values, water temperatures on the Newfoundland and Labrador Shelf increased from 2005 values, continuing the warm trend experienced since the mid to late 1990s. Newfoundland and Labrador Shelf water salinities, which were lower than normal throughout most of the 1990s, increased to the highest observed in over a decade during 2002 and have remained above normal in most areas during 2006.

An oceanographic assessment study was also conducted during the summer of 2006 on the Flemish Cap in NAFO Division 3M. Oceanographic data from the summer of 2006 on the Flemish Cap were examined and compared to the long-term (1971-2000) average. The cold near-surface temperatures (0.5^{o} to 2^{o}C below normal) experienced over the Cap from 1993 - 1996 had warmed to 0.5^{o} - 1.5^{o}C above normal by the summer of 1997, which increased further to >2^{o}C above normal by the summer of 1999. Upper layer temperatures over the Flemish Cap during the spring of 2001 and the summer of 2002 generally showed a downward trend with temperatures decreasing to below normal values. During the summer of 2003, temperatures directly over the Cap were highly variable while adjacent areas showed significant positive anomalies and during 2004 and 2006 they increased to above normal values. Near bottom temperatures over the Cap during 2006 were about 4^{o}C, which was near the long term mean. Salinities over most of the water column during the summer of 2002 to 2005 were generally saltier-than-normal but decreased to near-normal values in 2006. In general the colder than normal temperatures experienced over the continental shelf and on the Flemish Cap from the late 1980s up to the mid-1990s moderated by the summer of 1996 and continued to warm until 1999. During the summer of 2000 and into the spring of 2001 the observations indicate a reversal in the recent warm trend in some areas of the water column with temperatures decreasing to near normal values in most areas. During 2003 to 2006 however, upper-layer temperatures continued to increase reaching 3^{o}C above normal in 2006. During 2006 and throughout most of the 1990s and early 2000s summer chlorophyll levels in the upper 100-m of the water column over the Cap were higher compared to the adjacent Grand Bank indicating enhanced productivity over the Flemish Cap. Dissolved oxygen levels were about normal for the region with super-saturated values in the near surface layers reaching 105%. In general oxygen levels observed along this section are similar to that observed during most of the 1990s and are typical of the highly oxygenated water column of this region. Finally, it appears that the circulation pattern around the Cap was dominated by anti-cyclonic gyre circulation with an increase in strength during the summer of 2006 compared to that of 2005.

c) Multi-disciplinary studies - Subareas 2 and 3

A study on the spatial distributions and abundance of northern shrimp was also carried out for NAFO Divisions 3LNO. The study examined variations in the thermal habitat and shrimp distribution and abundance for NAFO Divisions 3LNO during spring surveys from 1998-2006 and for fall surveys from 1995-2005. The most recent oceanographic data from

spring and summer surveys in NAFO Divs. 3LNO during 2006 indicate that bottom temperature in the area continued to be above normal and increased over 2005 particularly in northern areas (3L). The area of the bottom covered by water with temperatures <0°C in the spring of 2006 was the 3rd lowest in 31 years. The cold-intermediate-layer (CIL) shelf water during the summer of 2006 was below-normal (implying warm conditions) across the Grand Bank for the 9th consecutive year, ranking the 5th lowest in the 56-year time series. The spatial distribution and abundance of northern shrimp indicate that the highest numbers of shrimp are generally found in the 2° - 4°C temperature range during the spring with lower numbers in water <2°C and >4°C. During the fall most shrimp are found in a colder temperature range of 1° - 3°C as a result of seasonal migration into the shallower colder water of the Grand Bank. The change in distribution is not believed to be related to seasonal temperature changes but may be related to reproductive cycles, other environmental factors, feeding behaviour or changes in trawl catchability. The average weight of individual shrimp indicates that larger shrimp (6-7 g) are associated with temperatures >3°C while smaller shrimp (4-5 g) are found in temperatures <2°C. Cumulative frequency distributions of available temperature and total catch indicate that about 90% of the shrimp were caught in the 2° - 4°C temperature range during the spring, while only about 50% appeared in this temperature range during the fall. The distributions by age show that younger male shrimp are associated with the colder habitat in both spring and fall, although there is an overall shift into warmer waters in spring. The distributions by maturity stage show that ovigerous females are found in the deeper warmer waters along the slope of the Grand Banks compared to females that have either spawned or are developing eggs. The numbers of age-2 male shrimp from the fall surveys show a significant increase in 1999-2001 but then decreased to lower values in the most recent years. The 2-year lagged temperature measurements also show a similar pattern with spring bottom temperatures showing the strongest correlation. The numbers of fishable shrimp from the fall surveys and the Station 27 bottom temperatures at time lags of 4 and 5 years also show a significant positive correlation. The total fishable numbers of shrimp experienced a significant increase beginning in 2000 which coincided with the increase in bottom temperatures in 1996, a time lag approximately equal to the ages of commercial size shrimp. While these results indicate that the increase in temperature may have resulted in better shrimp survival in recent years, we note that the time series of survey data is too short to draw firm conclusions.

2. Biological Studies

a) Flatfish

Analysis of sexual maturity data is conducted regularly on American plaice, yellowtail flounder and other species. The yellowtail and American plaice analyses are presented to NAFO during the biannual assessment of Div. 3LNO American plaice and yellowtail flounder. Research on yellowtail age and growth is ongoing, using a variety of methods. The most recent analysis of age validation studies was presented to NAFO SC in June 2001. Updates on the ageing problems have been presented to NAFO SC in June 2005 and 2006.

A study into changes in fecundity in several flatfish species (and cod) is ongoing. This study has found that fecundity is highly variable and that there have been large changes over time. The potential use of proxies for fecundity is being examined. New estimates of total egg production have been produced for several flatfish stocks, but their usefulness for assessment is limited since new estimates are available for only 6 years.

A study is ongoing into reproduction in Greenland halibut. The study will use histology and quantification of vitellogenin to verify the maturity status of large female Greenland halibut that are classed as juveniles by macroscopic examination of the gonad.

b) Seals

Multi-disciplinary studies on harp, hooded, and grey seal population dynamics and seal-fish interactions continued in 2006. The Atlantic Seal Research Program (ASRP), initiated in 2003, ended in March 2006. The objectives of the ASRP were to: 1) conduct surveys to estimate the abundance of the three seal species believed to be important groundfish predators; 2) determine seal distribution in relation to fish resources and provide current estimates of the diet of each species; and 3) evaluate the utility and test seal management tools, which might aid the recovery of Atlantic cod stocks (e.g. Seal Exclusion Zone, immuno-contraception). In addition, research is continuing on other aspects of seal biology and ecology (e.g. interannual changes in growth and reproductive status) in order to determine their role in the ecosystem of the Northwest Atlantic.

As part of the ASRP, analysis of the 2004 and 2005 hooded seal pup production surveys was completed and the results presented for peer review. Photographic and visual aerial surveys to determine current pup production of Northwest Atlantic hooded seals (*Cystophora cristata*) were conducted off Newfoundland, in the Gulf of St. Lawrence in March 2004, and off Newfoundland, in the Gulf and in Davis Strait during 2005. This is the first time estimations from all three whelping areas were available in the same year. Surveys in the Gulf and Front were corrected for the temporal distribution of births and the mis-identification of pups by readers. In 2004, pup production at the Front was estimated to be 123,862 (SE = 18,640, CV = 0.150). Pup production in the Gulf was estimated to be 1,388 (SE = 298, CV = 0.216) although this is considered to be negatively biased. In 2005, pup production at the Front was estimated to be 107,013 (SE = 7,558, CV = 0.071) while 6,620 (SE = 1,700, CV = 0.258) pups were estimated to have been born in the Gulf. Pup production in the Davis Strait whelping concentration was estimated to be 3,346 (SE = 2,237, CV = 0.668). Combing these areas resulted in an estimated pup production in the three northwest Atlantic whelping areas of 116,900 (SE = 7,918, CV = 6.8%). Comparison with previous estimates suggests that pup production may have increased since the mid 1980s. However, understanding if abundance has changed is hampered by our lack of understanding of the relationship among whelping areas.

A population model incorporating hooded seal pup production estimates since the 1980s, reproductive rates and human induced mortality (catches, by-catch in fishing gear and struck and lost) were used to estimate total abundance for the period 1965-2005. Pup production and total population size are affected by the type of pup production estimates that the model is fitted to. Using only pup production estimates from the Front, total population was estimated to be 535,800 (SE=93,600; 95% C.I. 350,600-711,300). Fitting to pup production estimates from all herds and making assumptions about numbers of hooded seals in the Davis Strait herd for years, when this area was not included in the survey program, results in an estimated total population of 593,500 (SE=67,200; 95% C.I.= 465,600-728,300). There is considerable uncertainty associated with these estimates which results from a lack of understanding of the relationship between the Davis Strait, Front and Gulf pupping areas, few surveys of all three areas, limited reproductive data and uncertain harvest statistics. Under the Objective Based Fisheries Management plan, hooded seals are still considered 'Data Poor', with harvests being set using conservative methods.

Consumption of prey by seals in NAFO divisions 2J3KL is estimated by integrating information on individual energy requirements, population size, distribution, and diet composition. New information on the diet of harp and hooded seals in nearshore and offshore areas of NAFO Divisions 2J3KL was collected during 2006. Analysis of these samples is almost complete and a new estimate of consumption is expected in 2007.

c) Capelin

A comparative study to determine factors governing capelin survival during egg development and larval emergence from beach sediments and from demersal spawning sites in Trinity Bay continued in 2006. Samples of adult capelin were collected in 2006 at spawning sites in Labrador, Div. 2J, the east coast of Newfoundland, Div. 3KL, the Southeast Shoal, Div. 3NO, the Gulf of St. Lawrence, Div. 4S, and the Scotian Shelf, Div. 4W as part of a genetic study on capelin biodiversity. An ongoing offshore acoustic survey initiated in the spring of 1999 to examine capelin distribution, behaviour, and feeding habits in Div. 3KL did not occur in 2006 due to operational problems with the research vessel. Fall and winter inshore surveys were conducted in 2006 to map the abundance and dispersal of larval capelin and to track seasonal distributions of capelin, cod, and marine mammals in Trinity Bay, Div. 3L. A survey to determine the distribution of mature capelin and to identify beach spawning habitat was conducted along the coast of Labrador in Div. 2J, in July 2006. The first year survey of a two-year study of the bottom spawning habitat and distribution of mature capelin on the Southeast Shoal, Div. 3NO, was conducted in July, 2006.

d) Salmon

Recent investigations have proposed that marine food webs have changed dramatically owing to increasing and unsustainable levels of exploitation – the so called 'fishing down marine food webs' hypothesis. In addition, evidence exists for dramatic changes in ocean climate conditions in the northwest Atlantic, particularly during the early 1990's. Ocean climate conditions have already been shown to affect productivity and survival of Atlantic salmon which is considered an opportunistic feeder during its marine life-history phase. Thus, salmon lends itself well to studies associated with marine environmental conditions and food web interactions. Accordingly, a study

was initiated to examine long term variability in the trophic ecology of Atlantic salmon using analyses of stable isotope signatures of carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$). Marine growth components were extracted from scale samples of one-sea-winter (1SW) salmon from 9 Canadian and 1 north European river from archived data sets that for some rivers extend over 27 to 34 years. Scales were analyzed for $\delta^{13}C$ and $\delta^{15}N$ at the Environmental Isotope Laboratory at the University of Waterloo. Laboratory analyses of approximately 2,500 specimens have been completed. Current investigations are focused on analyzing variation among rivers, as well as variation within rivers over time in relation to fluctuations in abundance and variability in marine climate conditions.

During the spring of 2006, Atlantic salmon smolts (N = 49) and kelts (N = 15) were tagged with acoustic transmitters and released from Conne River, Newfoundland, during April and May to determine movements and migration patterns throughout the Bay d'Espoir fiord, and obtain insight into the initial survival and residency time of both life history stages. A total of 21 Vemco VR2 receivers were positioned at various locations throughout Bay d'Espoir while manual tracking was also carried out in areas proximate to where fish were initially released. Of the 15 kelt that were tagged and released all were subsequently accounted for. Two (2) kelt returned to the general area of the mouth of Conne River after an absence of 54 – 57 days. The remaining kelt spent an average of 13 days (range = 5 to 33 days) in Bay d'Espoir before exiting the fiord. With respect to smolts, 35 of 49 (71%) provided tracking information. Smolts were found to use several routes to exit the fiord with an average residency time of 13 days, but ranging from 4 to 27 days. Results from this initial study indicated that immediate survival of tracked smolt appeared to be quite high by comparison with studies carried out in other areas.

SUBAREA 4

A. <u>Status of Fisheries</u>

Nominal landings from 1992 to 2006 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) *Atlantic salmon* – Subarea 4

A moratorium on the Canadian commercial fishery has been in place since 1992. The 2006 recreational harvest, including both retained and hooked-and-released, was 20,311 fish.

b) *Snow Crab* – Div. 4R

Landings in 4R declined by 71% during 2002-2006 (1,850 t - 540 t). The commercial catch rate has remained at a lower level than in other divisions. Fishery independent data from this area are insufficient to assess resource status. It is not possible to infer trends in exploitable biomass from commercial CPUE data because of recent changes in the spatial distribution of fishing effort. Recruitment prospects are unknown.

c) *Iceland scallops* – Div. 4R

The nominal catch from the Strait of Belle Isle (4R) in 2006 is estimated at 716 t (round) against a TAC of 1,000 t. CPUE in 2005 decreased by 0.5% from the previous year. The fishery here continues to be driven by the exploitation of an accumulated biomass consisting largely of cohorts of old, possibly well separated year classes with little potential for further growth. No significant larval settlement or recruitment has been detected in recent years. Fishing activity in high density scallop aggregations causes high collateral mortality to scallop spat and appears to have had a significant effect on recruitment dynamics in the area.

SUBAREA 2 + 3 + 4

A. <u>Status of Fisheries</u>

Nominal landings from 1992 to 2006 for fish stocks are listed in Table 1. Additional information on the status of the fisheries is as follows:

a) Lobster

Landings declined through the 1990s to 1,800 t in 2000, from a long-term high of 3,200 t in 1992. Preliminary figures indicate increases in recent years, to 2,100 t in 2002 and 2,300 t in 2003, followed by a decrease in 2004, to 1,900 t. A preliminary value for 2005 landings is 2,600 t. Landings continue to increase in LFA 11 in Division 3Ps, and in LFAs 13A, 13B and 14A in Division 4R, but have declined precipitously in LFA 10 in Division 3Ps, as well as LFA 4 in Division 3K. The lobster fishery is monitored at several localized sites through at-sea sampling programs and co-operative arrangements with harvesters who complete voluntary logbooks on commercial catch and effort. Data suggest that the fishery is characterized by high exploitation rates and a small size limit relative to growth rates and size at maturity. Sufficient data is not available to assess the overall status of the resource at this time.

B. Special Research Studies

1. Miscellaneous Studies

a) Sentinel studies

The Sentinel Surveys, initiated in October 1994, were continued in 2006. Data collected were tabled at regional stock assessments in the autumn of 2006 for 3Ps and the spring of 2007 for 2J3KL cod. Sites in 2J3KL, 3Ps and 3Pn4Rs 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 age 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.

b) Cod tagging and telemetry

A tagging program was restarted and telemetry studies were initiated in inshore cod in 2J3KL in 2006. Approximately 6,200 cod were tagged and released with Floy tags along with an additional 150 cod implanted with ultrasonic transmitters. A series of arrays of receivers were deployed along a 350 km area of the inshore to monitor cod movement patterns and survival over the next two years. The objectives are to obtain estimates of exploitation and population size to improve the assessment of this stock; and to study movements and migrations and survival rates. In addition, 164 cod with surgically implanted transmitters and 1,100 cod with Floy tags were released in the offshore of 3K during March 2006; the objective is to determine if the remnant offshore stock is continuing to migrate to the inshore during summer.

c) Hydrographic Surveys

The Canadian Hydrographic Service (CHS) priorities for Subareas 2, 3 and 4 for 2004-2005 were several sites throughout Newfoundland and Labrador.

CCGS Matthew

Placentia Bay is designated as a priority area in terms of integrated management. DFO has an integrated management team in place and a local committee convened to discuss issues and make decisions related to management of Placentia Bay. The Smart Bay Initiative is complementary to this activity and will enhance the integrated management effort in Placentia Bay. During the 2006 survey season the joint CHS/NRCAN sea bed mapping program of Placentia Bay, part of the Smart Bay Initiative, completed the mapping of several shallow water nearshore areas in Placentia Bay.

As in previous years, the Canadian Coast Guard Hydrographic Survey vessel CCGS Matthew conducted hydrographic surveys at various locations throughout Newfoundland and Labrador. Surveys were conducted at St. John's and Cartwright, Labrador. A multiyear program to map new inshore shipping routes in northern Labrador

was continued, with a preliminary route now established to the northern tip of Labrador. Next season this program will continue with surveys to widen the route in shallow shoal infested areas and other areas of restricted maneuverability along the preliminary route.

The CCGS Matthew also completed multibeam acoustic surveys in Newfoundland in support of two scientific research projects. The first was conducted in the coastal areas off Cape Freels on the northeast coast of the Island of Newfoundland. Data from this survey will be used to characterize demersal spawning areas for capelin. The second survey area was near Pool's Cove on the south coast of the Island of Newfoundland. This area is expected to experience major aquaculture growth in the near future. Data from this survey will be used by the DFO to effectively manage the expansion of aquaculture.

Two multibeam acoustic surveys were also completed on behalf of the Canadian Coast Guard in support of Coast Guard programs. The first was at the entrance to Port Harmon on the west coast of the Island of Newfoundland. The entrance to this port was recently dredged and repairs made to a breakwater. The survey data was used to update nautical products at this site for any changes as a result of the dredging and construction. The second multibeam survey was completed in Goose Bay and the Terrington Narrows, critical shipping channels into the port of Goose Bay, Labrador. Data from this survey was compared to multibeam data from a similar survey completed a few years earlier. This comparison was used to determine if these channels, which are no longer maintained by an annual dredging program, are experiencing silting. The results indicated that while silting in the channel is not presently occurring, silting is occurring adjacent to the channels and that over the next few years, this silting is expected to encroach on the channels.

Canadian Survey Launch William R. Curran

The annual W. R. Curran Revisory Survey, funded from the High Risk Charting Project, operated at several sites throughout Newfoundland and Labrador during the 2006 survey season.

These surveys were necessary for the updating of new and revised nautical charts and Sailing Directions publications and in response to ISO Quality Management System Client Feedback Reports. The majority of these projects fell on high risk charts.
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Chart No.	Risk Class	Location	Type Survey	Proposed Product
4847	Class A	Conception Bay, Bell Island Ferry Terminal Inset	Single beam acoustic and side scan survey	Revised chart inset
		Conception Bay, Port de Grave	Single beam acoustic and side scan survey	Revised chart inset
4617	Class A	Placentia Bay, Fair Haven	Single beam acoustic and side scan survey	Notices to Mariners Action
Sailing Directions Pub. ATL 101	N/A	Fermeuse	Single beam acoustic and side scan survey	Sailing Directions Diagram

Annual Sailing Directions Revisory Survey

The annual Sailing Direction Revisory survey gathered hydrographic data from many sites throughout Newfoundland and Labrador. This data is used in revising and updating the Sailing Directions publications ATL 101, 102 and 109 for Newfoundland and Labrador.

An integral part of the Sailing Directions Revisory Survey is chart dealership inspection. These inspections assured that CHS chart dealers are selling the most recent edition of charts to clients, an important marine safety consideration.

Table 1: Summary of preliminary catches for stocks within the DFO, Newfoundland and Labrador Region, 1992-2006. Note that unless otherwise specified, this table presents Newfoundland and Labrador landings only.

			Catch (t)														
Subarea	**Species**	**Division**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**	**1994**	**1993**	**1992**
0+1	Greenland halibut	SA 0 + 1A(offshore)+ 1B-F	4,045	4,005	4,993	4,017	2,560	3,184	2,614	3,876	3,300	1,700	1,453	5,852	3,723	2,561	8,200
	Shrimp*	0A		7,508	6,236	6,654	6,247	3,625	1,588	2,046	933	517	2,623	2,361	4,727	5,501	7,493
		0B		6,333	4,488	4,584	5,597	5,829	4,805	5,132	5,204	5,670	3,220	3,564	476	106	1,291
2	Cod	2GH	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
	Shrimp*	2G (SFA 4)	9,305	8,063	11,489	10,021	8,393	8,116	7,529	7,884	8,051	5,217	5,160	5,104	3,982	2,723	2,706
		2HJ (SFA 5)	24,552	23,417	26,863	16,534	15,332	15,036	14,645	15,109	15,170	15,103	7,383	7,616	7,499	5,719	6,315
		2J3K (SFA 6)	76,039	77,583	72,605	60,150	59,912	52,554	63,175	51,202	46,337	21,246	10,923	10,914	10,978	8,035	6,609
	Crab	2J		1581	1,933	2532	3,522	3,756	3,794	5,448	4,061	3,166	3,090	3,178	2,978	2,275	1,529
	Iceland scallop	2HJ	684	672	495	528	272	218	230	685	1,295	1,027	360	167	340	401	103
	Arctic Charr	2J3KLPs+4R	40	22	19	19	21	33	47	41	38	38	16	30	31	38	74
	Atlantic salmon****		30	31.9	32	22.1	17.8	16.3	15.6								
2+3	Redfish	2+3K	221	135	167	22	34	40	30	3	3	4	2	1		2	9
	Greenland halibut	2+3KLMNO	6,307	6,644	4,877	6,620	6,291	8,238	10,637	4,124	4,081	5,877	5,891	3,229	2,928	4,899	6,933
	American plaice	2+3K	60	29	16	33	100	133	67	6	6	2	16	28	16	77	103
	Witch	2J+3KL	53	40	26	110	167	148	90	2	1	6	4	10	11	343	1,632
	Cod	2J3KL	2,679	1,330	643	971	4,196	6,887	5,376	8,525	4,501	877	1,874	413	1,313	8,967	26,073
	Grenadier	2+3	99	151	135	183	274	212	234	145	209	98	225	125	130	614	992
	Capelin	2J3KL (offshore)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Squid	2+3	6,835	537	2,277	1084	228	23	328	19	815	12,748	8,285	48	1,954	276	924
3	Redfish	3LN	1	2	0	9	47	40	33	5	7	19	0	0	0	46	657
		3M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3O	3,580	5,364	2,340	3,093	2,988	4,557	880	2,027	6,121	1,895	128	24	1,192	677	845
	Yellowtail	3LNO	177	13,268	12,577	12,705	9,959	12,238	9,422	5,540	3,536	1				6,265	6,369
	American plaice	3LNO	93	1,466	1,290	1,607	1,374	1592	623	269	204	71	47	65	59	7,454	9,663
		3Ps	485	745	731	883	1,014	877	609	542	405	213	112	80	112	723	2,380
	Witch flounder	3NO	94	49	49	62	27	13	12	3	3	18	26	0	0	3,971	4,093
		3Ps	182	483	540	529	517	450	332	507	452	259	250	273	429	956	1,012
	Atlantic halibut	3	251	255	303	399	369	315	182	124	165	152	101	107	36	138	114
	Cod	3NO	73	459	441	714	422	487	171	485	306	289	54	31	3	3,719	5,232
		3Ps	10,506	11,400	11,046	12,469	12,618	13,339	19,683	24,328	15,690	7,327	767	581	575	13,865	23,493
	Haddock	3LNO	23	44	18	67	183	86	69	50	14	190	28	9	0	675	598
		3Ps	128	219	123	137	111	102	162	98	191	69	118	48	20	86	251
	Pollock	3Ps	733	500	296	333	492	815	709	729	428	592	435	248	59	113	437
	White hake***	3NOPs		2,063	1,572	1,469	1,847	1,430	1,390	920	626	893	1,054	603	657		
	Thorny skate***	3LNOPs		2,063	not available	423	1,014	511	414	350	127	486	488	206	274		
	Capelin	3L	15,412	15,534	16,066	13,270	8,639	13,898	12,041	11,403	19,809	3,560	16,840	100	890	23,480	3,160
		3K	14,352	12,194	11,342	4,067	1,553	5,022	4,066	7,254	10,225	9,230	8,920	30	70	13,525	19,350
	Shrimp*	3M		not available	0	0	8	293	618	490	469	785	906	970	1,041	3,724	
		3L	18,147	11,184	10,613	10,008	5,417	4,986	4,111								
	Sea scallop	3KLNO	12	35	0	0	0	0	0	0	6	20	27	9	10	9	6
		3Ps	516	2,132	3,473	647	51	338	85	70	266	9	8	418	534	483	0
	Iceland scallop	3LNO	347	128	0	0	0	39	336	141	1,300	3,986	9,454	6,501	3,941	817	22
		3Ps	102	1,748	40	87	478	498	1,148	1,197	2,792	5,367	608	1,061	440	667	5,967
	Crab	3K	10,717	8,685	16,460	16,502	16,352	15,288	15,390	21,470	16,788	14,830	14,190	12,245	11,039	9,760	7,295
		3LNO	30,717	29,649	30,717	31,638	30,032	28,172	26,773	32,725	23,533	22,185	16,656	13,790	12,237	8,979	6,652
		3Ps	3,099	3,169	4,720	6,113	7,637	7,843	7,917	7,909	6,615	4,753	3,047	1,853	1,590	704	121
	Lobster	3K	156	209	157	207	206	275	231	251	295						
		3L	111	111	73	116	128	124	126	158	146						
		3Ps	1,052	988	779	786	763	709	637	613	684						
		3Pn	48	29	14	22	11	25	17	25	25						
	Atlantic salmon**	2J3KLPs+4R	33	41	35	36	39	39	30	38	45	82	114	95	133	126	213
3+4	Redfish	3P+4V	1,433	1,918	3,428	3,956	3,451	3,213	4,459	4,726	4,101	3,825	4,566	3,978	7,594	9,350	4,635
4	Iceland scallop	4R	629	454	360	275	252	638	1,084	1,091	1,355	1,205	1,204	1,497	2,294	2,122	1,296
	Sea scallop	4R	0	0	0	0	0	0	1	0	0	0	0	2	37	0	0
	Lobster	4R	1,276	1,280	888	1,125	950	985	747	767	886						
	Crab	4R	543	862	1,462	1,562	1,851	1,683	1,627	1,597	1,060	927	838	869	634	141	238

Note: Table indicates Newfoundland and Labrador landings only unless otherwise specified

*Shrimp catches are for Eastern Canada (i.e. taken by vessels from Newfoundland and Labrador, Quebec, and Nova Scotia).

**Recreational catch.

***Canadian catches only.

**** Subsistence fisheries.

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Appendix I: Research Projects for the International Governance on the High Seas Program (2006-2008); DFO Newfoundland and Labrador Region

On April 29th, 2005, the Minister announced that the government will invest an additional $20 million over three years on initiatives to combat over-fishing and strengthen international fisheries governance on the Grand Banks.

Part of this initiative will focus on scientific research to increase knowledge of marine ecosystems, sensitive marine areas and species, and straddling and highly migratory fish stocks.

For the Newfoundland and Labrador Region, approximately $7.2M over 3 years, has been notionally allocated towards the new program which is primarily focused on 2 areas:

1. Sustainable Fisheries Technologies and Practices

   Focus will be research on fishing technologies and practices to better understand their effects on the environment. Areas of interest could include gear selectivity, reducing environmental impacts of fish harvesting and ecosystem impacts.

2. Research on Sensitive Areas and Species

   This component will aim at developing a better understanding of the ecosystems of the Labrador Sea, continental shelf and slope areas of the Region. Priority will be given to understanding the physical and biological components of this ecosystem. This may include projects examining the inter-relationships between the various commercial and non-commercial species, research on straddling resources (e.g. species that inhabit areas where the continental shelf extends outside Canada's EEZ) and highly migratory species, species interactions, studies on distribution and migration, development of conservation guidelines (e.g. PA) or identification of sensitive areas and species, e.g. corals.

List of International Governance Proposals	
Project Leader(s)	**Title**
K. Gilkinson D. Hamoutene G. Veinott	The ecology of deep-sea corals of Newfoundland and Labrador waters: biogeography, life history, biogeochemistry, and role as critical habitat
N. Cadigan	Accounting for mis-reported catches in stock assessment models
J. Morgan J. Banoub	Improving our knowledge of the reproductive potential of Greenland halibut
D. Kulka	Ecology and life history of the skate complex (Rajidae) in the Northwest Atlantic
B. Dempson	Use of stable isotopes to assess long term changes in trophic ecology of Atlantic salmon (*Salmo salar*)
P. Pepin	To assess the roles of onshore transport and on-shelf production to annual cycle of *Calanus* spp. on the Newfoundland Shelf and Grand Banks
P. Shelton	Developing precautionary harvesting strategies for high seas straddling stocks
K. Dwyer S. Walsh	Improving the accuracy of stock assessment and the precautionary approach framework for grand bank yellowtail flounder using age-based analysis
D. Power	Temporal verification of stock structure and identification of strong year classes by species to investigate recruitment synchronization in Redfish based on genetic analysis of archived otoliths
J. Carscadden M. Koen-Alonso E. Colbourne G. Lilly P. Pepin	Comparison of Marine Ecosystems (NORCAN and ESSAS)
J. Payne J. Lawson	Effect of seismic energy on selected marine species of commercial importance or identified as Species at Risk
F. Mowbray J. Carscadden E. Hynick K. Gilkinson	Forage fish on the Southeast Shoal, an ecologically and geo-politically sensitive area of the Grand Banks
G. Stenson	Habitat use by hooded seal (*Cystophora cristata*) in the Northwest Atlantic
J. Lawson	Aerial survey of marine megafauna on the Continental Shelf from Baffin Island to the Scotian Shelf

PART B

SUBAREA 0

A. Status of the Fisheries

1. Shrimp

a) Division 0A

The shrimp fishery in 0A is based on *Pandalus borealis* fished east of 60°30'W which corresponds to the Canadian Shrimp Fishing Area (SFA) 1. The quota in 0A rose from 8,500t in the early 1990s to 18,417t in 2004 and remained at this level through 2006. Reported catches rose from a low of 517t in 1997 to 7,508t in 2005 (Table1). 2006 saw a significant decrease (45%) in reported catch of 4,127t. The decrease is likely more reflective of low shrimp prices and increased operating costs than stock status of the shrimp in the area.

b) Division 0B

The 0B shrimp fishery is a mix of *Pandalus borealis* and *Pandalus montagui*. SFAs with corresponding quotas for each species are used to manage the shrimp fishing within 0B. Catches are reported for SFAs. Since the SFAs do no correspond exactly to NAFO boundaries the catches are estimated from a combination of SFAs. For this report shrimp reported in SFA2 and 3 are reported as 0B catch in this report. This is appropriate when the distribution of the fish effort is considered. The exception would be the portion of NAFO 2G from 60°30'N-61°N and 63°W-64°30'W which is also reported as SFA2 catch. Therefore the accuracy of the level as it relates to the NAFO Division can be questionable.

The quota for the area rose from 3,500t in 1996 to 9,150t in 2006 for *Pandalus borealis* and 1,200t in 1996 to 4,300t in 2002 for *Pandalus montagui* where it has remained since that time. Catches of *Pandalus borealis* in 0B have fluctuated between 3,220t to 6,333t from 1996 to 2005 with the 2006 catch of 6,143t falling near the high end of the range (Table 1). 87% of all *P. borealis* was caught in 2006 came from west of 63°W. 2,431t of *P. montagui* were caught in 2006, down slightly from the 2005 catch of 2,600t. Catch rates in 0B remain at a high level.

2. Shellfish

No harvest of shellfish reported in Nunavut for 2006.

3. Arctic Charr

Subsistence and commercial Arctic charr fisheries in the Baffin region (NAFO Subarea 0) are conducted in inshore lakes and rivers and nearshore coastal waters. Information on catches from these fisheries can be found in the "Annual Summary of Fish and Marine Mammal Harvest Data for the Northwest Territories" published until 1997 by Fisheries and Oceans Canada, Central and Arctic Region. Data for more recent years could be requested from the Eastern Arctic Area Office in Iqaluit or from Policy and Economics in Winnipeg.

4. Greenland Halibut

a) *Division 0B*

Inshore: The Cumberland Sound fishery began in 1987 and is the only inshore fishery that has operated on an annual basis in Subarea 0. Prior to 2005, the total allowable catch (TAC) for inshore fisheries in Subarea 0 was set at 1000 t with half of this (500 t) allocated to the Div. 0B Cumberland Sound since 1994. However, catches have not reached this level since the early 1990s. The fishery is exclusively a winter fishery (January to May) and the fishermen use long-lines set through holes cut in the land-fast sea ice. Sea-ice conditions can affect the success of the winter fishery by restricting access to deeper more productive areas and thereby curtailing effort. Catches were lowest in the late 1990s at less than 100 t with a slight increase in 2002 and 2003. However, the sea ice has been unstable again since 2004 with a catch in 2006 of only 72 t. Exploratory fishing was conducted in Cumberland Sound in the summer open-water season in 1995 and 2002 but they were not successful in locating exploitable aggregations of Greenland halibut.

Beginning in 2005, the Cumberland Sound inshore fishing grounds have been managed separately from the offshore with a TAC set at 500 t.

Offshore: Prior to 2005, Nunavut companies had a 500 t quota in the Division 0B offshore commercial fishery with the option to transfer surplus inshore quota to the offshore fishery. Catches in 0B have varied between 20 t and 1720 t from 1992-2005 (Table 2). In 2006, the TAC for Nunavut was set at 1500 t with 1219 t caught using otter trawl (single and twin trawls) and gillnet (Table 3). Standardized catch-per-unit effort was updated in 2006 for the Div. 0B trawl fleet (including Can-NF vessels) (Fig. 1). A length frequency distribution for the Div. 0B catch (Can-CA and Can-NF) was prepared using observer data from the 2006 gillnet fleet (24% observer coverage) and trawl fleets (100% observer coverage) (Fig. 3). There was no observer coverage of the CAN-NF Div. 0B long-line fleet in 2005 or 2006. Catch distribution for landings in Newfoundland region in 2003-2006 are shown in Figures 4 and 5. Catches from Scotia-Fundy and Central and Arctic were not available with corresponding location information.

b) *Division 0A*

Since 1996, Nunavut companies have had exclusive access to an exploratory fishery license to harvest Greenland halibut in NAFO Division 0A and there is 100% observer coverage for this fishery on all gear types. Between 1996 and 2000, catches were less than 330 t. In 2001, the TAC was set at 3500 t and had increased to 4400 t by 2005. Catches were 2625 t in 2001 and increased to 3753 t in 2004 (Table 1). The total catch for 2006 was 6635 t (Table 2). A majority of the catch throughout the years has been with bottom otter trawl (both single and twin trawl gears have been used). Long-line gear was used in this fishery in 2002 and 2003. Gillnet catch was 3001 t in 2006 compared to 1118 t in 2005 and 15 t in 2004. Unstandardized catch rates have been relatively stable since 2002 at approximately 0.8 t/h for single trawls and 1.3 t/h for double trawls (Fig. 2). Length frequency distributions for the Div. 0A catch was prepared using Newfoundland and Quebec region observer data (Fig. 3). Catch distribution for observer recorded catch in 2003-2006 are shown in Figures 6 to 8. There are a few trips from observers based in Scotia-Fundy and Quebec region that are not included here but it represented only a small amount of the overall catch.

c) *Subarea 0*

A summary of the gillnet mesh size and corresponding depths fished is provided in Table 3 and trawl codend and body mesh sizes are given in Table 5. Details on the main by-catch species in the Greenland halibut fisheries in Subarea 0 are summarized in Tables 6 and 7 and include catch data on wolfish species that have been listed under the Canadian Species at Risk Act. The Greenland halibut catch recorded by observers for the trawl fishery (100% observed) differs from the landed catch estimates (Table 3) due to differences in product weight to round weight conversion factors.

B. Special Research Studies

1. Environmental Studies

Three oceanographic sections were completed during two multi-species surveys conducted in Division 0A, Baffin Bay, during August-September and October-November, 2007. One was at Cape Christian on August 31 and two were at Broughton Island, Sept. 3 and Nov. 4. This is the first time that the Broughton Island Section has been surveyed. Temperature, salinity and fluorescence data were collected at 5-6 stations along each transect. In addition temperature was collected for each trawl set distributed between 100 m and 1500 m bottom depth (SCR 07/22).

2. Biological Studies

a) Greenland halibut

Two stratified-random otter trawl surveys were conducted in southern Division 0A (Baffin Bay) in 2006. The first was conducted from August 26 to September 5 (see below under shrimp) and the second from October 27 to November 7 covered previously surveyed strata (400 m to 1500 m). Additional detail on methods and results are available in SCR 07/41.

b) Shrimp

In 2006 the first shrimp survey in NAFO 0A east of 60°30'W was conducted. This was a standard multi-species survey for the production of biomass and abundance indices. The study area included waters from 100-800m from the southern boundary to 72.3°N outside the area of eastern 0A surveyed annually by Greenland. Oceanographic information was collected for each trawl set and at predetermined stations along two standard hydrographic transects.

2006 was year 2 of NAFO 0B survey conducted by the Northern Shrimp Research Foundation in partnership with DFO. The original 0B study area however was changed to provide better scientific advice on management issues in the area. The standard trawl survey will produce abundance and biomass indices of shrimp in this division. Oceanographic parameters were recorded on each set taken during the survey.

A study of shrimp aging using morphological lipofuscin techniques was conducted. Several structures shown to contain lipofuscin in other crustaceans were examined in *Pandalus borealis*. Results indicated that *P. borealis* produced insufficient quantities of lipofuscin for the technique to be useful for aging purposes.

c) Shellfish

None.

d) Marine Mammal Studies

Research on movements of bowhead whales continued in Cumberland Sound (NAFO Div. 0B) in 2006. Nine bowhead whales, all ranging between 9 m and 13.5 m in length, were tagged with position-only satellite tags on July 11 and 12. Eight of these tags remained functional for periods ranging from one to ten months. Five tags were still active in January. All but one of the eight whales moved to summering areas in Prince Regent Inlet and Gulf of Boothia. The tag on an eighth individual was active for about a month and documented activity along the east coast of Baffin Island (ending at Cape Adair, 700 km north of the tagging site). The spring and fall migration paths taken to and from summering areas in Prince Regent Inlet and Gulf of Boothia included both a southern route through Hudson Strait and Foxe Basin, and a northern route along the east coast of Baffin Island and through Lancaster Sound. Information on wintering distribution was obtained for six whales. Wintering sites included the mouth of Cumberland Sound, Hudson Strait and northeast Hudson Bay.

A project to update bowhead whale catch history was also undertaken in 2006/07. A summary was made of the available harvest data between 1500 and 2005 for the population of bowhead whales occurring in the waters of eastern Canada and West Greenland. Struck and loss information, quality of catch reporting, and the effects of technological advances on whaling efficiency were summarized to the extent possible. The data used were limited to that available in published sources, and almost all limited to those published in English. Preliminary results indicate that the total harvest in the years 1500-2005 was approximately 80,000 whales. The harvest series is still incomplete and research is ongoing. However, the use of this expanded harvest series, in combination with more detailed modeling techniques that incorporate uncertainty, will provide more accurate estimates of pre-whaling population size and improve conservation and recovery planning for bowhead whales in eastern Canada.
Our lab has also been studying beluga within Cumberland Sound and narwhal in Baffin Bay-Davis Strait for a number of years. There is an important subsistence harvest for these whales by hunters in the communities of Baffin Island. Cumberland Sound belugas have a proposed designation by COSEWIC as Threatened and a recovery strategy has been drafted. An aerial survey of Cumberland Sound belugas was completed in 2005. Aerial surveys of narwhals along Baffin Island were completed in 2002-2004. In addition, we collaborated in a narwhal tracking project with the Greenland Nature Institute and the Danish National Environmental research Institute from 1998-2004, tracking narwhals which summer in the Canadian Arctic archipelago and winter in Baffin Bay and Davis Strait.

Research results are reported to the North Atlantic Marine Mammal Committee (NAMMCO) and the Canada/Greenland Joint Commission on the Conservation and Management of Narwhal and Beluga (JCNB).

There was a proposal to fly surveys for walrus off south-eastern Baffin Island in 2006 but this survey did not occur.

Table 1. *Pandalus borealis* catch (t) reported by all Canadian vessels fishing from 1990-2006

Division	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990
0A	4127	7508	6236	6654	6247	3625	1588	2046	933	517	2623	2361	4727	5501	7493	6788	6177
0B	6143	6333	4488	4584	5597	5829	4805	5132	5204	5670	3220	3564	476	106	1291	1107	1609

Table 2. Greenland halibut catch (t) in SA0 by Central and Arctic licensed vessels, 1992-2005.

Div.	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992
0A	4268	3753	4142	3800	2625	320	0	42	203	329	0	0	0	0
0B[1]	1240	208	800	918	1017	1043	1568	1720	1446	1417	407	0	20	1020

[1]Does not include catches from the inshore Cumberland Sound long-line fishery which has been managed separately from Div. 0B offshore since 2005.

Table 3. Summary of 2006 catch (t) for Greenland halibut by Central and Arctic licensed vessels

Division	Gear type	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
0A	Gillnet				652	1147	972	230		3001
0A	Single Trawl			4	28	119	123	170		444
0A	Double Trawl			160	416	1020	1348	246		3190
Totals				164	1096	2286	2443	646		**6635**
0B	Gillnet	313	149	3						465
0B	Single Trawl		12						50	62
0B	Double Trawl	51	347						294	692
Totals		364	508	3					344	**1219**

Table 4. Summary of gillnet mesh sized used in the 2006 Div. 0A and 0B fisheries with corresponding depth fished.

	Mesh (mm)	Mesh (inches)	Depth Fished (m)
Division 0A	197	7 ¾”	875-1061
	203	8”	838-1369
	204	8”	1106-1106
	206	8”	1152-1152
	207	8”	830-1315
	208	8”	1051-1051
	212	8 ¼”	1158-1184
	222	8 ¾”	911-1200
	226	8 ¾”	1072-1195
	229	9”	1027-1027
Division 0B	203	8”	766-1329

Table 5. Summary of trawl mesh size used in the 2006 Div. 0A and 0b fisheries.

Division	Codend Mesh (mm)	Body Mesh (mm)
0A	145, 146	92, 93, 100
0B	145, 147, 150	89, 99, 100, 105

Table 6. Catch and by-catch in the 2006 Division 0A Greenland halibut fishery, gears combined. Data are from observers with 100% coverage on all fleets.

Species	Trawl Catch (t)	Gillnet (Catch t)	Total Catch (t)	% of Total Catch
Greenland halibut (*R. hippoglossoides*)	3875	3078	6953	98
Greenland shark (*S. microcephalus*)	53	13	66	<1
Arctic skate (*A. hyperborea*)	7	18	25	<1
Skate sp. (Raja sp.)	2	30	32	<1
Roughhead grenadier (*M. berglax*)	3	14	16	<1
Northern wolffish (*A. denticulatus*)	0.034	0.350	0.384	
Striped wolffish (*A. lupus*)	0.174	0.003	0.177	
Spotted wolffish (*A. minor*)	0.020	0.000	0.020	

Table 7. By-catch in the Division 0B Greenland halibut fishery, gears combined (includes catch from CAN-NF, CAN-M and CAN-C&A). Data are from observers with 100% coverage on trawl fleets and 24% coverage on the gillnet fleet.

Species	Trawl Catch (t)	Gillnet (Catch t)	Total Catch (t)	% of Total Observed Catch
Greenland halibut (*R. hippoglossoides*)	2272	553	2825	96
Greenland shark (*S. microcephalus*)	41	1	42	1
Roughhead grenadier (*M. berglax*)	8	17	25	<1
Spiny crab (*N. grimaldii*)	0	11	11	<1
Northern wolffish (*A. denticulatus*)	5.419	0.000	5.419	
Striped wolffish (*A. lupus*)	2.314	0.000	2.314	
Spotted wolffish (*A. minor*)	1.022	0.000	1.022	

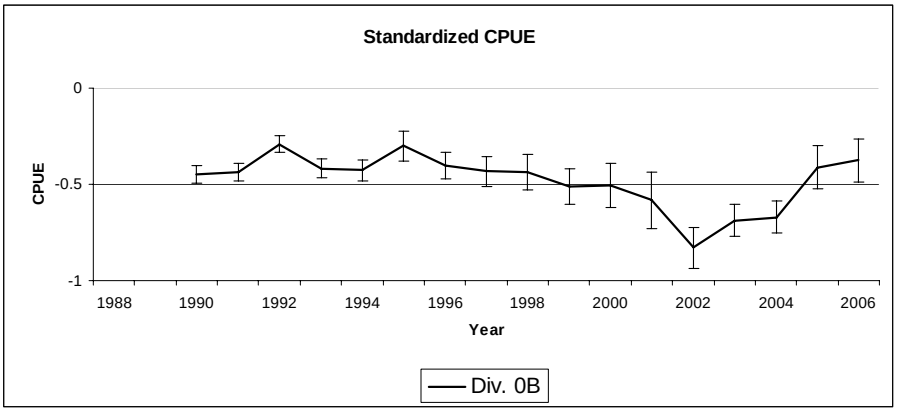

Figure 1. Standardized CPUE series from trawlers in Div. 0B with +/- S.E. Includes catch for vessels licenced by both Central and Arctic Region and Newfoundland Region.

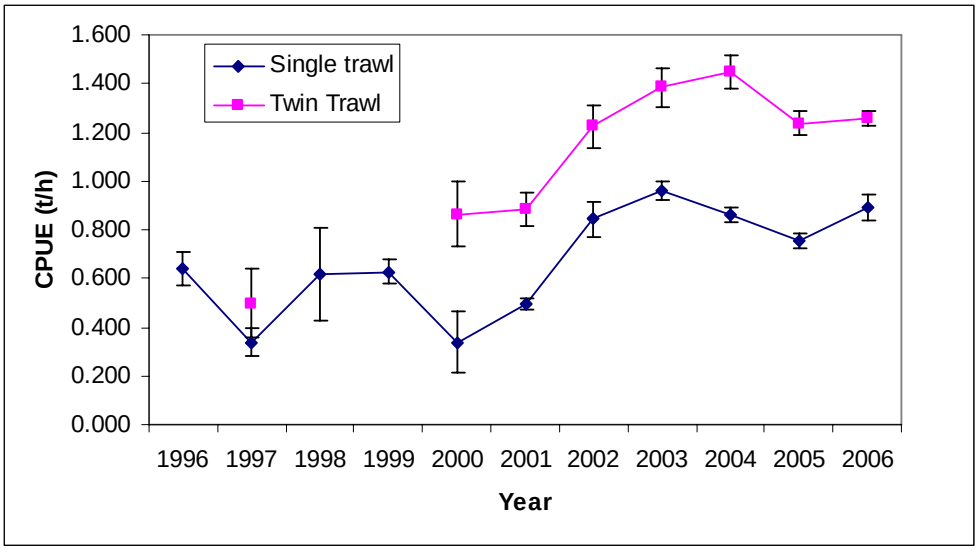

Figure 2. Division 0A trawl fleet, un-standardized mean catch per unit effort (CPUE) with 95% confidence limits for 1996-2002 and with standard error for 2003-2006.

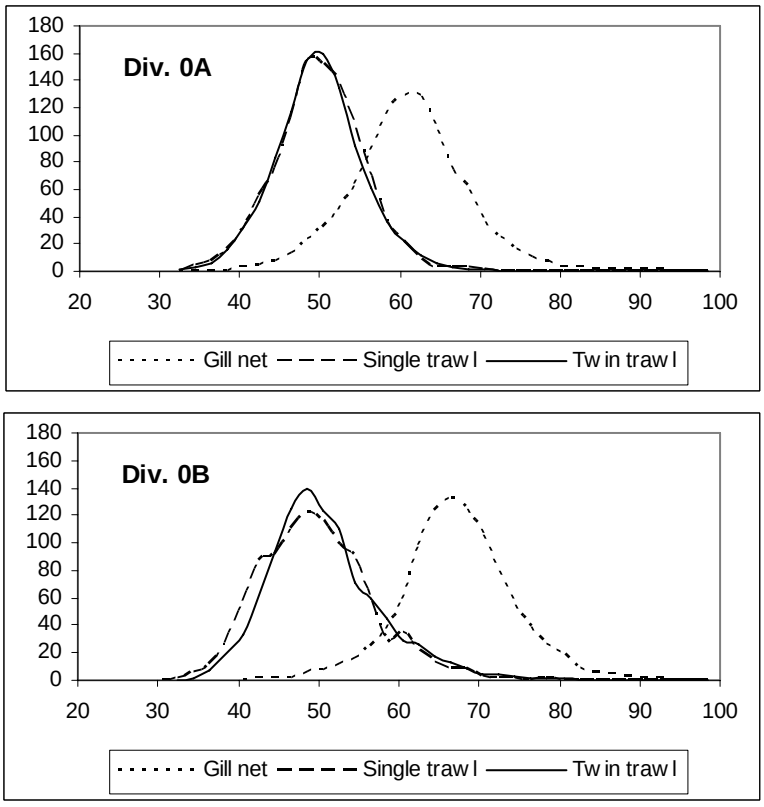

Figure 3. Length frequency for the 2006 Greenland halibut catches from Div. 0A (100% observer coverage) and from Div. 0B for three gear types, gillnet, single trawl and twin trawl. This does no include length data from a few observed trips from Scotia Fundy and Quebec Region.

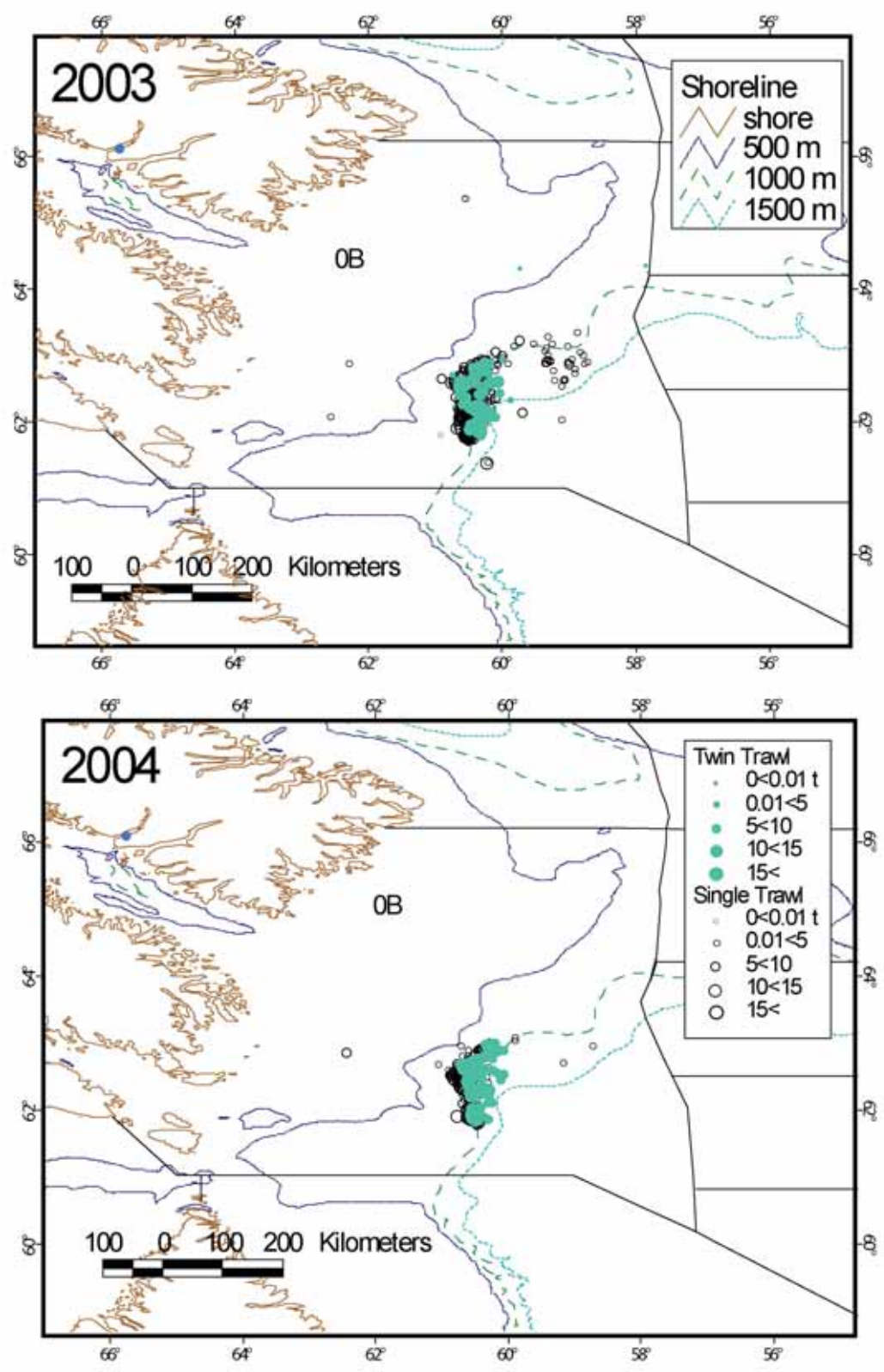

Figure 4. Division 0B single and twin trawl catch (t) distribution 2003-2006, Newfoundland region landings.

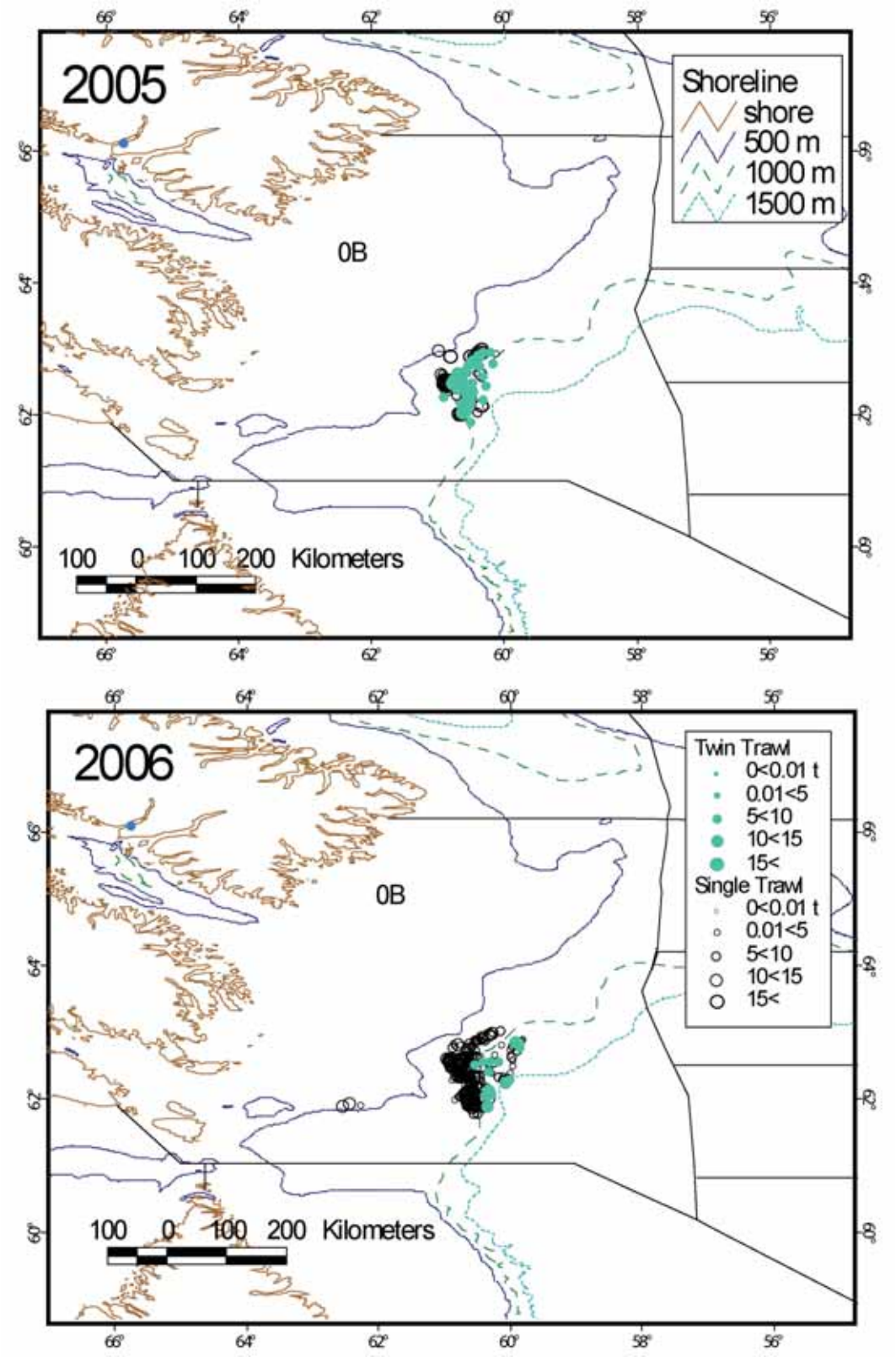

Figure 4. Con't.

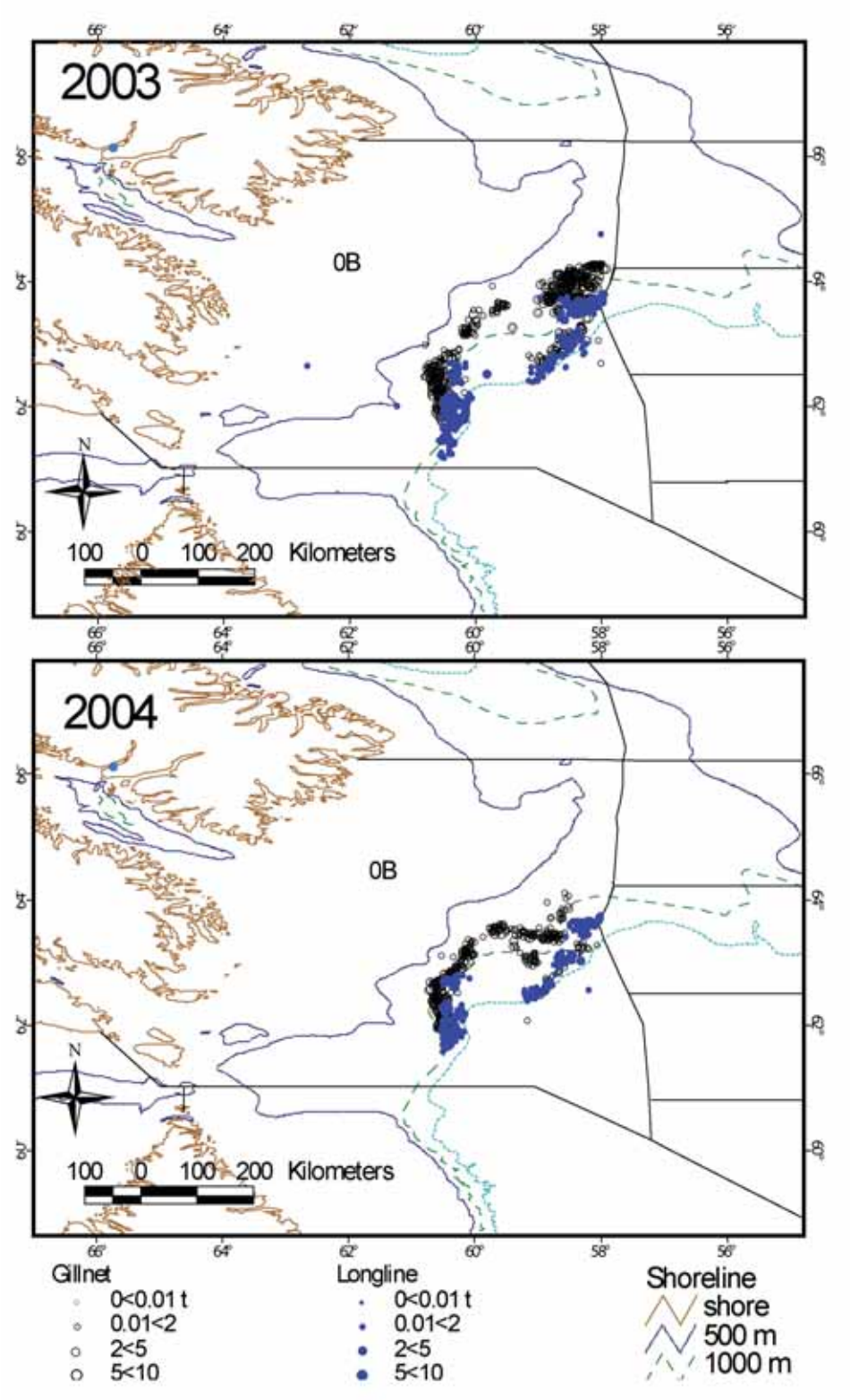

Figure 5. Division 0B gillnet and longline catch (t) distribution 2003-2006, Newfoundland Region landings.

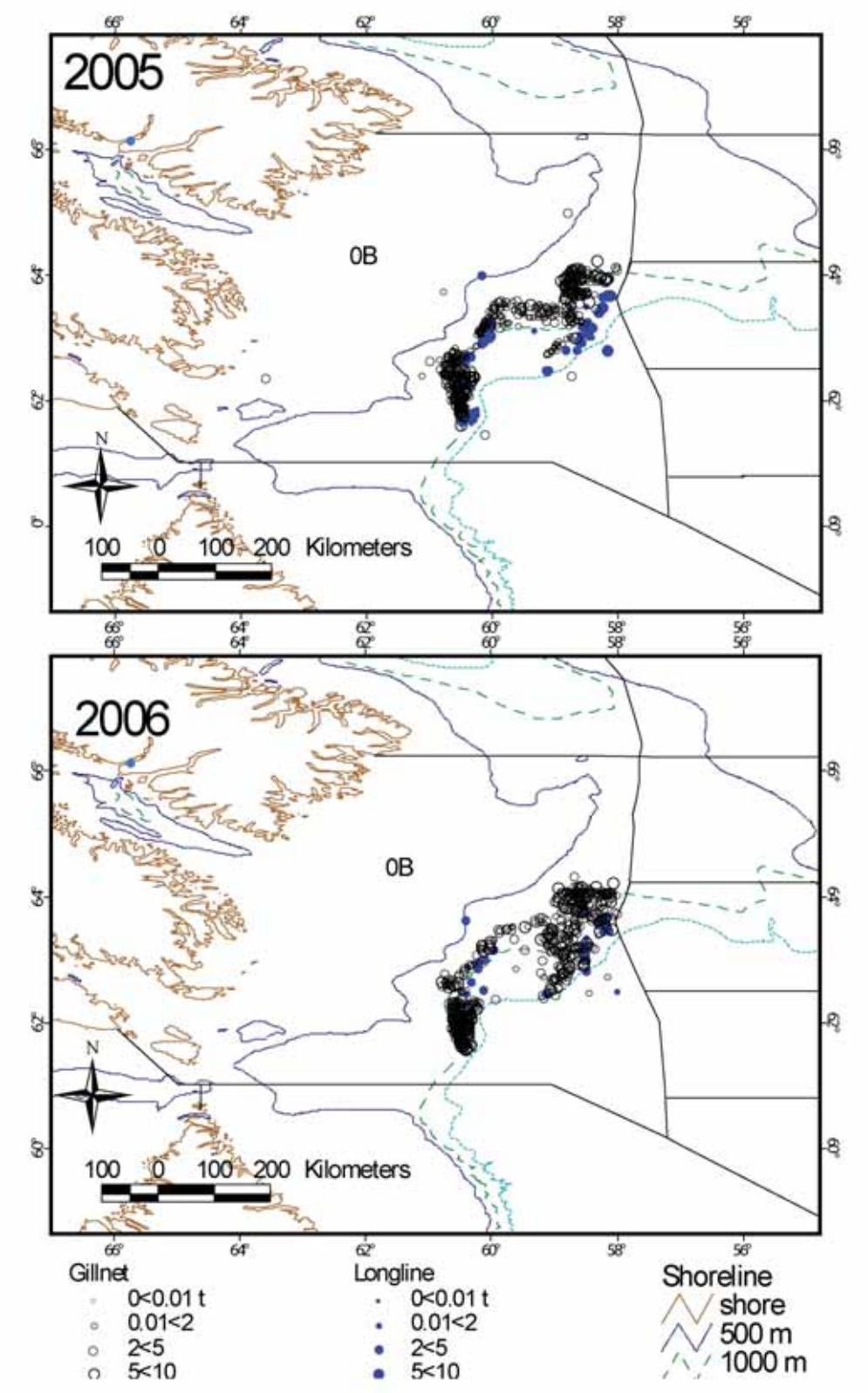

Figure 5. Continued.

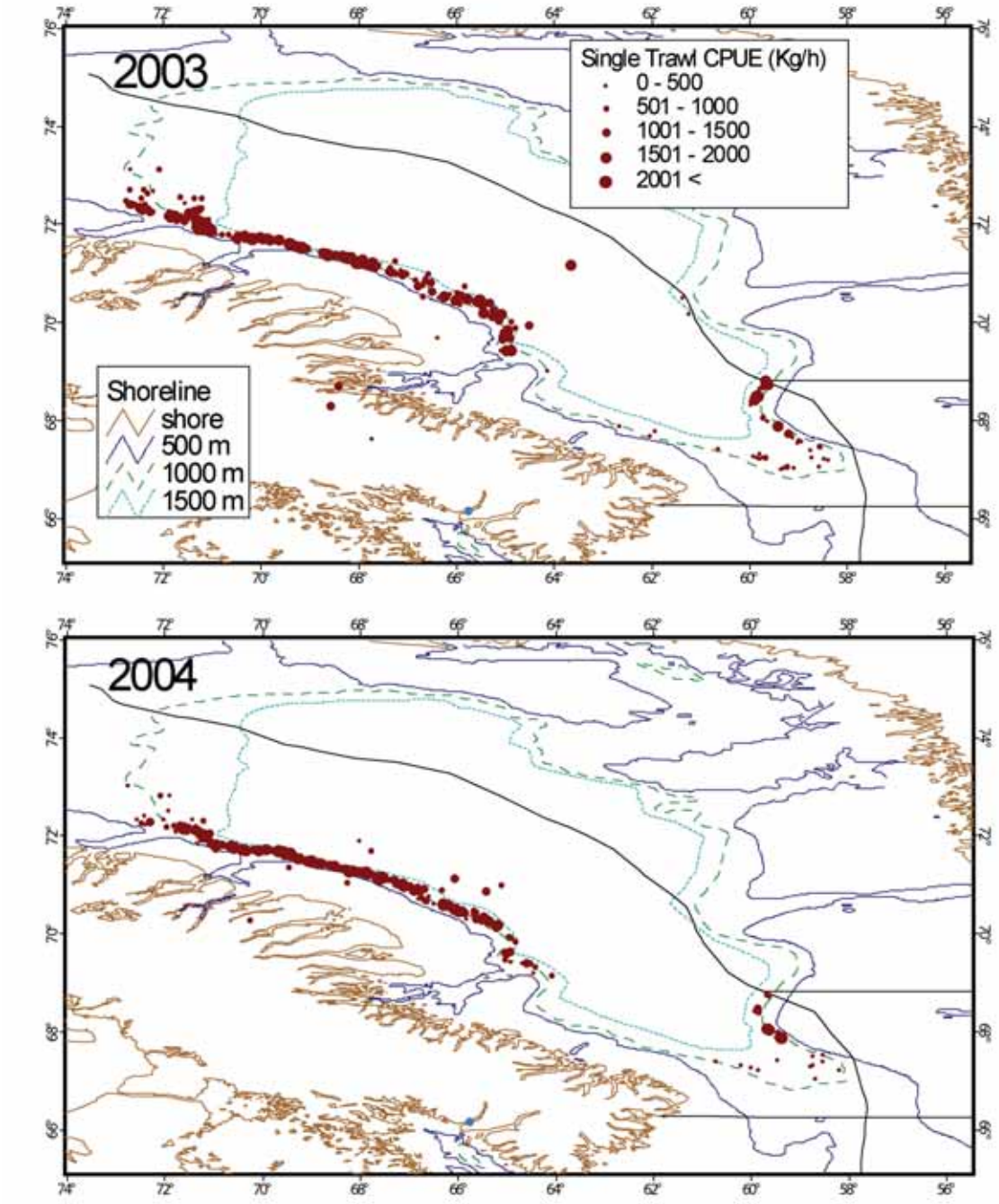

Figure 6. Division 0A single trawl catch (kg/h) for 2003-2006 from Newfoundland and Quebec region observer database (100% coverage).

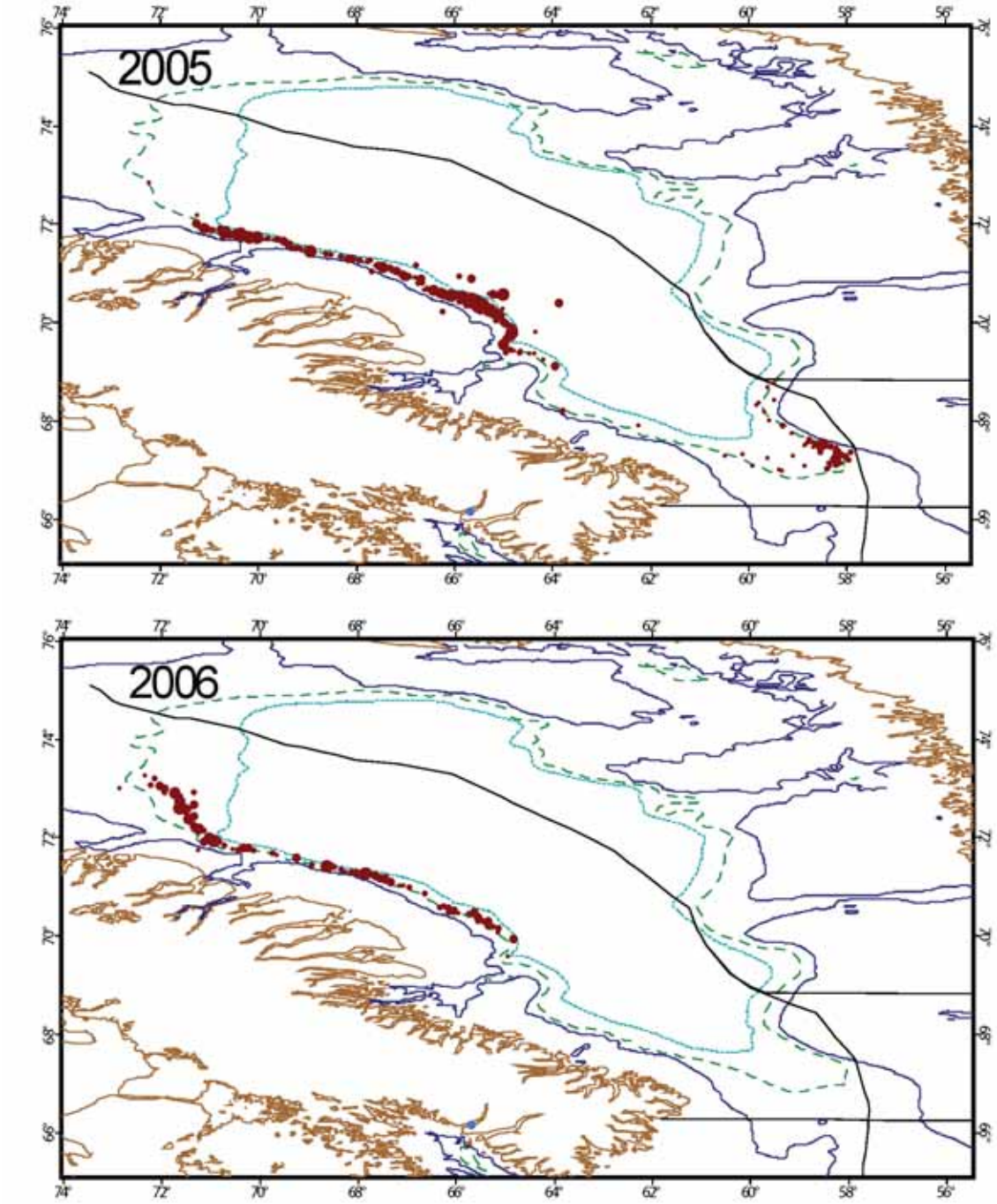

Figure 6. Continued.

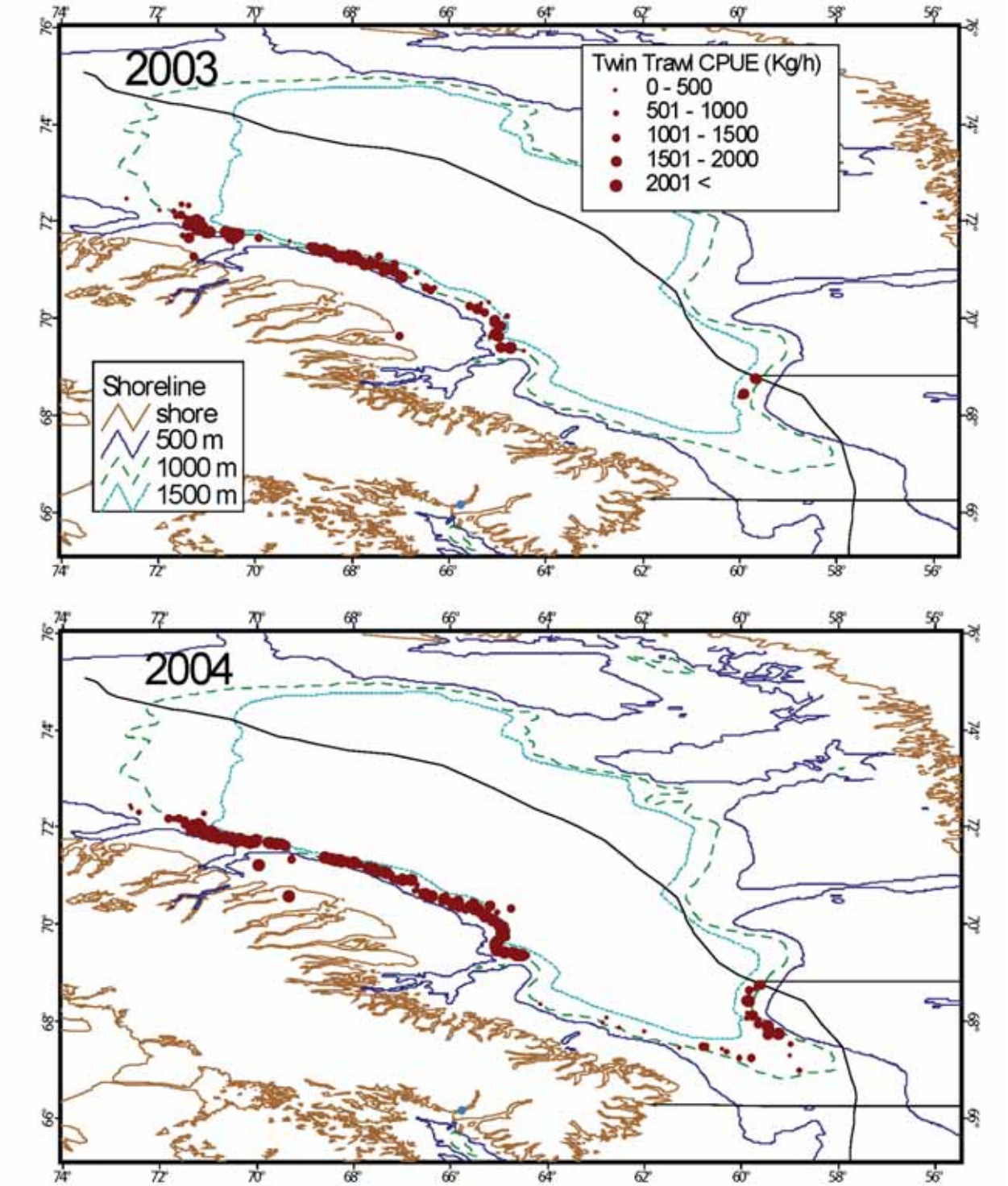

Figure 7. Division 0A twin trawl catch (kg/h) for 2003-2006 from Newfoundland and Quebec region observer database (100% coverage).

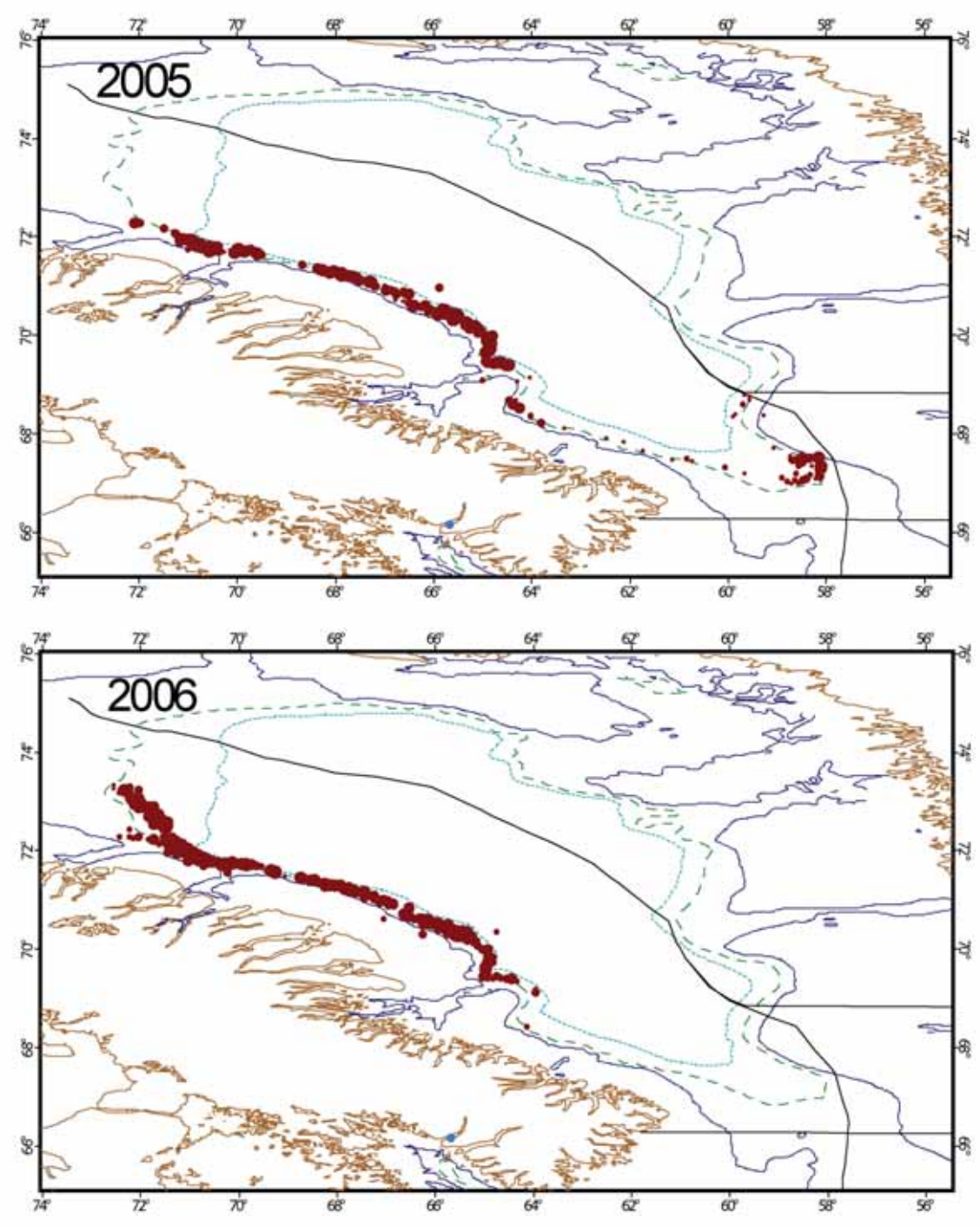

Figure 7. Continued.

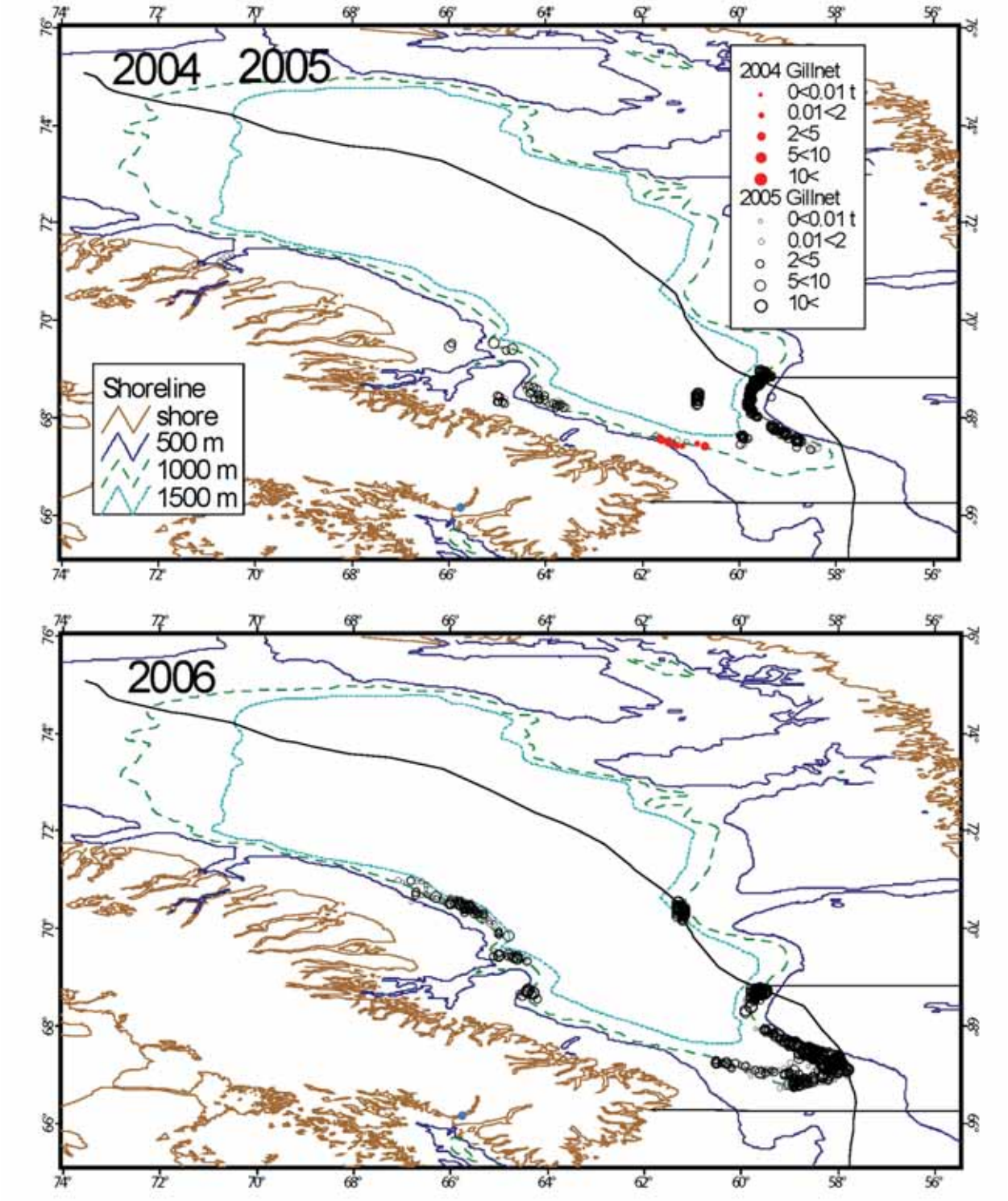

Figure 8. Division 0A gillnet catch (t) for 2004-2005 from Newfoundland region observer database (100% coverage).