Report

Fisheries Science Needs Assessment for Newfoundland and Labrador Commercial Species & Ecosystems

Submitted to:

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EXECUTIVE SUMMARY

The purpose of this project was to complete a comprehensive review of the fisheries scientific research activities in Newfoundland and Labrador and identify key priority areas of focus required to expand our understanding of primary and emerging fisheries and their associated ecosystems.

This assessment was completed through a series of consultations with Science Organizations, the Provincial Government, key Fishing Industry Associations as well as a former DFO Science Director. Science organizations provided their annual expenditures, descriptions of their science programs as well as some insights regarding science needs in Newfoundland and Labrador. Industry associations provided summaries of their collaborative science projects as well as their own financial contributions. Industry representatives also provided their perspectives of science needs based on their own experiences. Information from other jurisdictions was obtained from websites of national research institutions or through correspondence with key staff within these institutions.

Science Investments and Programs

The delivery of science in Newfoundland and Labrador is the mandate of the federal Department of Fisheries and Oceans (DFO). These science activities are completed by DFO's Newfoundland and Labrador Region in Divisions 2J3KLMNOP and for some species in Division 4R and in the Quebec Region for the remaining species in Division 4R as well as mackerel in subareas 3 and 4. These institutions conduct a wide spectrum of science programs, some of which includes:

- Completing fishery resource assessments.
- Conducting research vessel surveys.
- Sampling programs for commercial fisheries.
- Coordinating sentinel fisheries.
- Providing advice on resource abundance for domestic and international (NAFO) officials.
- Industry/DFO collaboration.
- Ecosystem and productivity research.
- Studying the effects of seismic activity on commercial species.

There are two Centres of study at The Fisheries and Marine Institute (MI) that have programs that contribute to the fisheries science knowledge base in Newfoundland and Labrador; the Centre for Fisheries and Ecosystem Research (CFER); and the Centre of Sustainable Aquatic Research (CSAR). CFER was established in 2010 with a goal to better understand fish stocks and the productivity of the NL marine ecosystem through fisheries research. CSAR has been a part of MI for some time and promotes the sustainable development of aquatic resources through collaborative industrial research and development, technology transfer and education services to the seafood industry.

The Province of Newfoundland and Labrador has also made a substantial contribution to science since 2010, with a significant investment to create the CFER. The provincial contribution also includes investments made through the Fisheries Research Grant Program since 2006.

There are also regular and substantial investments in science by industry associations in Newfoundland and Labrador. These investments are generally related to specific scientific projects completed by both inshore and offshore fleet representatives. These industry participants include the Fish Food and Allied Workers Union (FFAW), the Groundfish Enterprise Allocation Council (GEAC), the Canadian Association of Prawn Producers (CAPP) and the Northern Coalition. CAPP and the Northern Coalition have worked together to form the Northern Shrimp Research Foundation (NSRF). A sample of the projects conducted by these groups is as follows:

- DFO/Industry collaborative post-fishery survey for snow crab (FFAW).
- Groundfish stratified-random surveys in 3Ps (GEAC).
- A northern shrimp survey of shrimp fishing area 4. (NSRF).

In 2012, the *Fisheries Act* was amended to provide the DFO Minister with the authority to allocate fish for the purpose of financing science or fisheries management activities that contribute to the proper management and control of fisheries. DFO is now in the process of developing a national policy framework that will provide a transparent process to guide the application of this authority. Some of the funding contributions shown in this report have come from the allocation of fisheries resources.

The total annual Canadian fisheries science investment in NL in 2013-14 was just over $43M. The largest component was from DFO, but there were significant contributions from others as well. There was an additional $3-4M invested, for NAFO related work, by other countries on an annual basis. The largest portion of the NAFO work was an annual trawl survey conducted by the European Union in the areas outside 200 miles in Divisions 3LMNO. Including other jurisdictional spending, the total annual investment for 2013-2014 was ~ $47M.

Exhibit E1: Estimate of annual science investments (2013/14)

	DFO-NL	DFO-QC	DFO-Mar	CFER	CSAR	FFAW	GEAC/CAPP	Total
Salaries/wages	13,686,500	2,016,500		1,467,700	375,000			17,545,700
Operating	5,580,400	560,000		233,300				6,373,700
Vessel Costs	9,102,100	877,000		1,327,200				11,306,300
Cash contribution					560,000	315,400	1,870,000	2,745,400
In-kind contribution					265,000	626,000		891,000
Fish Allocation						2,019,000	750,000	2,769,000
DFA						358,200		358,200
Other (Grants, etc.)				613,400		228,700		842,100
Estimated			500,000					500,000
Total	$ 28,369,000	$ 3,453,500	$ 500,000	$ 3,641,600	$ 1,200,000	$ 3,547,300	$ 2,620,000	$ 43,331,400

Note: Fish allocation refers to Value of 'Use of Fish'

Best practices in other jurisdictions

The current stock assessment practices employed in other jurisdictions were examined and compared to Canadian assessment practices. There have been deficiencies identified in some of these practices, and methods to improve assessment models continue to be reviewed, tested and implemented. Significant developments in fisheries scientific research and stock assessment include the calculation of precautionary approach reference points and the evaluation of stocks against these. Further, there have been more attempts to include additional parameters in modeling to account for ecosystem impacts on fish stocks (e.g. predation, climate).

In July 2013, the World Conference on Stock Assessment Methods was held in Boston, USA. This was a contribution to the Strategic Initiative on Stock Assessment Methods within the International Council for the Exploration of the Sea (ICES), a global organization that develops science and advice to support the sustainable use of the oceans. This conference provided the most comprehensive report of fisheries stock assessment methods in some time.

The conference had three basic conclusions:

- Substantial coordinated strategic investment is needed to support stock assessment research. This investment should not only focus on "traditional single species stock assessment" but also consider the dynamics of fish populations and fisheries through space and the linkages with management needs for the ecosystem approach.
- 'Good practice' guidelines need to be developed. The most researched case studies should be used to provide initial guidance on good practices.
- A multi-organizational Global Assessment Methods Working Group for Sustainable Fisheries (GAME) should be formed.

The conference outcomes revealed the challenges regarding assessment of fishery resources, the implementation of improved assessment techniques and the integration of ecosystem considerations into stock assessments. Clearly, the challenges facing the international fisheries scientific community are similar to those facing scientists and biologists in Canada including Newfoundland and Labrador.

The following specific jurisdictions have been examined for this project:

- USA National Bodies – NOAA and NMFS
- New England States (USA)
- Iceland
- Norway
- New Zealand

A summary of assessment techniques currently in use in various jurisdictions is provided in the following exhibit. SPA refers to Sequential Population Analyses. In this type of assessment model data from commercial landings are used to construct population and mortality estimates. The commercial age-disaggregated data are usually compared to Research Vessel (RV) data to "calibrate" the population estimates. There are many commonly used variations of models in the SPA family, one is Extended Survivors Analysis (XSA) which was used for the Sub-Area 2 + 3KLMNO Greenland Halibut Assessment.

Exhibit E2: Current and prospective practices by jurisdiction

Jurisdiction/ area	Main species	Fishery Landed value[2]	RV for Science[3]	Comments on fish stock assessments
USA/New England	Lobster scallop	$1.19B	2	VPA type cod stock assessments. Maintains toolbox of methods.
Norway	Pelagics cod	$1.86B	8	VPA type cod stock assessments.
Iceland	Cod groundfish	$1.23B	2	VPA type cod stock assessments.
New Zealand[1]	Lobster hoki	$0.47B	2	VPA type assessments. Develops assessment software.
Canada/NL	Crab Shrimp Groundfish	$0.60B	3	Variety of methods – VPA, surplus production, XSA, etc. No VPA/catch at age data in most cod assessments

[1] based on export value of $ 0.94 billion
[2]value in $US
[3] RVs funded/used primarily by jurisdiction. Excludes charters, etc.

Research Vessel (RV) Surveys

A key activity of most large or national fisheries research institutes is monitoring of biological resources through research vessel surveys. These fishery independent time series of survey data are used as indices of abundance in stock assessments, and such series almost always need to be relatively long before being considered valuable. The actual number of years considered necessary for a useful time series of survey data can vary depending on the species surveyed, although five-plus years is often used as a benchmark for use as an index in a stock assessment. For many of the commercial fish stocks in the NL area, trawl survey data exists from the late 1970's, with the most comparable time series of data occurring from 1995 to the present.

Research vessel surveys comprise much of the work conducted by DFO in NL. There were 526 sea days utilized in 2013/14 at a vessel cost of $9.102 M and scientific staff cost of $1.159 M for total survey costs of $10.261 M.

Exhibit E3: DFO NL region survey costs (2013/14)

Vessel	Vessel Length (m)	Survey Days	Scientific Purpose	Amount
Hudson	90.4	24	Hydrographic surveys	933,783
Needler	50.3	188	Offshore trawl surveys	3,617,803
Teleost	63	147	Offshore acoustic/trawl surveys	3,537,309
Vladykov	25	167	Various Inshore Surveys	1,013,210
Total		**526**		**$9,102,105**

The vessel schedules related to fisheries scientific research remains similar year to year. Sea-days related to resource assessments are in the range of 350 to 375 days/year, including a combination of multi-species (215 days) and single species surveys (135-160 days). The remaining ~150 days are utilized for oceanographic studies, ecosystem and aquaculture research and tagging programs.

The following exhibit presents a recent comparison of all major bottom trawl (multispecies) research vessel surveys conducted in Atlantic Canada by DFO. All surveys use a stratified random design, and are conducted on DFO RVs Teleost and/or Alfred Needler. Although there have been some modifications to design and coverage in some surveys, these data give a reasonable picture of trawl survey coverage in Atlantic Canadian waters.

Exhibit E4: Canadian multi-species bottom trawl surveys (2013-14)

Region	Survey	Survey area (NM^2)	Minimum Fishing Sets	Vessel Days	Survey Intensity (NM2 / set)	Rank
NL	2HJ3KLNO Fall	150,128	674	142	222.7	6
NL	3LNO Spring	77,924	334	47	233.3	7
NL	3P	22,150	193	26	114.8	1
NL/Gulf	3Pn,4RST	37,692	250	32	150.8	3
Gulf	4T	21,308	175	21	121.8	2
Maritimes	4VsW	26,701	125	15	213.6	5
Maritimes	4VWX	53,485	200	28	267.4	8
Maritimes	5Ze	16,608	100	14	166.1	4

Source: Modified from data in Table 1B of Atlantic RV Survey WG report (DFO 2003 – Hurlbut ed.)

These data indicate the fall survey in 2HJ3KLNO, is almost three times the size of the next largest trawl survey area in Atlantic Canada. This is the only Canadian survey requiring simultaneous use of both DFO research vessels in the survey design. Also, the 3LNO (Grand Banks) portion of the NL area is surveyed twice per year, in spring and autumn. Overall, the survey intensity in the 2HJ3K area is at the lower end of the range (larger area per set), while the results for 3LNO (if both annual surveys are combined in a single calculation) and 3P would be at the higher end of the range.

The jurisdictional survey comparison illustrates the survey intensity also measured by nautical miles of ocean bottom per survey set. It must be recognized that different survey designs and target depth coverage exists in some cases (e.g. the Barents Sea survey is trawl-acoustic). Further, the table does not reflect un-surveyed areas. Surveys in the Barents Sea, Iceland, and NL-fall require the use of more than one vessel. The larger scale spring 3LNO and fall 2HJ3KLNO surveys in the NL Region are roughly in the middle of the range of coverage intensity. It is also noteworthy that spring and fall surveys of the same area are carried out in most jurisdictions.

Exhibit E5: Jurisdictional survey comparison

Country	Survey	Survey area (NM^2)	Minimum Fishing Sets	Vessel Days	Survey Intensity (NM2 / set)	Rank
Canada	NL 2HJ3KLNO Fall	150,128	674	142	223	5
Canada	NL 3LNO Spring	77,924	334	47	233	6
Canada	NL 3P	22,150	193	26	115	2
Canada	3Pn,4RST	37,692	250	32	151	3
Norway Russia	Barents Sea winter trawl-acoustic	167,000	354	~90	472	7
USA	New England NE shelf spring & autumn	68,938	370 (per survey)	60 per survey	191	4
Iceland	Iceland Shelf Spring groundfish trawl survey	Approx. 60,000	600	80 (est.)	100	1

Note: NM is nautical mile

In this report we have described many Canadian public-private partnerships in the delivery of stock assessment and related science activities. These types of partnerships also occur in other jurisdictions. In the northeastern USA, state and university researchers conduct inshore surveys in collaboration with the federal agency (NMFS), resulting in broader survey coverage for many key fishery resources. In Iceland, the main trawl surveys for groundfish resources use a number (up to six in some years) of chartered commercial trawlers in conjunction with the two main Icelandic RV's. Although not a true public-private partnership, the New Zealand approach, described in the report, presents a different model for funding fisheries research. The National Institute of Water and Atmospheric Research (NIWA), is a Crown Research Institute run as a company reporting to the NZ government, and is able to bring in revenue through scientific consulting and chartering of its vessels.

Trends in stock assessment modeling

The assessment methods currently in use, and some recently tested, for key stocks adjacent to NL are examined. This review is not exhaustive, but does examine both the traditional assessment methods and new methods that have been considered, across a range of species. The following exhibit provides a summary of the methods/models and inputs for a number of primary species and stocks.

Exhibit E.6: Summary of assessment methods for key NL Region stocks

Stock or species	Assessment method	Key Inputs for model or assessment	Comments
2J3KL cod	SURBA	Age disaggregated trawl survey abundance index	Survey based population analysis
3Ps cod	SURBA (HCR developed in Rebuilding Plan)	Age disaggregated trawl survey abundance index	Survey based population analysis
3NO cod	Adapt	Age disaggregated, fishery catch numbers, survey abundance indices	Sequential population analysis
3Pn4RS cod	VPA/Adapt	age disaggregated fishery catch numbers surveyabundance indices	Sequential population analysis
Snow crab	Surveys, CPUE	Trap and trawl survey indices, fishery CPUE	trends
Northern shrimp	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends
3LNO yellowtail	ASPIC	Catch, age aggregated survey abundance indices	Age aggregated surplus production
3LNO Am. plaice	Adapt	Age disaggregated. fishery catch at age, survey abundance indices	Sequential population analysis
3Ps Am. Plaice	Bayesian surplus production.	Catch, age aggregated survey abundance indices	Age aggregated surplus production
3NO witch	Surveys	Catch, age aggregated survey abundance indices	trends
2+ 3 G. halibut	XSA (MSE used to determine HCR)	Age disaggregated, fishery catch numbers, survey abundance indices	Sequential population analysis
4RST G. halibut	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends
Redfish 3LN	ASPIC (MSE developed)	Catch, age aggregated survey abundance indices	Age aggregated surplus production
Redfish 3O	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends
Redfish Unit 1+2	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends (surplus prodn used for RPA)
2J3KL capelin	Acoustic survey in 3L	Acoustic survey, other biological indices	trends
Lobster	Landings, CPUE, survival rates (molting)	Catch, CPUE, biological data	trends
4R herring	Survey	Acoustic survey	trends
3+4 Mackerel	SPA	Age-disaggregated fishery data, Egg density survey	Survey only covers relatively small portion of total stock area

Although many of the NL assessments use trends analyses to estimate stock status, a number of stock assessments currently utilize more analytical assessment methods, or at least have explored such methods. Comparison of the methods shows that similar techniques are in use elsewhere in the world. Reasons for not using analytical methods for all stocks include issues with catch data reliability, other data issues, and workloads. However, one class of assessment modeling that has not been widely tested for NL stocks permits estimates (where actual catches are not known with certainty) of fishery catch at age to be used in sequential population analyses.

For many stocks in the NL area, evaluation of the resource is conducted against reference points defined by a precautionary approach (PA) framework. Two such examples of these are the PA frameworks developed within Canada (DFO) and at NAFO. In many cases, the scientific advice is then based on where the assessment indicates the stock level is relative to established reference points adopted for the PA, which are often defined by biomass and fishing mortality.

Most Canadian Science Advisory Reports (SAR) in recent years contain sections on ecosystem and environment (oceanography). These often contain summaries of relevant data on temperature, habitat, predator/prey, etc. Although assessments attempt to evaluate impacts on stocks of significant changes in key indicators, no jurisdictions have a truly integrated an ecosystem assessment approach. The same is true for most NL stocks assessed by the NAFO Scientific Council. Effective modeling of stocks using an ecosystem approach has proven to be elusive, though many assessments now track numerous ecosystem indicators which are given consideration during regional and zonal assessment processes (e.g. impacts of predation, climate change).

The certification of fisheries has created an emerging science need for many commercial species. The predominant certifying organization, the Marine Stewardship Council (MSC), has developed an environmental standard for sustainable and well-managed fisheries. For a fishery to be certified, an assessment against this standard is completed and must meet predetermined score outcomes. Internationally secured scientists and managers who have expertise in the species being certified conduct peer reviews of these assessments. Upon completion of an assessment the entire document is made available to the public at large for review and feedback.

Resource Prospects

Stock assessments comprise the primary source of information documenting the status of individual fish stocks. Both DFO and NAFO have adopted multi-year assessment strategies with formal assessments occurring every two to five years with all significant fisheries having annual updates. Further, there are mechanisms within both institutions that permit ‘triggering’ a formal assessment in intermediate years as required.

The status of the resources examined can be described as healthy or in the safe PA zone (9 stocks), in moderate condition or in the PA cautious zone (7 stocks), low or below the PA Limit Reference Point (LRP) but increasing (6 stocks) and finally low or below the PA LRP, but not increasing (6 stocks). Summarized results of the resource prospects for all 27 stocks are presented in the following exhibit (NL snow crab is subdivided into 3LNO and 2J3KPs for this table).

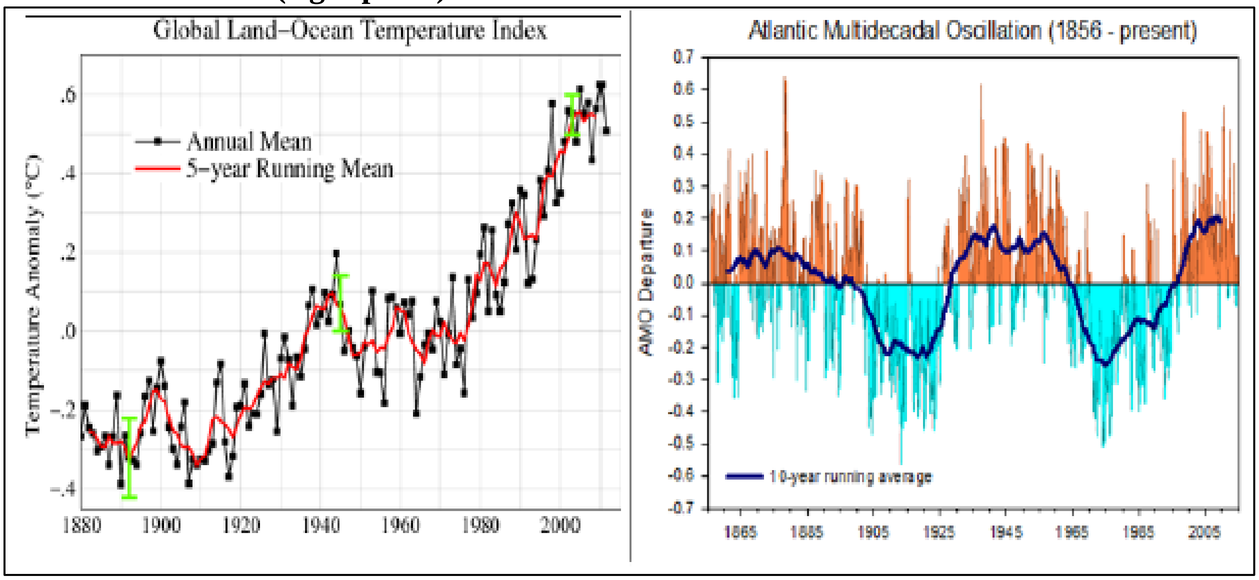
Exhibit E.7: Precautionary approach status or subjective view of stock status of fisheries reviewed

Healthy or PA Safe Zone	Moderate or PA Cautious Zone	Low or PA critical zone - rebuilding	Low or PA Critical zone - no rebuilding
3LNO Yellowtail	3Ps Cod	2J3KL Cod	4RS3Pn Cod
3+4 Atl Halibut	3NO Witch flounder	3NO Cod	U1+2 Reds Mentella
3LN Redfish	SFA 5 Shrimp	3LNO Am Plaice	3L Shrimp
SFA 4 Shrimp	SFA 6 Shrimp	2+3K Reds Mentella	3+4 Mackerel
4R Shrimp	2+3 GL Halibut	2+3K Reds Fasciatus	4RHerring
4RST Atl Halibut	4RST GL Halibut	U1+2 Reds Fasciatus	2J3KPs Snow Crab
4RST Capelin	3LNO Snow crab		
	NL Lobster		
	2J3KLPs Capelin		

A special meeting of DFO to look at Short-term Stock Prospects for cod, crab and shrimp in the Newfoundland and Labrador Region (Divisions 2J3KL) is described in this report. The latest resource prospects are included as is data on recent climate and ecosystem structure trends. The recent warming trend in the climate system is clearly shown in

Atlantic Multi-decadal Oscillation (AMO) and the global land-ocean temperature index (Exhibit E8).

Exhibit E.8. Global land-ocean temperature index (left panel) and Atlantic Multi-Decadal Oscillation (right panel)



The fish community in Div. 2J3KL was historically dominated by groundfish, with capelin as its core forage-fish species. Climate changes and overfishing led to a regime shift in the early-mid 1990’s and the ecosystem became dominated by shellfish species like northern shrimp, while traditional groundfish species and capelin declined to very low stock levels. Between the mid-1990’s and early 2000’s, the fish community showed a relatively stable structure. By the mid-late 2000’s the community structure started to change. Fish functional groups began to show increases in biomass, and shellfish started to decline. If current trends persist, it could be expected that the ecosystem in Divs. 2J3KL would return to a groundfish-dominated structure. It remains uncertain how similar this emerging structure will be to the historical ecosystem, in terms of both species composition and overall biomass levels, or at what rate these changes will occur.

For snow crab, overall, recruitment is expected to decline in the next 2-3 years and the warming oceanographic regime suggests weak recruitment in the long term. The exploitable biomass has recently declined (and is expected to remain low) in Divisions 2J and 3K, and a decline is expected in Divisions 3LNO in the near future. The nature and magnitude of the expected decline in Div. 3LNO, and Div. 2J3KLNO overall, within the next five years, are unknown.

Northern shrimp fishable biomass in NAFO Divs. 2HJ3KL has declined to its lowest level in the time-series. The severity of the decline increases from north (SFA 5: Div. 2HJ) to south (SFA 7: Div. 3L). The fishable biomass is expected to remain low or decline further over the next five years, based on the delayed response of shrimp production to recent and anticipated unfavorable conditions.

Based upon the autumn DFO surveys, the three year average SSB for 2J3KL cod increased from 12% of the limit reference point (LRP) in 2010-2012 to 18% in 2011-13. The stock has shown some improvement after 2005 but has remained below the LRP since the early 1990's. Under productivity conditions observed during 2010-2012 the average SSB has been projected to remain stable, well below the LRP. Indications from the 2013 survey suggest improved survival and more abundant pre-recruits. If these conditions persist then SSB could improve in 4-5 years (2018-2019), but would likely remain below the LRP. If the 2013 survey estimates were over-estimated (year effect) the stock will continue to experience relatively high total mortality and will decline rather than experience growth.

Preliminary observations by CFER scientists suggest that the distribution of 2J3KL cod has been expanding during recent Celtic Explorer surveys. This is consistent with perspectives from fish harvesters who participate in the annual stewardship fishery. These harvesters contend that the high abundance and the current distribution of cod resemble historical patterns and is evidence that a significant recovery has and is taking place.

Science Gaps

Several science gaps are identified throughout this report. Additionally there are other gaps that have been identified though the consultation process of this project. The gaps are categorized into three themes:

- Fisheries science/stock assessment/monitoring in Newfoundland and Labrador.
- The Centre for Fisheries and Ecosystem Research at the Fisheries and Marine Institute.
- Collaboration opportunities between science institutions and/or fishing industry.

In addition there are a small number of gaps that do not fit into the above three themes, but are cited in a catchall category.

Fisheries Science/Stock Assessment gaps:

- Lack of science capacity related to stock assessment modeling.
- Lack of assessment models for some key stocks (snow crab, shrimp, capelin).
- A number of stocks do not have specific reference points to enable the implementation of Precautionary Approach Frameworks
- There is no process for the implementation of PA Frameworks for data-poor stocks.
- Lack of Management Strategy Evaluation expertise for the determination of Harvest Control Rules (capacity for this work not available at DFO).
- There is no analytical integration of ecosystem considerations into stock assessments.
- There is a lack of required multi-species data to fully implement ecosystem approaches.
- For some stocks there is not a complete record or estimation of total removals.
- There is a gap in coverage for the spring capelin acoustic survey.
- Additional work on study of long-term productivity of the ecosystem would be beneficial.

Centre for Fisheries and Ecosystem Research gaps:

- Ongoing funding for maintaining CFER operations and vessel charter is required.
- There can be additional collaboration between CFER and DFO on assessment modeling projects.
- CFER does not have research survey capacity in near-shore areas.

Collaborations between science institutes and industry gaps:

- There is a requirement for a substantial stable funding source to facilitate collaboration between science institutes and/or fishing industry participants.
- No defined funding source for the science work required for emerging fisheries.
- No defined funding source for the science work required for certification of fisheries.
- Collaboration should be encouraged related to work on Aquatic Invasive Species.

Other identified gaps:

- Scholarships in the fisheries and ecosystem field of research.
- Industry participants are not utilized in a general way to collect data from commercial fisheries.

Recommendations

There are 22 recommendations put forward for action using the Fisheries Investment Fund. These recommendations are consistent with the three themes previously discussed. There should be a high priority associated with the science gaps related to stock assessment and the stabilization of funding for CFER. A summary of recommendations are provided below.

General Recommendation:

- It is recommended that the funding for the science initiatives identified in this report be distributed over a 5-10 year period. It will be advantageous to have a time frame at the longer end of this range.

Fishery Science/Stock Assessment Modeling and Application Recommendations:

- It is recommended that resources from the Fisheries Investment Fund be allocated for the hiring of post-doctoral fellows to immediately assist current stock assessment scientists, biologists and modelers while training to become the stock assessment experts of the future. The individuals selected for this initiative require training in fish population dynamics, mathematics, statistics and computer programming. A new Master of Marine Studies Program (Statistical Fish Stock Assessment) at MI should also be supported.

- Most of this capacity should be directed at addressing stock assessment gaps, however it is recommended that a portion of this capacity should be directed at studying long-term productivity of the ecosystem.

- It is also recommended that funding be divided between DFO and CFER.

- Additionally it is recommended that Memorial University of Newfoundland and Labrador and the Fisheries and Marine Institute be encouraged to increase the number of faculty in the field of quantitative biology and ecology.

- It is recommended during research vessel surveys conducted by DFO and CFER that length data be collected on a variety of marginally commercial and non-commercial species.

- It is further recommended that stomach content data be collected during RV surveys to provide information on predator/prey interactions.

- These kinds of data collection and analyses come with considerable costs. It is recommended that these incremental costs be covered by the Fisheries Investment Fund.

- It is recommended that the Fisheries Investment Fund be used to charter an additional 30 sea days of the Celtic Explorer from the Irish Marine Institute for the purpose of conducting a hydro-acoustic survey for capelin (and other species) in the areas of Division 3K not surveyed by the DFO acoustic survey. It is also recommended that the survey plan for these additional days be determined through consultation between DFO and CFER.

- Additionally it is recommended that the funds used for this purpose should cover charter costs as well as staff and equipment costs that will be incurred by both institutions participating in this survey.

Centre of Fisheries and Ecosystem Research Recommendations:

- It is recommended that the Fisheries Investment Fund be used to provide the necessary funding to continue CFER’s operation and large vessel charter for the term of the Investment Fund.

- It is also recommended that there be enhanced collaboration between CFER and DFO on projects regarding stock assessment techniques/modeling.

- Additionally it is recommended that funding be provided to assist in the upgrade of the current or a new multi-tasked at-sea work platform to bring it to full science capacity, enabling CFER to conduct research in near-shore areas.

Collaboration Recommendations:

- It is recommended that the Fisheries Investment Fund be used to provide an appropriate level of funding to support collaborative arrangements between fisheries science institutes and the fishing industry. This level of funding should be in the range of $1-1.5 million per year for the term of the Fisheries Investment Fund.

- It is recommended that collaborative projects from the Fisheries Investment Fund be processed utilizing the DFA Fisheries Research Grant Program with projects being eventually approved by a Fisheries Investment Fund Steering Committee, or other oversight group.

- It is further recommended that funding be made available to enable DFA to hire additional human resources to deal with increased workload related to this initiative.

- It is recommended that the Fisheries Investment Fund be used to provide funding to support the completion of the scientific components of emerging fisheries. Projects of this type can be vetted and approved through the same process as other collaborative arrangements as described above.

- It is recommended that the Fisheries Investment Fund be used to provide funding to support the various science components required for the certification of fisheries. This type of work may include research related to: stock assessment, habitat and ecosystems and by-catch recording and evaluation. Certification projects, like emerging fishery projects can be vetted and approved through the same process as the collaborative arrangements described above.

- It is recommended that the Fisheries Investment Fund be used to support collaborative work between industry and scientific institutions (mainly DFO) in furthering knowledge related to the biology, distribution and eradication of aquatic invasive species in NL waters.

Other Recommendations:

- It is recommended that $70,000 be allocated annually from the Fishery Investment Fund for the implementation of a Fisheries and Ecosystem Scholarship Fund. This would provide a single $30,000 scholarship for a PhD student and two $20,000 scholarships for Masters Students.

- It is recommended that the Fishery Investment Fund be used to investigate the feasibility of a fishing industry data collection program that could employ inshore fish harvesters and crewmen on offshore vessels to augment the collection of fishery-dependent data for use in annual stock assessments and related analyses.

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1.0 BACKGROUND

Fisheries scientific research has been ongoing in Newfoundland and Labrador for about 80 years. Most of the early work in this field was related to marine fisheries ecology. Fisheries stock assessments in some form began in the early 1970's, mainly using cohort analysis or surplus production techniques. The assessments using cohort analysis continued for many Atlantic fisheries for the next couple of decades. It was difficult to provide precise estimates of stock abundance in the early years because of the lack of independent time series of stock abundance as well as the lack of computing power necessary to complete the required analysis. The main indices of abundance used today for assessment purposes are research vessel surveys of one form or another.

While analysis techniques improved and research vessel survey databases grew, it was quite common during the early 1970's and into the 1990's to rely only on a single point estimate taken from a single-species stock assessment to determine resource abundance. While single-species assessments are still quite common, during the past 20 years there has been a number of changes in thinking related to resource assessments for important fisheries as well as the management of fisheries and oceans resources in general.

Through the work of the United Nations Environment Programme (UNEP) the Convention on Biological Diversity (CBD) came into force in late 1993. Included in the Convention text (Article 8. In-situ conservation) were many of the drivers for change in the way fisheries and oceans are managed today. The CBD called on contracting parties to the Convention to, among other things:

- Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;
- Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;
- Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species;
- Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations.

There are clear links between the CBD work and the development and implementation of legislation and policies related to fisheries and oceans management in Canada. The Canada Oceans Act was passed in late 1996 and is the basis for Canada's Oceans Strategy, Integrated Management of oceans activities, and the development of a network of Marine Protected Areas (MPAs). The Species at Risk Act (SARA) was adopted in 2002 for the purpose of preventing wildlife species in Canada from disappearing, to provide for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. Canada has also implemented strategies to deal with Aquatic Invasive Species and Canadian scientific community are continuing work on ecosystem approaches to science and management for important fishery resources.

The United Nations Fisheries Agreement (UNFA-1995, Article 6) provided the driver and the direction for the implementation of the precautionary approach. The UN FAO's Code of Conduct for Responsible Fisheries, also adopted in 1995, was consistent with these instruments and provided a necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment. Further, the UN General Assembly (UNGA), in its 64th session, adopted a resolution to protect vulnerable marine ecosystems such as corals, seamounts, sponges and hydrothermal vents (UNGA Resolution 64/72, Section X. Responsible fisheries in the marine ecosystem).

Additionally, fish consumers and Environmental Non-Government Organizations (eNGO's) began to question the sustainability of many commercially fished resources, leading to a demand to have fisheries certified as being conducted in a sustainable manner.

While this new thinking is rapidly advancing, the practical application of the above initiatives is slower to occur. There have been some implementation of these initiatives in Canada and at the Northwest Atlantic Fisheries Organization (NAFO); Precautionary Approach (PA) frameworks are in place for many stocks, there are a number of Marine Protected Areas (MPAs) and other closed areas in Atlantic Canada, and ecosystem considerations are regularly included in stock assessment reports. In addition, many fisheries have been certified by organizations like the Marine Stewardship Council. While there has been success, more work is required. This has been explored further as it relates to science activities in Newfoundland and Labrador as part of this science needs assessment.

Objectives: The purpose of this project was to complete a comprehensive review of the fisheries scientific research activities in Newfoundland and Labrador and identify key priority areas of focus required to expand our understanding of primary and emerging fisheries and their associated ecosystems.

Project methodology: This assessment was completed through a series of consultations with science organizations, the Provincial Government, key fishing industry associations as well as a former DFO Science Director. Science organizations provided their annual expenditures, descriptions of their science programs as well as some insights regarding science needs in Newfoundland and Labrador.

Industry associations provided summaries of their collaborative science projects, their own financial contributions as well as their perspectives of science needs based on their experiences dealing with science through participation in:

- Stock assessment processes.
- Species advisory meetings.
- NAFO processes.
- Individual fisheries certification processes.
- Work on their company or broader industry based science initiatives.

Information from other jurisdictions was obtained from websites of National research institutions or through correspondence with key staff within these institutions.

Trends in stock assessment modeling were also examined using results of specific assessments for a variety of key stocks within Canada and also in other jurisdictions. This jurisdictional scan provides a contrast of:

- The quality of input data into the assessment.
- The specific model(s) used.
- The presence of precautionary approach reference points.
- The inclusion of specific harvest control rules.
- Consideration of ecosystem impacts.
- The trajectory of stock trends.

Resource prospects, along with supporting information, are included for 27 fisheries in waters adjacent to Newfoundland and Labrador. This includes stocks that are assessed by DFO-Newfoundland and Labrador, DFO Quebec, DFO Maritimes and a number of stocks assessed by the Scientific Council (SC) of NAFO.

2.0 SCIENCE INVESTMENTS

2.1 Summary of Investments

The total annual Canadian fisheries science investment in NL in 2013-14 was just over $43M. The largest component was from DFO, but there were significant contributions from others as well. There was an additional $3-4M invested by other countries on an annual basis on NAFO related work. This brought the total investment for 2013-2014 to ~ $47M.

Exhibit 2.1: Estimate of annual Canadian science investments (2013/14).

	DFO-NL	DFO-QC	DFO-Mar	CFER	CSAR	FFAW	GEAC/CAPP	Total
Salaries/wages	13,686,500	2,016,500		1,467,700	375,000			17,545,700
Operating	5,580,400	560,000		233,300				6,373,700
Vessel Costs	9,102,100	877,000		1,327,200				11,306,300
Cash contribution					560,000	315,400	1,870,000	2,745,400
In-kind contribution					265,000	626,000		891,000
Fish Allocation						2,019,000	750,000	2,769,000
DFA						358,200		358,200
Other (Grants, etc.)				613,400		228,700		842,100
Estimated			500,000					500,000
Total	$ 28,369,000	$ 3,453,500	$ 500,000	$ 3,641,600	$ 1,200,000	$ 3,547,300	$ 2,620,000	$ 43,331,400

Note: Fish Allocation represents value of 'Use of Fish'

The delivery of fisheries science in Newfoundland and Labrador is the mandate of the federal Department of Fisheries and Oceans (DFO). These science activities are completed by DFO's Newfoundland and Labrador Region in Subareas 2+3 and for some species in Division 4R, in the Quebec Region for the remaining species in Division 4R as well as Mackerel in Subareas 3 and 4, and in the Maritimes Region for some research.

The Province of Newfoundland and Labrador has also made a substantial contribution to science specifically since 2010, with a significant investment to create the Centre for Fisheries Ecosystem Research (CFER) within the Fisheries and Marine Institute (MI) in St. John's. The MI also houses the Centre for Sustainable Aquatic Research (CSAR), which makes an annual contribution to fisheries biology/stock assessment/ecosystem type research. The provincial contribution also includes investments made through the Fisheries Research Grant Program since 2006.

Industry associations also contribute to science conducted in the province with the Fish Food and Allied Workers Union (FFAW), Groundfish Enterprise Allocation Council (GEAC) and Northern Shrimp Research Foundation (NSRF) collaborating with DFO and CFER on a variety of science projects.

Foreign countries participate in research both in and outside the Canadian Exclusive Economic Zone (EEZ). The estimated value of these research activities is $3-4 M annually. At the low end of the range, the only current at-sea work would be the ongoing EU-Spanish trawl survey in 3LMNO, and at the high end, additional at-sea work such as mesh selection studies and/or some ecosystem survey work would also be included. The estimated total expenditures would cover survey and vessel costs, scientific observers on fishing vessels, research projects, salaries, and meeting/travel expenses.

Funding from 'Use of Fish': Until 2006, some fish surveys and other science activities were funded, in part, by allocations of fish quotas, commonly referred to as 'Use of Fish'. DFO allocated these quotas to industry participants in exchange for their contribution to research costs including science data collection and analysis. These collaborative arrangements were governed by joint project agreements (JPA's). The Federal Court of Appeal decision in *Larocque* (June 2006) and the Federal Court of Canada (Trial Division) decision related to the Association des Pêcheurs de Poissons de Fond de l'Acadie (APPFA) (October 2006) put an end to the collaborative practice of "use of fish". The two court decisions determined that the Minister (DFO) did not have the authority to engage in such activities.

In 2012, the *Fisheries Act* was amended to provide the DFO Minister with the necessary authority to allocate fish for the purpose of financing a science or fisheries management activity that contributes to the proper management and control of fisheries. DFO is now in the process of developing a national policy framework that will provide transparent process to guide the application of this authority. Some of the funding contributions shown below have come from the allocation of fisheries resources.

2.2 Fish, Food and Allied Workers (FFAW) Investments

The Fishermen's union in NL was first certified by the Provincial Labour Relations Board in 1971. In 1991,the NL government passed the Fishing Industry Collective Bargaining Act, giving inshore fish harvesters the right to bargain for the price of fish. Today, the Fish Food and Allied Workers (FFAW) union represent ~12,000 individuals throughout NL, most of whom are employed in the fish processing and harvesting sectors of industry.

The FFAW became involved in fisheries science in 1994 and since that time have developed research capacity internally under its Science Program. Under this program the union and harvesters contribute to scientific research on almost all commercially harvested species in NL. There has been over 50 fisheries science projects (some of these are included in Appendix V) developed and managed in the last five years related to: Atlantic cod, snow crab, capelin, Atlantic halibut, lumpfish, lobster, seals, shrimp, Greenland halibut, mackerel, and herring. The FFAW's current science projects include:

- DFO/Industry collaborative post-season trap surveys for snow crab.
- Cod sentinel survey (2J3KL3Ps using gillnet and longline)
- Cod mobile sentinel survey (4R using small otter trawlers)
- Lobster science program (volunteer logbooks and an at-sea sampling program)
- Tagging programs (2J3KL and 4R cod inshore, 4RST Atlantic Halibut).
- Various Telephone surveys / questionnaires.

One example of collaborative success: One of the flagship science projects in which the FFAW participates is the DFO/Industry post season crab survey in Divisions 2J3KLOPs4R. Prior to 2003, the primary index of abundance for the assessment was the fall DFO multi-species trawl survey. At the time, industry supported development of a dedicated trap survey, utilizing commercial and modified traps, to improve scientific accuracy and management of the resource.

Through consultations between DFO and the FFAW protocols for a collaborative post-season trap survey were developed and implemented in 2003. Currently, the annual survey is conducted after commercial fishing has ceased. The survey now has an 11 year time series and provides a valuable index of abundance which, since 2008, has been fully integrated into the scientific assessment.

The development and implementation of the survey demonstrates the capability of industry to partner with DFO both in scientific data collection and the assessment process. This successful partnership in management of the resource has resulted in industry stakeholders taking on the role of stewards of the snow crab stock.

The FFAW objectives for the survey include:

- To implement a scientifically sound post-season survey of Crab Management Areas (CMAs) in NAFO divisions 2J, 3K, 3L, 3N, 3O, Sub-Division 3P and 4R.
- Work in consultation with DFO on the design of the annual survey.
- To ensure industry vessels and harvesters are utilized in completing the survey.
- To use the results of the snow crab survey in developing a biomass index for each crab management area.
- To have the analysis of the data fully integrated into the stock assessment and regional assessment processes.

Since the beginning of the collaborative survey, approximately 1,000 snow crab harvesters have participated in data collection. Sampling is carried out at approximately 1,500 stations each year, covering all crab management areas.

Investments: A summary of the value for FFAW projects completed or underway for 2014, including DFO contributions included above, is as follows:

Exhibit 2.2: FFAW projects (2014)

Funding Source	Amount
FFAW Cash	315,400
FFAW In-Kind	626,000
DFA	358,200
DFO	1,644,000
Use of Fish[1]	2,019,000
Other[2]	228,700
Total	$5,191,300

Note: 1) Value of 'Use of Fish'
2) Including National Science and Engineering Research Council of Canada (NSERC) grants

2.3 The Offshore Sector Investments

The offshore fishing sector is comprised of an offshore groundfish sector as well as an offshore shrimp sector. The groundfish sector is represented by the Groundfish Enterprise Allocation Council (GEAC) with the shrimp sector represented by the Canadian Association of Prawn Producers (CAPP) and the Northern Coalition.

Offshore groundfish investments: In the 1980's, the offshore groundfish sector landed up to 350,000 MT of groundfish annually, with a market value of more than $500 M. License holders utilized more than 150 vessels that supplied fresh fish for processing at dozens of fish processing plants located across all five provinces in the Atlantic region. Today, the offshore groundfish sector has a value of ~$50 M across all Atlantic Canada; only ~10% of the value achieved in the 1980's.

Offshore groundfish license holders continue to invest in vessels, on-shore processing facilities, and in groundfish related scientific research in the region. Initiatives undertaken to facilitate the rebuilding of the groundfish stocks include:

- Undertaking focused scientific research with the objective of enhancing the collective understanding of the groundfish resources and their environment.
- Embracing conservationist resource management measures and fishing methods.
- Improving the design and selectivity of fishing gear.
- Adopting a cooperative conservation and management approach with government and like-minded fishing organizations.

In 1997, GEAC was established to represent offshore groundfish fishing enterprises in Atlantic Canada. GEAC, and member companies, have participated in scientific research for some time. An example of both company-funded and GEAC sponsored surveys include:

- Yellowtail flounder grid surveys on the Grand Banks (completed)
- Groundfish stratified random surveys in 3Ps (completed)
- Redfish surveys in Units 1 and 2. The Unit 2 redfish survey has been ongoing

since 1997 and continues today. Initially this survey was conducted annually, however it is now conducted every two years.

In addition to participating in joint industry/DFO resource surveys, GEAC and member companies also participate in a number of other science projects (Appendix VI).

Offshore shrimp investments: The northern shrimp fishery began in the early 1970's when an exploratory fishing program confirmed the presence of shrimp stocks in the waters stretching southward from Baffin Island to the northeast coast of Newfoundland. Between 1978 and 1991, 17 offshore licences were introduced and quotas established using an Enterprise Allocation regime. Landings increased in the 1990's and peaked at 185,974 MT in 2007 and have declined since that time. NL inshore enterprises in 2J3KL4R were granted access to resources in 1997 which led to expansion of onshore shrimp processing facilities.

CAPP is a national organization created by licensed at-sea producers of coldwater shrimp. CAPP represents the interests of these companies, with a particular focus on the sustainable and responsible management of the coldwater shrimp resource. CAPP also supports research devoted to the cold-water shrimp resource, nutrition and health benefits of coldwater shrimp, and conducts promotional activities in international markets including Russia and China.

The Northern Coalition was established in 1996 to protect existing shrimp allocations for its member groups. This organization is comprised of six community based groups representing over 20,000 Aboriginal Inuit and Metis people located in remote northern communities. All members of the Northern Coalition are offshore license holders.

CAPP and the Northern Coalition worked together to form the Northern Shrimp Research Foundation (NSRF) which was founded in 2002. The NSRF is responsible for managing allocations of shrimp that were established under the use of fish program to contribute to the science of this valuable resource. The NSRF in collaboration with DFO, participates in the development and execution of an annual shrimp survey in SFA 4. The NSRF are also involved in shrimp ageing and stock assessment model development projects. Current projects in which the offshore shrimp sector is involved are described, and associated costs provided, in Appendix VI.

A summary of anticipated costs for all GEAC/NSRF projects in the current year are provided:

Exhibit 2.3: Offshore groundfish and shrimp investments (2014)

Funding Source	**Amount**
GEAC/NSRF Cash	1,870,000
Use of Fish	750,000
Total	$2,620,000

2.4 CFER/MI Investments

Background: In July, 2010 the province of Newfoundland and Labrador announced the establishment of the Centre for Fisheries and Ecosystems Research (CFER) to be included as part of Memorial University of Newfoundland and Labrador's Fisheries and Marine Institute. The provincial government provided $11.75 M to establish CFER for five years. This funding provided $6.5 M for human resources and operating costs as well as $5.25 M to be used to charter a large offshore research vessel. In April 2014 the province allocated an additional $3.35 M to maintain CFER activities through to the spring of 2016. Initially CFER employed 14 staff, including fisheries scientists, technicians and support staff. Today CFER has 6 research scientists, 5 research and technical personal, 2 administrative positions as well as 4 post-doctoral fellows and 19 graduate students.

SCIENCE GAP: Funding for CFER, including operations and large offshore vessel charter beyond spring 2016 has not yet been identified.

Mandate and programs: The goal of CFER is to better understand fish stocks and the productivity of the NL marine ecosystem through fisheries research. Specifically, CFER's mandate is to:

- Focus research on NL fisheries and the sustainability of stocks.
- Offer research and training opportunities to graduate students both locally and internationally.
- Collaborate with the Department of Fisheries and Aquaculture and DFO regarding scientific research activities and fisheries management.
- Collaborate with other researchers and institutions within Canada and abroad.

Research vessels: Vital to advancing scientific methodologies are access to state-of-the-art fishing platforms. CFER utilizes two research vessels to conduct at sea research activities. The vessels are the RV Gecho II, which is a CFER owned small inshore vessel, and the RV Celtic Explorer, which is a large offshore research vessel chartered by CFER.

The RV GECHO II is a 10 meter fisheries research vessel, designed for work in the coastal waters off NL. This vessel enables research in coastal bays with unique inshore spawning and nursery habitats. It also enables the province to better monitor inshore and offshore species migration. The vessel is specifically equipped for surveying fish with two scientific echo-sounders that are capable of detecting and measuring marine life from plankton to large fish.

The RV Celtic Explorer is a 65.5 meter fisheries research vessel capable of conducting offshore acoustic and bottom trawl surveys as well as oceanographic work year-round in offshore areas. The vessel accommodates 35 personnel including 16 to 18 scientific staff. The current charter arrangement covers a 36 day period in late-winter. Offshore acoustic surveys have been conducted annually since the first charter in 2011. This vessel also participates in many other projects initiated by CFER scientists and in collaboration with other scientists from MUN and DFO. The vessel is fitted with the latest electronics and scientific equipment, including scientific echo-sounders, ocean mapping technologies, mid-water and bottom trawling capability and dry and wet laboratory space.

CFER's current activity: Since its creation in 2010, CFER has rapidly grown to fulfill its mandate. The Centre is now attracting post-doctoral fellows and post-graduate students to assist in completing complex scientific studies. In 2014 CFER scientists were involved in 41 separate research projects, many in collaborative. The nature of these projects includes 20 collaborations with DFO, and other collaborations with industry (9), international institutions (8) and other Canadian universities (6).

This work is related to improvements in stock assessment modeling, species biology and distribution, ecosystem considerations as well as other projects of interest to the fishing industry in NL. A sample of some of these projects includes:

- Satellite tagging of cod to study migration, stock structure, fish behavior and survey impact.
- Northern cod acoustic-trawl spawning surveys, methods and design.
- Implementation of a Gulf-wide conventional tagging survey to estimate exploitation rate in the 4RST halibut stock.
- Spatial analysis of demersal fish communities to support ecosystem based management.

While CFER had an initial focus on projects related to cod, they are now working on projects that cover a number of other fish species on the Newfoundland Shelf, including: American Plaice, Atlantic halibut, shrimp, snow crab, capelin, herring, lobster and haddock.

CFER scientists have completed or are currently working on projects related to stock assessment modeling techniques. There is currently a project related to the development of an improved, state-of-the-art stock assessment model for 3LNO American plaice as well as some other assessment related projects. For these types of projects it would be beneficial to include DFO stock assessment researchers as collaborators.

SCIENCE GAP: There does not appear to be sufficient collaboration between CFER and DFO scientists respecting projects related to stock assessment techniques /modeling.

A summary of costs for CFER projects and operations is provided in the following exhibit. A brief description of the 41 current CFER projects is provided in Appendix IV.

Exhibit 2.4: CFER science investments

Funding Source	Amount
Staff Costs (Provincial funding)	1,267,100
Staff Costs (MUN funding)	200,600
Operations (Provincial funding)	233,300
Vessel Charter[1] (Provincial funding)	1,327,200
Grant Expenditures[2]	613,400
Total	$3,641,600

Note: 1) Vessel charter is 36 days including 7 days transit
2) From Research and Development Corporation (RDC) and NSERC. Includes student and post-doc stipends as well as material and supplies and travel.

2.5 Centre for Sustainable Aquatic Resources (CSAR)

The Centre for Sustainable Aquatic Resources (CSAR) promotes the sustainable development of the aquatic resources through collaborative industrial research and development, technology transfer and education services to the fishing industry. CSAR does this through a number of initiatives:

- **Fishing gear design and testing**: The development of fishing gear for the commercial fishing industry has changed dramatically over the last few decades. Driven by the need for species and size selectivity, bycatch restrictions, reducing environmental impact of gear and improving vessel fuel efficiency, CSAR provides design and testing of advanced fishing gears.

- **Biological resource assessments**: CSAR staff conducted several biological resource assessments for under-utilized species. Working with industry and government, research staff have developed offshore sampling surveys, documented biological and morphological characteristics for species of interest, mapped population distributions and habitat preferences and provided scientific advice for sustainable exploitation. Recent species include Atlantic hagfish, orange-footed sea cucumber and toad crab.

- **Fisheries development:** CSAR researchers participate in development of new fisheries and improvements in existing fisheries. This may involve investigating the commercial viability through economic, biological and operational analysis of non-traditional fishing grounds and/or species.

- **Fish behaviour:** Several factors are known to affect fish behaviour in relation to fishing gear. These include factors intrinsic to the animal, related to the environment, as well as aspects related to the fishing gear itself.

  Using underwater cameras and acoustics, CSAR staff examines the behaviour of finfish and shellfish species in relation to fishing gear under both field and laboratory conditions. The resulting video and data are then used to not just describe behaviour, but also seek functional explanations for the patterns of behaviour observed.

- **Hydrodynamic testing**: The flume tank is an ideal test facility for evaluating the hydrodynamic performance of various structures and devices. Recent examples include seismic vanes, oil and gas structures, hull designs, underwater intervention devices, AUV's, ROV's, gliders, and marine turbines.

- **Support for sustainability certifications:** In addition, CSAR has been assisting industry in meeting their condition of fisheries certification requirements, particularly for northern shrimp. Additionally they are involved in work on Aquatic Invasive species respecting green crab.

Specific areas of CSAR research conducted in fiscal year 2014/15 included:

- Fishing gear design and evaluation - work on developing and testing a semi-pelagic shrimp trawl system.

- Fisheries development - Projects have included trap design and selectivity analysis for Atlantic hagfish, winter longline fishery for Greenland halibut on Baffin Island, and niche market development for pot-caught cod on Fogo Island.

- Biological resource assessments for underutilized species. Recent species include: hagfish, orange-footed sea cucumber and toad crab.

- Fish capture behaviour - Recent research included factors intrinsic to the animal (e.g., species, size, condition, sex, experience, hunger), factors related to the environment (e.g., water temperature, depth, ambient light intensity, bottom currents, substrate type), as well as aspects related to the fishing gear itself (e.g., rigging and operation). One such study involving CSAR published in 2014 was on density-dependent catchability of prawns observed using underwater video.

- Survey trawl standardization - CSAR has provided DFO Science with continuing expertise in building, measuring, testing, and maintaining its standard survey trawls and related equipment, which is a vital element of DFO's resource surveys.

CSAR Financial Summary: Salary costs for CSAR are ~ $1.1 M for 12 full-time staff and four graduate students. In 2013-14, the Centre completed 34 science-related projects with a total value of $3.6 M, including salaries.

Given the nature of CSAR work, it is difficult to attribute all projects completed as fisheries science related as many projects are technology based initiatives. After examination of CSAR projects it was determined that 30-40% of the work, $1.0-$1.4 M, is NL based fisheries science (biology/assessment/ecosystem) related.

Exhibit 2.5: Estimated CSAR science investments

Funding Source	Amount
Staff Costs	$375,000
Project Financing (Cash)	$560,000
In-kind contributions	$265,000
Total	$1,200,000

2.6 Department and Fisheries & Oceans (NL and Quebec)

DFO is the federal ministry responsible for managing Canada's fishery resources. Operations are delivered across Canada through DFO's six administrative regions:

- The Newfoundland and Labrador Region
- The Quebec Region
- The Gulf Region
- The Maritimes Region
- The Central and Arctic Region
- The Pacific Region

Three of these DFO regions, NL, Quebec and Maritimes, participate in management and science activities for resources adjacent to NL. The NL Region provides most DFO services in NL; however, the Quebec Regions provides some of the science-based work on the West Coast of Newfoundland in Division 4R. DFO Maritimes is also involved in a few specific cases (e.g. hydrographic/oceanographic research on CCG Hudson in NL area as well as the Atlantic halibut assessment for 3NOPs4VWX5Zc).

2.6.1 DFO - Newfoundland and Labrador Region

The NL Region encompasses over 29,000 kilometers of coastline and a continental shelf of 2.5 million square kilometers. The region has responsibilities in the Gulf of St. Lawrence and includes three international boundaries including the Northwest Atlantic Fisheries Organization (NAFO) Regulatory Area, St. Pierre and Miquelon (France) and Greenland. The region covers an area from near-shore to the Flemish Cap, 320 NM offshore.

The science sector in NL delivers programs through three divisions, including:

- **Aquatic resources division:** This division is responsible for resource assessment research surveys, sampling programs, industry science programs, the sentinel survey, aquaculture research and regulatory advice provisions, species at risk assessment and research and the completion of resource assessments for the provision of domestic and international (NAFO) advice on resource status.

- **Environmental sciences division:** This division is responsible for ecosystem research, productivity research, and anthropogenic effects on aquatic resources including impacts of seismic, aquatic invasive species, benthic ecology, monitoring and reporting on ocean climate conditions in NL.

- **Canadian hydrographic services division:** This division conducts hydrographic surveys, monitors tides and water levels in specific areas, and produces nautical charts.

A list of related activities for the three divisions is provided in Appendix VII.

DFO Science in the NL Region is involved in many collaborative projects (Appendix VIII) with industry, CFER and other academia. Some of these projects include:

- **Post season crab survey:** Collaboration with the FFAW using a Section 10 (use of fish allocation) resource allocation and Fisheries Science Collaborative Program (FSCP) funding.

- **Northern shrimp research foundation survey**: Shrimp fishing area 4, using a Section 10 resource allocation.

- **Torngat Joint Fisheries Board collaborative project:** Satellite tracking of ringed seals in Lake Melville region.

- **Environmental Studies Research Fund (ESRF):** Administered by Natural Resources Canada.

- **Environmental monitoring:** Development, validation and implementation of an operational ocean forecasting system for the Grand Bank and Orphan Basin for daily operational delivery at the Canadian Meteorological Centre.

Scientific investments: Research vessel (RV) surveys are a large component of the work conducted by DFO in NL. There were 526 sea days utilized in 2013/14 at a vessel cost of $9.102 M and scientific staff cost of $1.159 M for total survey costs of $10.261 M.

Exhibit 2.6: DFO NL region survey costs

Vessel	Vessel Length (m)	Survey Days	Scientific Purpose	Amount
Hudson	90.4	24	Hydrographic surveys	933,783
Needler	50.3	188	Offshore trawl surveys	3,617,803
Teleost	63	147	Offshore acoustic/trawl surveys	3,537,309
Vladykov	25	167	Various Inshore Surveys	1,013,210
Total		526		$9,102,105

Vessel capabilities: The hydrographic vessel Hudson was built in 1963 while the Needler and the Teleost were built in the 1980's. All three of these vessels are now scheduled for replacement. The Vladykov, the newest vessel in the CCG-NL science fleet, was built in 2012.

The vessel schedules related to fisheries scientific research remains similar year to year.

Sea-days related to resource assessments in in the range of 350 to 375 days/year, including a combination of multi-species (215 days) and single species surveys. The remaining ~150 days are utilized for oceanographic studies, ecosystem and aquaculture research and tagging programs.

The expenditure for DFO-NL Science during 2013/14 was $28,369,000. Of this amount approximately 72% is expended in the Aquatic Resources Division, which is responsible for data collection and stock assessments.

2.6.2 DFO – Quebec Region

The DFO Quebec region encompasses more than 6,000 km of coastline running along the St. Lawrence River, the estuary and part of the Gulf of St. Lawrence as well as Nunavik (Ungava Bay, eastern James Bay, eastern Hudson Bay and the southern part of Hudson Strait).

Quebec Regional activities are divided into five major programs, Fisheries Management, Coast Guard, Science, Small Craft Harbours and Ecosystems Management. The Regional Science Branch is located at the Maurice Lamontagne Institute in Mont-Joli. Research, monitoring and assessments are conducted, among other things, in relation to fisheries, marine mammals, oceanography, and habitats of the Estuary and Gulf of St. Lawrence and Northern Quebec.

With respect to Newfoundland and Labrador interests, the Quebec Region Science Branch conducts stock assessments on the following fishery resources:

- Cod in 3Pn4RS
- Greenland halibut in 4RST
- Atlantic halibut in 4RST
- Unit 1 Redfish
- Shrimp in the Esquiman Channel
- Capelin in 4RST
- Herring in 4R
- Mackerel in Subareas 3+4

For these stocks the Quebec Region completed the following tasks:

- Sampling and data acquisition & research
- Stock assessment and data treatment
- Data management and administrative support
- CSAS and advice production

The total cost associated with this work for fiscal year 2013/14 was $3,456,500.

2.6.3 DFO – Maritimes Region

DFO Maritimes Region, based in Dartmouth, N.S. and home to DFO's Bedford Institute of Oceanography (BIO), conducts some fisheries-related research in the NL area. This includes a commercial-based longline survey for Atlantic halibut, oceanographic research, and ecosystem-based research mainly in the NAFO Regulatory Area (e.g. on Orphan Knoll, Sackville Spur, and Flemish Cap areas). The cost of the latter can vary quite a bit between years, depending mainly on program time allotted on the RV Hudson, with total costs in some years likely in excess of $1 M. A figure of $0.5 M likely represents a reasonable annual minimum for recent years, and is the value used in the summary here.

Exhibit 2.7: DFO science investments (2013-14)

Expenditure Account	NL Region	Quebec Region	Mar. Region	DFO Total
Salary and wages	13,686,500	2,016,500		15,703,000
Operating costs	5,580,400	563,000		6,143,400
Vessel Costs	9,103,100	877,000		9,980,100
Estimated			500,000	500,000
Total	$28,369,000	$3,456,500	$500,000	$32,325,500

2.7 Department of Fisheries and Aquaculture Investments

In 2005, the Canada-NL Action Team for cod recovery published a report entitled "A Strategy for the Recovery and Management of Cod Stocks in Newfoundland and Labrador: A Federal-Provincial Approach". The report considered factors affecting rebuilding, detailed specific goals and objectives toward rebuilding, and discussed management strategies and research priorities.

In response to the report, in 2006 the Government of Newfoundland and Labrador announced an annual budget of $300,000 for cod recovery initiatives to be administered by the Department of Fisheries and Aquaculture (DFA). The Cod Recovery Program was developed to fund research initiatives that enhance understanding of the NL adjacent cod stocks and thus promote sustainable management. In 2008, the annual budget was increased to $450,000 and in 2014 it was reduced to $300,000.

Through this initiative, a number of projects have been approved and 45 collaborations have been initiated, with approximately $3.3 million in funding provided to date. This is in addition to funding provided to implement and support CFER. Funding has primarily been provided for research focusing on the province's cod stocks. However, recognizing the importance of other key fish stocks to the province's fishing industry, the initiative recently expanded to include research on other commercially harvested species and is now referred to as the Fisheries Research Grant Program.

From 2006 to the present there have been contributions made to scientific institutions and industry associations through this program. The participants and related number of projects since 2006 are provided in the following exhibit.

Exhibit 2.8: Fisheries research grant program sponsored projects

Institution	# of projects
DFA - Wilfred Templeman Scholarship fund	1
Marine Institute (pre-CFER)	11
Marine Institute – CFER	3
Marine Institute – CSAS	1
Marine Institute - CCFI	1
Memorial University	3
DFO -Science	5
FFAW	10
Association of Seafood Producers	1
Northern Shrimp Research Foundation	2
GEAC	1
Icewater Seafoods	1
Other groups/academia	5
Total	45

For 2013-14 there was just over $440,000 expended on 17 initiatives. Some of these initiatives included:

- The purchase of pop-up tags to be used in a CFER project related to satellite tagging of Atlantic cod.
- The stock assessment of the 3Ps hagfish fishery conducted by CSAR. This project was conducted during 2012-13, 2013-14 and 2014-15.
- Studying the abundance and life history of haddock in waters on the south coast of Newfoundland and Labrador.
- Contributions to cod studies in 4RS3Pn (cod condition, tagging and reproductive potential) and 2J3KL (cod tagging).
- DFA Fisheries Scholarship and Dr. Wilfred Templeman Memorial Scholarship annually since 2008-09and 2009-10 respectively.

A full summary of projects from 2010/11 to 2014/15 with related details is included in Appendix XI.

2.8 Non-Canadian Investments

There are many other nations which contribute in some manner to scientific research in the NL area through collaborative approaches. Several of these nations participate indirectly through their role in NAFO, whereas others such as France and the EU contribute directly to research activities.

Though financial information from these nations was requested, it was not fully available in all cases. . Qualitative financial information is provided based on estimated charter rates and participatory costs for NAFO collaboration.

2.8.1 Participating NAFO Countries.

A number of countries have conducted extensive fisheries research in the NL area. In the 1950's and 60's, scouting and research vessels from the former USSR contributed knowledge and information regarding the distribution and abundance of fish stocks both adjacent to NL and in the rest of the Northwest Atlantic. These initiatives resulted in the development of standardized research surveys by USSR/Russian vessels, which continued until the early 1990's, the results of which were used regularly in the assessment of numerous NAFO stocks. Other countries with some history of fisheries research or surveys off NL include the former West and East Germany, some other former East-bloc nations, Japan, and Denmark/Faroes. These countries, or their successors, are generally not active in at-sea fisheries research off NL at present, but those with NAFO fisheries contribute data and scientists to NAFO SC. Scientists from many countries , such as Russia, Norway, USA, and Iceland regularly participate in and sometimes chair NAFO SC meetings, where the NL Region's Grand Banks (straddling) stocks are assessed, and other related fisheries science research is peer reviewed. Many scientists from various NAFO countries collaborate with Canadian scientists on analysis of fishery and survey data for stock assessments and biological studies for these stocks.

Given the sporadic nature of fisheries research efforts by the countries described above, it is not possible to quantify annual expenditures. Assuming typical rates for vessel charters, and the extensive at-sea work carried out occasionally on focused projects, the estimated costs in recent years ranged from $0.3-$1.0 M, depending on how observer costs, participation of scientists in NAFO work, etc. are accounted for.

2.8.2 Contributing Country - France.

The French national agency responsible for fishery and oceans research is Institut français de recherche pour l'exploitation de la mer (IFREMER), or Research Institute for Exploitation of the Sea. It has an annual budget of about 200 M euros and employees 1,600 employees worldwide. IFREMER supports four major centres in France and one in French Polynesia, along with 26 sites spread along the coastline of France and in French overseas regions, including one in St. Pierre and Miquelon (SPM), the French territory off the south coast of Newfoundland (3Ps area). IFREMER has a fleet of eight research vessels (including four ocean-going ships), one manned submarine, a remotely-operated vehicle for deep sea explorations and two autonomous underwater vehicles. These vessels are not currently used in the NL area.

The IFREMER centre in SPM typically has one or two fisheries researchers that conduct work on stocks and species of interest to the French harvesters there. In the past, France conducted large scale surveys throughout the NL area, but in recent years has focused on specific work in the SPM and the associated French EEZ area. A recent example is the scallop survey in 3Ps conducted in 2011, using the SPM chartered fishing vessel Marcel Angie.

Canada and France have a formal agreement dating to 1994 for shared management of several species/stocks in the 3Ps area. There is considerable cooperation among French and Canadian scientists in research and assessment of these stocks, such as 3Ps cod and scallops. Scientists from each country are invited to participate in each other's surveys, and French scientists attend the Canadian Stock Assessment Secretariat (CSAS) and NAFO SC assessment meetings for the NL stocks. In addition, they collaborate on a variety of studies, including age reading of cod, trawl and dredge surveys, and grey seal diets and movements in the SPM area. Total value of the French fisheries science annual efforts in the NL area (primarily 3Ps), is estimated to be $250,000 CAD including at least some survey work such as the 2011 scallop survey, salaries, research projects, and meeting/travel costs.

2.8.3 Contributing Nations - EU

The European Union (EU) through its Directorate-General for Maritime Affairs and Fisheries (DG MARE) contributes substantial funding to EU-member states for fisheries research in the NL area, primarily in the NAFO Regulatory Area (NRA). This includes funding for some scientists based in EU countries to attend NAFO meetings. In addition, EU countries, such as Spain, Portugal, and Germany contribute to fisheries/ecosystem research and stock assessment in the NRA, through funding provided by national governments to various Spanish and Portuguese research institutes, such as the Spanish Institute of Oceanography.

There is a large scale multidisciplinary RV survey, financed by EU and Spain, conducted annually in the NRA (Grand Banks and Flemish Cap, 3LMNO). In 2013, about 400 stations were surveyed in the period from June 1 to August 19 (NAFO SCS Doc 14/06). The results of these surveys, including biomass indices, biological data, oceanographic information, etc. are presented annually to NAFO SC by scientists from EU, and are used in the assessments of numerous stocks such as Greenland halibut in 2+3KLMNO, cod and flatfish in 3LNO, and redfish and cod in 3M.

A unique survey took place over several months in both 2009 and 2010 in the NRA in 3MNO, carried-out by the state of the art Spanish RV Miguel de Oliver. This survey used an assortment of tools (e.g. multi-beam acoustics, seabed corers and grabs, ROVs) to collect detailed and precise information on the sea floor depths and structure, and benthic organisms. Canadian and other international scientists participated in this survey, and the RV Hudson was also used in Canadian waters to collect some related data. The project, known as NEREIDA (NAFO PotEntial VulneRable Marine Ecosystems-Impacts of Deep-seA Fisheries) focused on improving knowledge of the vulnerable habitats and ecosystems as well as the definition and delimitation of areas candidates to protect in the NRA. The data have been instrumental in the work NAFO has done to protect vulnerable marine ecosystems, and funding for the analysis of samples and data collected on these cruises is still ongoing through 2014.

Other initiatives, including collaborations, funded through EU and/or its member state governments include a joint Spain-Canada research project on the reproductive potential of the 2+3KLMNO Greenland halibut stock, studies on the Flemish Cap ecosystem, and placement of scientific observers on some EU fishing vessels in the NRA.

In total, annual expenditures for fisheries science by EU countries in the NRA (including

Grand Banks and Flemish Cap) are estimated to be $2.0-$3.5M CAD, which includes the cost of the annual 3LMNO RV trawl survey. In 2009-10, when the NEREIDA surveys were being conducted, this total was likely doubled. Some of this funding would be from EU sources directly, while the remainder would come from the governments of EU member states.

Exhibit 2.9: Estimated research expenditures in NL – Other jurisdictions

	Estimated Range of Cost[3]			
Country	**Lower**	**Higher**	**Mid-point**	**Program**
France-SPM	200,000	300,000	250,000	Research lab in SPM, surveys in 3Ps, NAFO participation
EU[1]	2,000,000	3,500,000	2,750,000	Surveys & observers in the NRA, NAFO participation
Other NAFO[2]	300,000	1,000,000	650,000	Occasional Research, NAFO participation
Total estimate	$2,500,000	$4,800,000	$3,650,000	

Notes: 1) Does not include NEREIDA surveys
2) Russia, Norway, Iceland
3) These are estimated values based on known costs for conducting similar research.

3.0 BEST PRACTICES

3.1 Introduction

The following section provides a synopsis of current practices from the jurisdictions reviewed. The information is intended to provide some comparisons with the fisheries research and stock assessments conducted in the NL Region. There have been deficiencies identified in some of these practices, and methods to improve assessment models continue to be reviewed, tested and implemented. Significant developments in fisheries scientific research and stock assessment in particular include the calculation of reference points and the evaluation of stocks against these, as well as more focus on using additional parameters in modeling to account for ecosystem impacts on fish stocks (e.g. predation).

Exhibit 3.1: Current and prospective practices by jurisdiction for major fisheries

Jurisdiction/ area	Main species	Fishery Landed value[2]	RV for Science[3]	Comments on fish stock assessments
USA/New England	Lobster scallop	$1.19B	2	VPA type cod stock assessments. Maintains toolbox of methods.
Norway	Pelagics cod	$1.86B	8	VPA type cod stock assessments.
Iceland	Cod groundfish	$1.23B	2	VPA type cod stock assessments.
New Zealand[1]	Lobster hoki	$0.47B	2	VPA type assessments. Develops assessment software.
Canada/NL	Crab Shrimp Groundfish	$0.60B	3	Variety of methods – VPA, surplus production, XSA, etc. No VPA/catch at age data in most cod assessments

[1] based on export value of $ 0.94 billion
[2] value in $US
[3] RVs funded/used primarily by jurisdiction. Excludes charters, etc.

Recent undertakings in stock assessments: In July 2013, the World Conference on Stock Assessment Methods (WCSAM) was held in Boston, USA. This was a contribution to the Strategic Initiative on Stock Assessment Methods within the International Council for the Exploration of the Sea (ICES), a global organization that develops science and advice to support the sustainable use of the oceans. Many of the world's leading stock assessment experts attended to discuss and test stock assessment methods. The conference, which also consisted of a two-day workshop phase, examined application and future of stock assessment methods, and "considered single stock approaches for data rich and poor stocks, and also multispecies and ecosystem based approaches". This conference provided the most comprehensive report of fisheries stock assessment methods in some time.

Three major recommendations as a result of this conference are:

- Substantial coordinated strategic investment is needed to support stock assessment research. Most strategic research should be conducted regionally (e.g., within Regional Fishery Management Organizations) to meet objectives that vary among regions. Global initiatives are required to help with sharing information and tools to promote parallel advancement of effective methods. This investment should not only focus on "traditional single species stock assessment" but also consider the dynamics of fish populations and fisheries through space and the linkages with management needs for the ecosystem approach.

- WCSAM proposed that 'good practice' guidelines be developed. The most researched case studies should be used to provide initial guidance on good practices. At the same time, research should be expanded to represent other species/taxa, size or stage-based approaches, and data-limited together with data-poor situations, as well as other management systems.

- A multi-organizational Global Assessment Methods Working Group for Sustainable Fisheries (GAME) should be formed. This will provide a forum to bring regions together to compare developing methods and test new ideas. It will also be able to lobby for investment in research into stock assessment methods.

Subsequent to the World Conference, ICES has followed up on some of the work conducted there, mainly through its Working Group on Methods of Fish Stock Assessment. Among the tasks carried out and planned for future meetings of this WG are to:

- Review and advise on methods for the evaluation of selected harvest control rules using management strategy evaluation.
- Develop and test methods to deal with inaccuracies in catch data used in stock assessments.
- Improve methods to estimate reference points.
- Evaluate the performance of data-limited stock assessment methods.
- Conclude the evaluation of alternative catch-at-age based assessment methods for identified stocks.

This ICES conference provides the best summary of current stock assessment methods globally. Although this is not actual guidance on best practices in stock assessment, it does give some perspective on current thinking on methodologies by one of the leading scientific fisheries bodies. It is also interesting to observe that this ICES WG noted the current (new) methods of fish stock assessment have not been documented in a textbook, and that this would be a worthwhile exercise. Future work of ICES should be monitored for progress on developing stock assessment methods and related documentation, including any additional workshops that may occur.

Fisheries Research in other jurisdictions: Examination of current and emerging methods of fisheries research and stock assessment in other jurisdictions is summarized. A summary of fishery information in each jurisdiction is provided in order to provide the context for how the fisheries are assessed and managed, as well as some information on the fisheries science activities. Material was obtained from public information and clarification provided, as necessary, by scientists or managers within the jurisdictions. Detailed information pertaining to stock assessment in each jurisdiction, with a focus on key cod stocks where possible, is contained in Appendix X.

3.2 USA National bodies - NOAA and NMFS

In the USA, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) created eight regional fishery management councils responsible for the fisheries that require conservation and management in their region. The councils are composed of members representing commercial and recreational fishing sectors, in addition to environmental, academic, and government interests.

Under the MSA, councils are required to:

- Develop and amend Fishery Management Plans (FMP's).
- Convene committees and advisory panels, and conduct public meetings.
- Develop research priorities in conjunction with a Scientific and Statistical Committees.
- Select fishery management options.
- Set annual catch limits based on best available science.
- Develop and implement rebuilding plans.

The National Oceanic and Atmospheric Administration (NOAA), which is under the Department of Commerce, is responsible for fisheries science in the USA, through its National Marine Fisheries Service (NMFS). The national budget request for the NMFS for 2014-15 was $US 917M. The Office of Science and Technology (ST) is a liaison among NMFS' field scientists and NOAA/NMFS leadership, and is responsible for coordinating the direction of science programs at the national level and across NMFS' science Centres, including managing and supporting numerous stock assessment-related activities at the national level. The Office of Sustainable Fisheries (OSF) supports the regional management councils by conducting the annual nomination and appointment process, training new members, and facilitating periodic coordination meetings. It also provides communication avenues among our constituents and Councils. OSF provides national policy and oversight for NMFS interactions with coastal states and works to increase communication between the agency, their constituents and the general public.

The Northeast Fisheries Science Center (NEFSC) is the research arm of NOAA Fisheries in the Northeastern US, including New England, and consists of six research facilities and operates two vessels: the FSV Henry B Bigelow is 64m in length, and the RV Gloria Michelle is 22m. The mission is to "Conduct ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources, and to generate social and economic opportunities and benefits from their use". Key science functions include resource evaluation and assessment, fisheries and ecosystem monitoring, and research on ecosystem processes.

Fisheries research is also conducted by state-funded organizations, such as the Massachusetts Department of Marine Fisheries (MADMF). Their research is concentrated in the inshore or near-shore areas of coastal state waters, using the NOAA vessel Gloria Michelle. Data from a trawl survey carried out by MADMF from 1978-2014 was used in the recent Gulf of Maine cod stock assessment. A group at Virginia

Institute of Marine Science (VIMS) is responsible for surveys that cover inshore waters of North Carolina to Rhode Island. VIMS is a graduate school of the College of William and Mary, and undertakes significant responsibilities in resource monitoring and advisory services in the region.

3.2.1 New England Fisheries

The New England region, which provides the most relevant contrast to NL in both geography and species fished, includes the states of Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. Preliminary data for 2012 indicate landings of around 301,000 t with a landed value of around US $1.19 B. About one-third of the landed value came through the port of New Bedford, MA, ranked first among all USA ports in landed value. Lobster and sea scallop comprised 36% and 33% of the landed value of the Region, and no other species accounted for more than 3.3% of the value. Cod, with landings of about 4,800 t, was just under 2% of the total landed value. Appendix X contains relevant information on the stock assessment process followed in New England, along with information on the key cod stock assessments.

3.2.2 Assessment Advances

One evolving aspect of stock assessments for NOAA Fisheries has been advancing its stock assessment program to the 'next generation' level. The intent of this next general assessment is to provide NOAA, fisheries managers, and the public with more timely, accurate, and complete information on sustainable catch levels and fish stock status. This involves implementation of a newly developed assessment prioritization process, which intends to provide a consistent approach for establishing assessment priorities in each region. By considering numerous stock and fishery attributes, the process will determine stocks in need of assessment, and set target assessment frequencies and levels for each stock. Prioritization is key, as there are 478 managed stocks in 46 Fishery Management Plans, (Annual Report on Status of U.S. Fisheries) and at present, NOAA Fisheries has the capacity to update only about 100 assessments each year.

Important gaps in data collection or analysis will be identified, and for certain stocks, assessment efforts may be reduced. NOAA Fisheries is also currently developing a new Stock Assessment Improvement Plan (SAIP). Through this exercise, NOAA Fisheries is looking holistically (e.g. environment, ecosystem, socioeconomic) at the stock assessment program for its next generation stock assessment framework. The prioritization process will be an important component of the next generation assessment framework, but the SAIP will touch upon numerous elements of the assessment program to find a balance between timeliness, efficiency, and thoroughness.

Another noteworthy aspect of stock assessment development in the US is the existence of the NOAA Fisheries Toolbox (NFT) a suite of biological modeling software programs that are used in fisheries stock assessments. NOAA's Office of Science and Technology direct the NFT. A committee consisting of representatives from each Science Center provides oversight, and NFT's main programmers are located at the Northeast Fisheries Science Center. A wide range of models and programs from this toolbox can be accessed freely via the internet, and are used widely in fisheries stock assessments.

3.3 Iceland

Icelandic fisheries are the responsibility of the Icelandic Ministry of Fisheries and Agriculture. The Marine Research Institute (MRI) is the Centre of scientific research for marine resources, and it has a staff of about 150, including 100 scientists and research assistants. It operates two research vessels (Bjarni Sómundsson - 55 m, and Árni Friðriksson - 70 m). These ships were used in 2013 for fisheries research in Icelandic waters for about 160 and 174 days respectively. The main activity of MRI is the assessment of marine stocks and an advisory role for the management of fisheries. The management component has three main sections, Environment, Resources, and Advisory. The institute publishes an annual report that provides the state of the marine stocks and quota prospects for the coming year. This includes recommendations to the Minister of Fisheries and agriculture on the TAC for each stock.

The Fisheries Management Act, passed in 1990, established the Individual Transferable Quota (ITQ) system for most of the commercial fisheries. The quotas represent shares in the total allowable catch, and are permanent, divisible, and transferable.

3.3.1 Fisheries

Icelandic waters have a diversity of species, providing about 30 commercially exploited stocks of fish and invertebrates. The total catch of Icelandic fishing vessels in 2013, provided by Statistic Iceland, was 1,363,000 t, with a landed value of $US 1.23 B (1$ = 124 ISK). Groundfish fisheries, mostly gadoids, accounted for about two-thirds of the landed value. The cod catch of 236,000 t was 17% of the total weight landed and 31% of the total landed value. Catches of haddock, saithe (Pollock), and redfish were all in the range of 45,000 to 70,000 t. Important pelagic fisheries include capelin, 33% of the landed weight and 10% of landed value, and mackerel, ~10% of landed weight and value. Shellfish, primarily shrimp, accounted for just under 3% of the landed value in 2013. The most commonly used fishing gears for demersal species are otter trawls, longlines, seines, gillnets and jiggers while the pelagic fisheries use pelagic trawls and purse seines. See Appendix X for relevant information on the stock assessment process followed for most Icelandic stocks, along with a brief summary of the recent Icelandic cod stock assessment.

3.3.2 Assessment Advances

The ICES assessment of Icelandic cod in 2014 used the same statistical catch at age model and formulation as was used in 2013, noting the assessment was quite consistent. However, other approaches were attempted, including a time series analysis that explored survey effects, different results when using spring survey versus fall survey indices alone, and estimation of natural mortality. The North Western Working Group (NWWG) report noted that although there are indications there may be some issues with the accepted assessment model and it would be considered premature to base the advice on one of the alternative models. These issues will be further scrutinized prior to the ICES benchmark meeting in early 2015.

In spring 2009, the Icelandic Government adopted a management plan for the Icelandic cod stock. The current plan includes a management harvest control rule, based on averaging the TAC in the current year and 20% of the biomass of age 4 and older cod in the assessment year. The exploitation percentage applied to the biomass is set as 20% when SSB is above a certain threshold, and if SSB falls below this level, percentage shall be reduced based on the ratio of the SSB to the threshold. ICES evaluated the plan and concluded that it is in accordance with the precautionary approach and the ICES MSY approach.

3.4 Norway

Norwegian fisheries are the responsibility of the Norwegian Ministry of Trade, Industry, and Fisheries (MTIF); there are two government ministers, one for Trade and Industry and one for Fisheries. The Institute of Marine Research (IMR), within this department, is Norway's largest Centre of marine science, with a staff of about 750 including vessel crews. Their main task is to provide advice to Norwegian authorities on aquaculture and the ecosystems of the Barents Sea, the Norwegian Sea, the North Sea and the Norwegian coastal zone and to ensure that Norway's marine resources are harvested sustainably.

IMR is organized into main program areas, four of which correspond to the Seas/Regions outlined above. Other programs include Aquaculture, Climate-Fish, Oil-Fish, and Ecosystem/Population Dynamics. Various research groups exist within these main programs. IMR's budget for 2014 was approximately $US 205 M (1.4 billion NoK). In some recent years, about fifty percent of its activities have been financed by the MTIF, with significant sources of other funds coming from sale of fish catches, the Research Council of Norway, and other government departments.

IMR has its headquarters in Bergen, with four other research stations located in coastal areas of Norway, including Tromsø. The IMR operates eight research vessels, including the 78m state of the art research vessel G.O. Sars, and charters commercial ships for various research activities. In 2012, some 2,200 days at sea, including charters, were used by IMR, approximately 77% of which were in Norwegian waters. The 2,200 days included research in the Antarctic, as well as in other countries, some of which was the responsibility of the Centre for Development Cooperation in Fisheries (CDCF), which is within IMR. The CDCF provides technical assistance for development of sustainable fisheries and aquaculture in cooperating countries, including several in northwest Africa.

3.4.1 Fisheries

Norwegian landings were about 2,090,000 t in 2013, valued at $US 1.86 B (1 $US = 6.82 NoK). Pelagic species accounted for 53% of the landings and ~38% of the landed value. Cod harvests of 471,000 t comprised 23% of the total landed weight and 32% of the landed value. Haddock and saithe combined totaled almost 250,000 t of landings, comprising ~15% of landed value. Shellfish accounted for about 6% of the landed value, most of which were shrimp catches. See Appendix X for information on the Norwegian stock assessment process, as well as summaries of recent cod stock assessments.

3.4.2 Assessment Advances

Most of the ICES Arctic Fisheries Working Group (AFWG) assessments are analytical, but some survey-based and trends-based assessments are also used. The AFWG report includes a comprehensive chapter on ecosystem considerations. Interactions between species are also taken into account, and predation by cod on capelin, haddock and cod (i.e. cannibalism) is included in the assessments of these three stocks. Ecosystem information including data based on climate, was input into models used for prediction of recruitment at age 3 (AFWG 2014 report).

For the North East Atlantic cod stock, a prediction method comparing the bottom trawl survey against VPA numbers, using data from the period 1981-1995, indicates that for the recent strong year classes, the survey estimates at different ages are not consistent with each other. The AFWG notes that this issue will be examined in depth at the 2015 benchmark meeting.

North Sea cod is assessed using a state-space assessment model – SAM (Nielsen and Berg, 2014). Recruitment is modeled from a stock–recruitment relationship, with random variability estimated around it. Instead of assuming catches to be known without error, SAM assumes that catches include observation noise, i.e. fishery catch-at-age data are not considered to be known without error, unlike the assumption in the "traditional VPA" methods. SAM was considered by the recent benchmark of North Sea cod ICES WKCOD Report 2011 to be the most appropriate modeling approach for this assessment.

3.5 New Zealand

Fisheries in New Zealand are the responsibility of the Ministry for Primary Industries (MPI). NZ manages the fourth largest fishing zone in the world, and NZ marine fisheries waters, EEZ legal continental shelf plus territorial seas, encompass approx. 4.4 million square km. (NIWA Annual Report 2013). The EEZ is divided into ten fisheries management units. MPI is also responsible for delivering research to support fisheries management.

The National Institute of Water and Atmospheric Research (NIWA), is a Crown Research Institute (CRI) which has been designated by the NZ government as the lead CRI in the delivery of research on freshwater and marine fisheries. NIWA is run as a stand-alone company, with the Government of New Zealand as its only shareholder. It is chiefly funded by two NZ Government departments (52 % from Ministry of Business, Innovation, and Employment and 16% from MPI), but also brings in revenue through scientific consulting and chartering of its vessels. The revenue budget in 2012-13 was about 121 Million $NZ, $38 M of which was acquired through consulting services. NIWA's science services are delivered by thirteen national science Centres, including the National Climate Centre, the National Aquaculture Centre, and the National Fisheries Centre.

In collaboration with the fishing industry and MPI, NIWA carries out research to assess and monitor the stock status of numerous commercially valuable species. The work includes assessing fisheries resources within New Zealand's EEZ, monitoring and assessing international fisheries, and determining the environmental impact of fisheries. Much of NZ's offshore marine research is undertaken onboard RV Tangaroa (70 m), New Zealand's only ice-strengthened deepwater research vessel, owned and operated by NIWA. A wide range of inshore and coastal research is done on the NIWA-operated vessel RVs Kaharoa (28 m), and its survey launches (10-14 m), Ikatere and Pelorus. The Tangaroa was used for fisheries research in the NZ EEZ for approximately 77 days on average over the past few years and the Kaharoa for 63 days. It is anticipated that research activity for these vessels will decline in coming years.

Deepwater fisheries, which cover the area from 12 NM of the coastline to the 200 NM limit of the NZ EEZ, comprise a large portion of the total NZ fishery. Proportionate to the quota owned, MPI levies deepwater quota owners to manage their fisheries, recovering costs for monitoring fish stock abundance, managing environmental effects, and enforcement and compliance. Deepwater Group (DWG) is a non-profit organization that represents participants in New Zealand's major deepwater commercial fisheries, working in a formal partnership with MPI to ensure that New Zealand gains the maximum economic yields from their deepwater fisheries resources, managed within a long-term sustainable framework. DWG undertakes fisheries research and stock assessment programs, is involved in implementing and monitoring fisheries management programs, and in maintaining standards that meet or exceed those required for Marine Stewardship Council certification.

3.5.1 Fisheries

About 130 species are fished commercially in NZ waters, 97 of which are covered by a quota management system. For the 12 month period ending Sep. 30, 2013, catches of NZ commercial fisheries totalled about 430,000 t. Key finfish landings (total 302,000 t) included hoki (132,000 t), jack mackerel (44,000 t), and blue whiting (34,000 t). Other finfish species caught include tunas, barracouta, ling, oreo, snapper, red cod, orange roughy, and gurnard. Key shellfish landings (total 45,000 t) include arrow squid (25,000 t), dredge oyster (13,000 t), and spiny red rock lobster, or crayfish (3,000 t). Several deepwater species, including orange roughy, oreo, and alfonsino occur are fished around seamounts.

Based on 2012-13 data, the export value of NZ fishery landings, excluding aquaculture, is around $US 940 M (1.2 – 1.3 billion $NZ at 0.78$US). Top species in order of export value are rock lobster, hoki, squid, tunas, and jack mackerel. These five species accounted for about 50% of the total export value in 2012-2013, with some variation in the order and percentages of the latter three between years. See Appendix X for descriptions of the assessment process for NZ stocks, as well as a brief summary of one of the recent key (hoki) assessments.

3.5.2 Assessment Advances

Stocks in NZ are evaluated against a number of PA reference points for biomass and fishing mortality. As well, assessment reports contain extensive sections on climate effects on recruitment, and on ecosystem and environmental considerations. This includes predator-prey interactions, habitat considerations, as well as fishery impacts on benthos and other by-catch species.

CASAL (C++ Algorithmic Stock Assessment Laboratory) is an advanced software package developed by NIWA for fish stock assessment. It is used for quantitative assessments of the status of most of New Zealand's fish stocks including deepwater (e.g. orange roughy), middle depth (e.g. hoki), inshore (e.g. snapper), and shellfish fisheries. It has been used internationally to assess Patagonian and Antarctic toothfish, as well as swordfish fisheries. The software implements an age or length-structured assessment model that allows a great deal of choice in specifying the population dynamics, parameter estimation, and model outputs, and is designed for flexibility. As noted for the hoki assessment, it can be used for multiple stocks, areas, and/or fishing methods, and the user can choose the sequence of events in a model year. Estimation can be by either maximum likelihood or Bayesian approaches.

3.6 Time Series of Research Vessel Survey Data

A key activity of most large or national fisheries research institutes is monitoring of biological resources through research vessel surveys, which makes it a useful subject for comparison between jurisdictions. These fishery independent time series of survey data are used as indices of abundance in stock assessments, and such series almost always need to be relatively long before being considered valuable. Although certain types of "one-off" surveys can yield useful results, such as data on stock distribution and species biology, annual surveys providing spatial and temporal indices of abundance and/or biomass are most beneficial for stock assessment purposes. Such time series of surveys allow stock assessors to follow trends in relative abundance, biomass, and recruitment, to track cohorts, fish born in the same year, as they enter and support a fishery, and to obtain estimates of the effects of fishing on the stock. These surveys also provide overviews of oceanographic changes and ecosystem considerations. They are often most useful when combined with data from commercial fisheries in various forms of population modelling, but can be used on their own when other data sources are not available.

The actual number of years considered necessary for a useful time series of survey data can vary depending on the species surveyed, although five-plus years is often used as a rough benchmark for use as an index in a stock assessment. For many of the commercial fish stocks in the NL area, trawl survey data exists from the late 1970's, with the most comparable time series of data occurring from 1995 to the present.

For time series of abundance data, it is vital that the surveys be conducted with consistent methods and sampling protocols, to reduce survey variability and to ensure comparability of results between years. Important considerations to keep constant from year to year are timing of the survey to avoid or minimize seasonal effects on species distribution; use of one survey sampling tool including the same vessel and trawl gear; statistical survey design and geographical coverage; and rigorous sampling protocols. Where deviations occur, analyses of the changes should be conducted; for example, comparative fishing is carried out when it is necessary to change vessels or trawl gears in a survey series, so that the data collected by the new vessel/gear can be compared with the older data.

3.7 Comparison of Surveys in NL and Other Jurisdictions

NL multi-species trawl surveys: The multispecies ecosystem trawl surveys comprise a large portion of DFO- NL research survey and monitoring efforts and costs, and require at least two-thirds of the NL Region's Teleost and Needler sea-days.

The following exhibit contrasts key research survey inputs (sea days, sets) and provides a common measure, sets per square nautical mile (NM^2), which indicates the intensity of survey coverage for each survey and area.

Given the importance and expenditures for surveys and monitoring, DFO has conducted a number of internal reviews (Hurlbot ed. 2003 DFO WG Report) of these activities, both for the Atlantic Region, as well as for all DFO Regions. In addition, the surveys are presented at various national and international assessment fora, where the methods and results are peer reviewed. The NL survey design and results, for example, are reviewed regularly at NAFO SC (e.g. Healey et al 2012), as well as in CSAS assessments for many stocks.

Comparison of DFO major bottom trawl (stratified random design, multispecies/ecosystem type) surveys conducted, indicates that survey intensity varies considerably in areas within NL and compared to other regions. Noticeable from these data are the survey areas of the NL Region, with the fall survey of 2HJ3KLNO being almost three times the size of the next largest trawl survey area in Atlantic Canada. This is the only survey requiring simultaneous use of both DFO research vessels in the survey design. Also, the 3LNO (Grand Banks) portion of the NL area is surveyed twice per year, in spring and autumn. Overall, the survey intensity in the 2HJ3K area is at the lower end of the range (larger area per set), while the results for 3LNO (if both annual surveys are combined in a single calculation) and 3P would be at the higher (better) end of the range.

Exhibit 3.2: Canadian multi-species bottom trawl surveys

Region	Survey	Survey area (NM^2)	Minimum Fishing Sets	Vessel Days	Survey Intensity (NM2 / set)	Rank
NL	2HJ3KLNO Fall	150,128	674	142	222.7	6
NL	3LNO Spring	77,924	334	47	233.3	7
NL	3P	22,150	193	26	114.8	1
NL/Gulf	3Pn,4RST	37,692	250	32	150.8	3
Gulf	4T	21,308	175	21	121.8	2
Maritimes	4VsW	26,701	125	15	213.6	5
Maritimes	4VWX	53,485	200	28	267.4	8
Maritimes	5Ze	16,608	100	14	166.1	4

Source: Modified from data in Table 1B of Atl RV Survey WG report (DFO 2003 – Hurlbut ed.)

All surveys use a stratified random design, and are conducted on DFO RV's Teleost and/or Alfred Needler. Though some modifications to survey design and coverage has occurred over time, these provide a reasonable contrast of trawl survey coverage in Atlantic Canadian waters.

The identified shortcomings in some areas include:

- Division 2G has not been included in the NL fall survey design since the early 2000's (however this area is surveyed for shrimp by the Northern Shrimp Research Foundation on an annual basis).

- Recent adjustments to the fall survey, reflected in the table, include removal of some survey coverage in areas of 3NO (>731 m), western 3M, and 3KL inshore, as these areas have not always been included in the survey design, and in general have been surveyed sporadically.

Jurisdictional survey comparison to NL: The following exhibit contrasts key NL multispecies trawl surveys and similar surveys carried out in other jurisdictions.

The jurisdictional comparison shows a range in coverage intensity, although it must be recognized that different designs and depth coverage's exist in some cases (e.g. the Barents Sea survey is trawl-acoustic). In addition, the table does not reflect un-surveyed areas. Surveys in the Barents Sea, Iceland, and NL-fall require the use of more than one vessel. The larger scale spring 3LNO and fall 2HJ3KLNO surveys in the NL Region are roughly in the middle of the range of coverage intensity. It is also noteworthy that spring and fall surveys of the same area are carried out in most jurisdictions.

Exhibit 3.3: Jurisdictional survey comparison

Country	Survey	Survey area (NM^2)	Minimum Fishing Sets	Vessel Days	Survey Intensity (NM2 / set)	Rank
Canada	NL 2HJ3KLNO Fall	150,128	674	142	223	5
Canada	NL 3LNO Spring	77,924	334	47	233	6
Canada	NL 3P	22,150	193	26	115	2
Canada	3Pn,4RST	37,692	250	32	151	3
Norway Russia	Barents Sea winter trawl-acoustic	167,000	354	~90	472	7
USA	New England NE shelf spring & autumn	68,938	370 (per survey)	60 per survey	191	4
Iceland	Iceland Shelf Spring groundfish trawl survey	Approx. 60,000	600	80 (est.)	100	1

Brief summaries of the surveys in each jurisdiction are further described:

- **USA – Northeast Shelf.** Trawl surveys of the Northeast Shelf are conducted twice annually (spring and autumn), NAFO SCS 14/024, dating back to the mid 1960's. In 2012 and 2013, between 353 and 382 survey tows were completed in each of the four surveys during this period.

  Surveys in recent years have been done on the Henry Bigelow, and cover an area from southwest of Nova Scotia to just south of Cape Hatteras, North Carolina, in depths from 18 to 366 m. In 2012-13, the survey has been conducted in 50 to 75 days, with 60 days being the target.

- **Norway – Barents Sea.** An annual trawl-acoustic winter survey of Barents Sea (Mehl et al 2013) has been conducted jointly by Norway and Russia in the January to March period since 1981. The main objectives are to obtain indices of abundance and biological data for the major commercial groundfish stocks.

  In recent surveys, an average of 354 bottom trawl tows has been done annually (mean 2008-2011), with additional tows for acoustic support and sampling. The surveys are usually done over six weeks or so, but typically use multiple vessels from Norway and Russia, resulting in about 90-100 vessel days at sea per survey. The area covered by the survey (in square nautical miles) varies from <150,000 to >200,000 NM^2 in the most recent years, with the mean from 2008-2011 being 167,000 NM^2.

  This survey is actually smaller in scope than the annual Norway-Russia trawl-acoustic survey of Barents Sea conducted during autumn, which is also focused on plankton, pelagic fish, and juvenile fish (e.g. cod in their first year). In some years, over 200 vessel-days at sea have been used in this survey. Other surveys are conducted in the Barents Sea by Russia and Norway separately.

  A recent analysis of the surveys in the Barents Sea, by Norwegian scientists from IMR recommended that the two major joint Norway-Russia trawl-acoustic surveys described above be continued, and that the required vessel time for these surveys would be in the range of 310 vessel days at sea (combined, Russia and Norway), in addition to the survey time for the other existing Barents Sea surveys.

- **Iceland trawl survey**. Iceland conducts two major shelf-wide surveys annually, one in spring (March) since 1985, and the other during autumn since 1996. The spring survey covers an area of about 60,000 NM^2 to depths of 500 m and is directed at groundfish primarily. The autumn survey covers some additional deeper waters to 1500 m, but is also focused on groundfish.

  The surveys use a design involving both research and commercial vessels, and a mixture of sets chosen randomly by scientists and others chosen by the commercial fishers. The 2011 spring survey, for example, used the two Icelandic RVs noted previously, along with three commercial trawlers, and occurred from March 1-19. Surveys in some other years have occurred with multiple vessels over a shorter period. Some time is included in many of the surveys to allow for comparisons and inter-calibrations between different vessels used in the survey.

Sea day costs: There is a wide range in sea-day vessel costs in the various jurisdictions, and caution should be exercised in any comparisons of these data, as costs stated are likely accounted for in various manners. It should be noted that several participants indicated that survey vessels are available for lease to other jurisdictions. For those jurisdictions that did relay survey costs a description of the vessel and costs are provided.

- **USA**. The Gloria Michelle (22 m), one of two USA/NOAA vessels used in the New England area surveys has an average cost is $3,800 US /sea day. The Henry B. Bigelow (64 m), which is used for the two major Northeast Shelf groundfish surveys, the average sea day cost for the vessel is about $14,500 US.
- **Iceland**. The Bjarni Sómundsson (55 m) average cost per sea-day was $17,000 US, and the Árni Friðriksson (70 m) was $22,500 US.
- **New Zealand:** The current charter cost for the Tangaroa (70 m) is $40,500 US / sea day, and for the smaller Kaharoa is $8,200 US per day. These are based on long term charter agreements between NIWA and MPI, in which rates can fluctuate annually based mainly on fuel prices.

3.8 Public-private Partnerships in Other Jurisdictions

There are clearly a number of different approaches to funding and methods of conducting scientific fisheries research in various jurisdictions. In the northeastern USA, state and university researchers conduct inshore surveys in collaboration with the federal agency (NMFS), resulting in broader survey coverage for many key fishery resources. In Iceland, the main trawl surveys for groundfish resources use a number (up to six in some years) of chartered commercial trawlers in conjunction with the two main Icelandic RVs. In addition, the survey design has called for a certain number of industry-chosen tow locations to be combined with the scientifically chosen stratified random tows in developing the abundance indices. The use of multiple vessels allows the surveys to be conducted over a much shorter period of time, reducing temporal variability, and gives the fishing industry a key role in planning and carrying out the work. Standardization of the vessels and gears, through comparative fishing, is also an important component of this survey design.

Although not a true public-private partnership, the New Zealand approach, as noted previously, presents a different model for funding fisheries research. The National Institute of Water and Atmospheric Research (NIWA), is a Crown Research Institute run as a company reporting to the NZ government, and is able to bring in revenue through means such as scientific consulting and chartering of its vessels. The NIWA corporate structure is comprised of a number of subsidiaries, including NIWA Vessel Management Ltd, which owns and operates the fleet of NZ research vessels. Part of the vessel usage includes charters to the government-funded fisheries researchers in the NZ Ministry for Primary Industries, who conduct the surveys and stock assessments.

The NZ approach has some similarity with that used in the United Kingdom, where the primary fisheries research body in the UK, the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), is an Executive Agency of the Department for Environment, Food and Rural Affairs. CEFAS is partly financed from this government department, and partly by external organisations both public and private. Its clients include other UK Government departments and regulatory bodies, the European Commission, non-governmental and environmental organisations, and industry, both in the UK and internationally. CEFAS, which is headquartered in Lowestoft, England, employs about 530 people, owns a research vessel, and its services are delivered alone or in partnership with others, depending on the most effective way of meeting client needs.

4.0 STOCK MODELING

4.1 Introduction

This review of assessment methods currently in use and some recently tested, for key stocks adjacent to NL is not exhaustive, but does examine both the traditional assessment methods and new methods that have been considered, across a range of species. The following exhibit provides a summary of the methods/models and inputs for a number of primary species and stocks.

Exhibit 4.1: Summary of assessment methods for key NL Region stocks

Stock or species	Assessment method	Key Inputs for model or assessment	Comments
2J3KL cod	SURBA	Age disaggregated trawl survey abundance index	Survey based population analysis
3Ps cod	SURBA (HCR developed in Rebuilding Plan)	Age disaggregated trawl survey abundance index	Survey based population analysis
3NO cod	Adapt	Age disaggregated, fishery catch numbers, survey abundance indices	Sequential population analysis
3Pn4RS cod	VPA/Adapt	age disaggregated fishery catch numbers surveyabundance indices	Sequential population analysis
Snow crab	Surveys, CPUE	Trap and trawl survey indices, fishery CPUE	trends
Northern shrimp	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends
3LNO yellowtail	ASPIC	Catch, age aggregated survey abundance indices	Age aggregated surplus production
3LNO Am. plaice	Adapt	Age disaggregated. fishery catch at age, survey abundance indices	Sequential population analysis
3Ps Am. Plaice	Bayesian surplus production.	Catch, age aggregated survey abundance indices	Age aggregated surplus production
3NO witch	Surveys	Catch, age aggregated survey abundance indices	trends
2+ 3 G. halibut	XSA (MSE used to determine HCR)	Age disaggregated, fishery catch numbers, survey abundance indices	Sequential population analysis
4RST G. halibut	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends
Redfish 3LN	ASPIC (MSE developed)	Catch, age aggregated survey abundance indices	Age aggregated surplus production
Redfish 3O	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends
Redfish Unit 1+2	Surveys, CPUE	Trawl survey indices, fishery CPUE	trends (surplus prodn used for RPA)
2J3KL capelin	Acoustic survey in 3L	Acoustic survey, other biological indices	trends
Lobster	Landings, CPUE, survival rates (molting)	Catch, CPUE, biological data	trends
4R herring	Survey	Acoustic survey	trends
3+4 Mackerel	SPA	Age-disaggregated fishery data, Egg density survey	Survey only covers relatively small portion of total stock area

SCIENCE GAP: A number of key stocks (NL snow crab, shrimp, lobster and capelin) in Newfoundland and Labrador are not assessed using analytical assessment models/techniques.

4.2 Current Assessment Methods for Key Stocks in NL

4.2.1 Current Species Model Description

Cod assessment models: The stocks in 2K3KL and in 3Ps are assessed with a Survey Based Assessment (SURBA), which is based on analysis of age-disaggregated RV survey data. Age data from the commercial fishery catches are not available due to uncertainty with the total landings of these stocks in some years, and so this precludes the use of the many common catch-based analytical models.

The stock in 3NO is assessed using a method known as ADAPT, which incorporates age by age data from the commercial fishery as well as several RV survey indices of abundance.

For 3Pn4RS cod, a Sequential Population Analysis (SPA) model was used to integrate all the information. Further details on the type of SPA model used were not available in the Science Advisory Report from the most recent assessment (2012), but in previous assessments, ADAPT was used.

Snow crab assessment models: Assessments by stock area are based on trends in CPUE from the fishery and key survey indices in several areas. This includes both trap and trawl surveys. Estimates of fishable biomass, recruitment, pre-recruits, and mortality are obtained from these surveys.

Shrimp assessment models: Assessments for each shrimp fishing area (SFA's 4-7) are based on CPUE from the fishery, and key survey indices in several areas. Several biomass estimates are calculated including total biomass, fishable biomass, and spawning (female) biomass. Other indicators gleaned from the survey data and used in the assessment are recruitment and mortality.

Use of a surplus production models (SPA), based on a Bayesian framework, as used in the assessment of West Greenland shrimp stocks, has been explored recently, and work is ongoing to further develop this approach.

Flounder assessment models: 3LNO yellowtail flounder is assessed using an age-aggregated surplus production model known as ASPIC. Re-ageing of yellowtail based on recent studies is progressing towards conducting an age-disaggregated assessment. 3LNO American plaice is assessed using the ADAPT method. 3Ps American plaice is assessed using an age-aggregated Bayesian surplus production model. 3NO witch flounder assessment is based on evaluation of research vessel survey series and bycatch data from commercial fisheries. In 2014, the application of a surplus production model in a Bayesian framework was explored, but results were found to be sensitive to survey catchability. Although the model shows promise, it was not considered to be acceptable for use in the assessment at this time.

Greenland halibut assessment models: 2+3KLMNO Greenland halibut is assessed using a method known as Extended Survivor Analysis (XSA), which incorporates age by age data from the commercial fishery as well as several age-disaggregated RV survey indices of abundance. However, the total allowable catch each year is determined by the established harvest control rules, developed from a management strategy evaluation (MSE) which examined several operating model formulations.

4RST Greenland halibut assessments are based on analysis of commercial fishery data and information from RV surveys.

Redfish assessment models: 3LN redfish is assessed using the ASPIC surplus production model. Harvest control rules have been developed from an MSE carried out in 2014. The assessment of 3O redfish is based on trends in catches and survey data. Unit 1 and 2 redfish stocks are assessed separately by species, using all available data from commercial fisheries and various RV survey indices. Recently, there has been state-space Schaefer surplus production modeling carried out for redfish (*Sebastes fasciatus*) in Units 1 and 2 to determine stock trends against various reference points, for the purpose of assessing recovery potential.

Capelin assessment models: The most recent assessments of capelin use data from the spring 3L acoustic survey, recruitment indices mostly from Trinity Bay, and various other indices such as biological data on growth, condition, and maturity. An examination of two methods in 2013, one based on projections from the acoustic survey, and the other based on capelin consumption by fish and marine mammal predators, concluded that neither model was acceptable for providing limit reference points for stock assessment and fisheries management. One key limitation is that the current acoustic survey covers only the 3L portion of the 2J3KL stock.

SCIENCE GAP: The current DFO spring acoustic survey for 2+3KL capelin does not cover the entire distribution of this resource. The current survey covers 3L and a smaller area in southern 3K. Additional distribution may occur in other areas in 3K.

Lobster assessment models: Lobster in NL is assessed by grouping lobster fishing areas (LFA's) into four regions. The key indicators for the assessments are reported landings, nominal effort, mean catch per unit effort, and survival rate indicators based on molting.

Herring assessment models: The key index for the 4R herring assessment is the acoustic survey. Some modeling was attempted recently using an ADAPT method, but it was not accepted as the basis for the assessment, due to problems with the low number of survey points and possible issues with age determinations.

Mackerel assessment models: The spawning biomass of the Canadian mackerel stock component is evaluated using an analytical assessment, calibrated by the abundance index from an egg survey conducted annually in the southern Gulf of St. Lawrence. The assessment uses a sequential population analysis (SPA) model, encompassing the stock in Subareas 3 + 4.

Summary: The stock assessments for the NL stocks listed above can be classified into four main categories:

- **Sequential Population Analyses (SPA).** In this type of assessment (e.g. 3LNO American plaice, 3NO cod) data from the commercial landings are used to construct population and mortality estimates, and the analysis is calibrated with data from one or more survey indices, usually from research vessels. Data from both the commercial fishery and surveys is available on an age disaggregated (age-by-age) basis. There are many commonly used variations of models in the SPA family, including ADAPT, XSA, virtual population analysis (VPA), cohort analysis, etc. Results of SPA assessments are typically used to project future stock sizes and landings under various assumptions.

- **Survey Based Assessment (SURBA)** is based on analysis of age-disaggregated RV survey data. This type of model is used for 3Ps and 2J3KL cod, as age data from the commercial fishery catches are not available due to uncertainty with the total landings of these stocks in some years. Limited stock projections can be done with this model, but do not include catches.

- **Surplus Production Models.** In this approach, data on commercial landings and at least one index of abundance (often RV survey based) are required. Data do not have to be age-disaggregated. Surplus production models estimate the productivity of a fish stock that can be harvested on a sustainable basis. The models are often represented by a relationship between catch and fishing effort or indices of abundance. Such a model (specific form is ASPIC) is used for 3LNO yellowtail flounder and 3LN redfish, with associated stock projections produced for management advice. In some cases (e.g. 3Ps A. plaice), a Bayesian framework has been used, which is a statistical approach where expert beliefs or knowledge are analyzed together with data, making use of probability to quantify uncertainty.

- **Trend analysis.** Where analytical methods are not usable or acceptable for a given stock, for any number of reasons, assessments are usually conducted by analyzing trends in various indices of abundance, as well as other commercial fishery data (e.g. catch, fishing effort). Such analyses can be used to infer trends in abundance, mortality, and recruitment in a stock, and to help determine sustainable fishing levels. These types of analyses have also been useful in helping to calculate reference points for stocks under the precautionary approach.

Although many of the NL assessments use trends analyses to estimate stock status, a number of stock assessments currently utilize more analytical assessment methods, or at least have explored such methods. Comparison of the methods shows that similar techniques are in use elsewhere in the world. Reasons for not using analytical methods for all stocks include issues with catch data reliability, other data issues, and workloads. However, one class of assessment modeling that has not been widely tested for NL stocks permits estimates (where actual catches are not known with certainty) of fishery catch at age to be used in sequential population analyses. This modeling technique includes approaches such as Statistical Catch at Age (SCAA). This has been used in conjunction with another sequential population model (XSA), in the MSE for Greenland halibut, to develop harvest control rules.

SCIENCE GAP: In some cases there is no record of total annual removals from specific stocks. This gap is noted in cod and mackerel assessment documents, but may also be an issue for other stocks.

The DFO Technical Expertise in Stock Assessment (TESA) program was created in 2008 to help rebuild capacity in fish stock assessment and to develop analytical approaches. The TESA program includes a Stock Assessment Methods Committee that provides review and advice on assessment issues. The TESA program offers a Stock Assessment Technical Training/Upgrading process by coordinating annual training and disseminating information to stock assessment practitioners. The TESA program is led by a Steering Committee, one member from each region, a National Science Directors Committee (NSDC) champion and a Science manager.

4.2.2 Jurisdictional Collaboration

Many jurisdictions have been examined in this report to compare processes with Canadian approaches. Quite a few stocks on the east coast of Canada are assessed at the Scientific Council of NAFO. Although a large number of Canadian scientists participate in these proceedings there is also substantial participation by scientists from many of the reviewed jurisdictions: EU, Norway, Iceland and the United States. In these cases, scientists from Canada and those from other jurisdictions share perspectives on and peer review assessment techniques. In many cases Canadian assessments are exposed to and use assessment models and approaches employed in other countries, including models such as XSA, SCAA, ASPIC, various Bayesian models, etc. In addition, models developed in Canada (ADAPT, SURBA, etc.) are used within NAFO and/or in other assessment fora (e.g. ICES) by non-Canadian scientists who were initially exposed to these techniques at NAFO. In addition, Canadian scientists are members of numerous ICES assessment working groups, and participate in various assessments using a variety of techniques.

4.2.3 Science–Industry Collaboration on Stock Assessments

There are numerous examples of successful collaboration on surveys and stock assessments between scientists and the fishing industry in NL. Previous sections have outlined many of the science-related projects currently underway in organizations such as GEAC, CAPP, and FFAW, in collaboration with DFO, CFER, CSAR, etc. Some of the more noteworthy ongoing collaborative efforts include the inshore sentinel survey for cod, the post season trap survey for crab, and the northern shrimp surveys. All of these surveys provide considerable data to the assessments of these resources, and in certain areas are the only indices of abundance currently collected. Previous examples of successful collaborations include a series of grid surveys (Fisheries Products International-DFO) directed at 3LNO yellowtail flounder, which played an important role in providing key data to stock assessments immediately prior to the reopening of the fishery in 1998. More information on collaborative efforts is contained in Section 5.

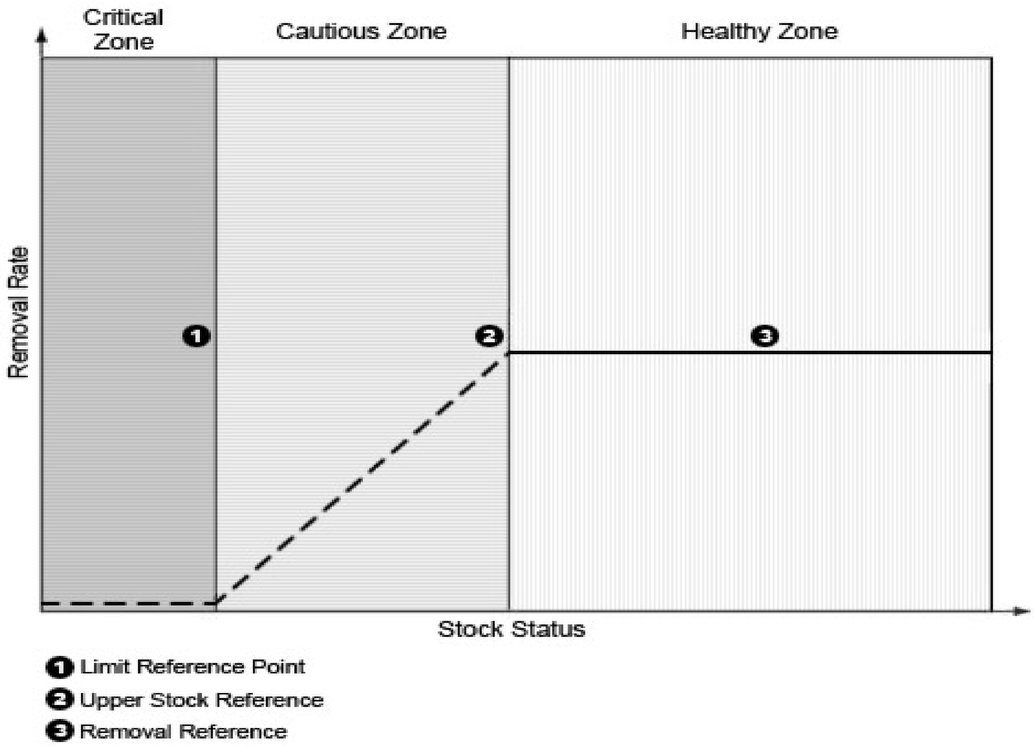
SCIENCE GAP: While there is currently ongoing collaboration between science institutions and the fishing industry, funding for these collaborations comes from a variety of sources. Some of these sources are relatively stable, but there is no substantial single source of funding to augment current ad-hoc funding levels, that can be used to facilitate collaborative work on an ongoing basis.

4.3 Precautionary Approach and Use of Harvest Control Rules

For many stocks in the NL area, evaluation of the resource is conducted against reference points defined by a precautionary approach (PA) framework. Two such examples of these are the PA frameworks developed within Canada (DFO), and that implemented in NAFO.

In many cases, the scientific advice is then based on where the assessment indicates the stock level is relative to established reference points adopted for the PA, which are often defined for biomass and fishing mortality.

Exhibit 4.2: DFO Precautionary Approach Framework



In the DFO PA Framework shown above (Exhibit 4.2), the Limit Reference Point (LRP) represents the stock status below which serious harm is occurring to the stock (i.e. stock in Critical Zone). At this stock status level, there may also be resultant impacts to the ecosystem and a long-term loss of fishing opportunities. The LRP is based on biological criteria and established by Science through a peer reviewed process.

The Upper Stock Reference (USR) can perform two functions in the DFO PA. First, the USR is the stock level threshold below which removals must be progressively reduced in order to avoid reaching the LRP (i.e. when the stock moves from the Healthy Zone to the Cautious Zone). Secondly, the USR can function as a target reference point (TRP) determined by productivity objectives for the stock, broader biological considerations and social and economic objectives for the fishery. The USR would be developed by fishery managers informed by consultations and collaborations with the fishing industry and other interests, with advice and input from Science. A TRP is a required element under UNFA and in the United Nations Food and Agriculture's (FAO) guidance on the application of the PA, as well as eco-certification standards based on it, such as those of the MSC. The PA diagram indicates the TRP is the same as the USR, while this is common for many stocks, these two points do not have to be equal

The Removal reference is the maximum acceptable removal rate for the stock. It is normally expressed in terms of fishing mortality (F) or harvest rate, and includes all mortality from all types of fishing. To comply with the UNFA, the Removal reference must be less than or equal to the removal rate associated with maximum sustainable yield (MSY). In the Cautious zone, the adjustment of the Removal reference does not have to follow a linear relationship as shown in the diagram, but a progressive reduction in removals is required.

Canadian management plans that have adopted the PA also clearly state that other factors including social and economic considerations will be considered when setting annual allocations. The PA is also intended to give managers considerable flexibility in setting catch limits when stock levels are healthy. In a few cases, such as the recently adopted DFO rebuilding plan for cod in 3Ps and for some of the northern shrimp stocks, there are TAC adjustments specified based on changes in stock size, biomass, mortality and/or recruitment. These specified adjustments, known as harvest control rules, vary in direction and degree based on stock trajectory, position of the stock relative to reference points, and recruitment prospects.

There are also numerous examples of the NAFO Fisheries Commission closing fisheries, e.g. 3LNO shrimp (fishing area SFA 7), 3LNO plaice, and 3NO cod, due to stock assessment results and advice applied to the NAFO PA.

Management strategy evaluation (MSE) was carried out in developing a harvest control rule in NAFO for the 2+3KLMNO Greenland halibut stock.. Several stock assessment operating models were included in this comprehensive evaluation, including various types and formulations of population models (Miller and Shelton 2010). Following evaluation of numerous management strategies on the stock, using a number of performance criteria, a harvest control rule, in which TAC adjustments are based on annual changes in the three major RV survey indices, was implemented by NAFO. A similar exercise has recently been completed for 3LN redfish.

SCIENCE GAP: Management strategy evaluations (MSE) for the analytical determination of Harvest control rules (HCR) have only been completed for 2 stocks in the NL area. Additional work in this regard is required. DFO currently does not have the scientific expertise to complete this analysis. There are only a small number of scientists world-wide who have the experience required for this type of work.

In response to requirements under the Species at Risk Act (SARA), DFO conducts work on reference points and recovery potential assessments (RPA) for numerous species. In recent years this has included work on key commercial species such as cod, American plaice, and redfish. Various population models and long-term projections have been applied in these cases, and they sometimes differ from the stock structure and assessment models used for provision of fisheries management advice.

4.4 Ecosystem Approach

Most CSAS Science Advisory Reports (SAR) in recent years contain sections on ecosystem and environment (oceanography). These often contain summaries of relevant data on temperature, habitat, predator/prey, etc. Although assessments attempt to evaluate impacts on stocks of significant changes in key indicators, no jurisdictions have a truly integrated ecosystem assessment approach. The same is true for most NL stocks assessed by the NAFO SC. Effective modeling of stocks using an ecosystem approach has proven to be elusive, though many assessments now track numerous ecosystem indicators which are given consideration during regional and zonal assessment processes (e.g. impacts of predation).

SCIENCE GAP: Analytical stock assessments for stocks assessed in Newfoundland and Labrador do not formally integrate ecosystem considerations. It should be noted that this Science gap in also prevalent in virtually all international jurisdictions.

In 2012, an evaluation of DFO NL Region's Ecosystem Research Initiative (ERI), conducted between 2008 and 2012, was carried out in a CSAS review process. The main outcomes of the program included a description of status and trends in main forage (prey) fish species, as well as changes in the fish community over time. Further, information on benthic species and key trophic interactions in the NL marine community was analysed. A key recommendation from the report was that relevant information from the ERI should be explicitly incorporated into stock assessments whenever possible (e.g. effects on natural mortality). It was noted that Ecosystem-based management will require more data and development of new approaches compared with the traditional single-species approach to management. Therefore, more dedicated resources and increased collaboration will be required. It concluded that a stable funding source, including appropriate human resources, tools and equipment, is key to implementing an ecosystem research program on the level of the NL Region ERI.

SCIENCE GAP: For full Ecosystem-based management there is a lack of multi-species data and approaches compared with traditional single species approaches to science and management.

Within the NAFO SC, efforts have been progressing since 2007 on development of an ecosystem approach. This has led to an SC WG of scientists, as well as a joint Scientific Council – Fisheries Commission Working Group of managers and scientists to tackle various issues. Included in the early progress, has been establishment of a number of closed areas to protect corals and sponges, and identification of potential vulnerable marine ecosystems (VME). Ongoing work includes development of a roadmap to an ecosystem approach to fisheries, which was developed around the concept of integrated ecosystem assessments. This approach, among other characteristics, will consider long-term ecosystem sustainability. An initial step has been to define the regional ecosystems in Atlantic Canada.

An important component to be addressed is evaluating significant adverse impacts on VME. Specifically, the adopted approach will be to take account of known and predicted VME habitat and then evaluate this as part of a review of existing fishery closures. These analyses involve the production of detailed map layers showing fishery intensity, and species data from RV surveys showing VME. The work is underway in NAFO SC, but not due to be completed until 2016, and will constitute part of a broader analysis on the assessment of bottom fishing activities in the NRA. Considerable work will be required on the data and methods used to identify, describe and assess the impacts of the activity, the identification of gaps in knowledge, and an evaluation of uncertainties in the fisheries assessment. Following these analyses and review, there will be scientific input required, likely through joint working group meetings of scientists and managers, into development of proposed mitigation and management measures needed to prevent significant adverse impacts on VMEs, and the measures required to monitor effects of the fishing operations.

4.5 Marine Stewardship Council (MSC) Certification

Introduction: Eco-labels indicate a set of attributes for a product whether on consumer labels, bulk packaging, counter labels, or menus. In the case of seafood eco-labels it normally indicates that the seafood supply is sustainable both in terms of harvesting practices and in the broader context of the ocean ecosystem.

The Marine Stewardship Council (MSC) is the most prominent wild fisheries eco-label with more than 10% of world harvest and 25,000 products certified. The MSC is an independent, global, non-profit, FAO compliant organization whose objective is to reverse the decline in global wild fishery stocks by influencing consumer purchasing power. This is accomplished by promoting globally environmentally responsible stewardship of fisheries.

The MSC has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices. Consumers, concerned about overfishing and its environmental and social consequences, are able to choose seafood products, which have been independently assessed and labeled against the MSC Standard.

The MSC approach provides detailed review procedures including extensive stakeholder consultations, peer reviews and permit public critique of the assessment. Stakeholder consultations are done throughout the entire process and include harvesters, producers, regulators, and eNGO's. Independent scientists and managers who have expertise in the species under assessment conduct peer review of draft assessments. Upon completion of a draft assessment the entire document is made available to the public at large for review and feedback.

The process for achieving MSC certification normally takes 18-24 months.. Costs associated with each of these tasks have been estimated, and provide the range of costs that could be anticipated for the five year certification cycle. Similar costs would likely be incurred for subsequent re-assessments. Tasks include:

- **Pre-assessment**. The client group provides current scientific and management information regarding the fishery to a certifying body (CB). The CB reviews the submitted information and other source documents and prepares a confidential pre-assessment report to the client group. This report identifies, in broad terms, the data gaps that exist and may affect successful certification.

Cost of pre-assessment - $10,000 - $20,000

- **Assessment**. An assessment provides a comprehensive review of all performance indicators that are included in the three principles 'Sustainable Fish Stocks', 'Minimizing Environmental Impacts', and 'Effective Management'. It is necessary that the client group provide evidence regarding the three principles.

  The assessment process takes 9-12 months and requires a formal submission of evidence from the client group to the CB. There is a site visit by the CB to meet with the client group, industry stakeholders, regulators and other interested parties.

  A confidential client draft report is provided subsequent to the site visit, permitting the client group an opportunity to provide feedback regarding the findings of the CB. After receiving client group feedback, the draft report is peer reviewed and posted to the MSC website for public review and feedback. If there are no objections as a result of the public review, the final report is posted and the certification granted to the client group.

  Cost of assessment- $100,000 - $150,0000

- **Conditions of certification**. Any performance indicator which scores <80 has a condition imposed that must be addressed during the term of certification which is five years. These conditions can be quite onerous to meet, requiring extensive research, changes in management policy, and collaboration among stakeholders.

  Cost of conditions - $20,000 - $200,000

- **Surveillance audits.** Annual audits by the CB are completed to determine if there has been any change in the status of the fishery and to measure progress on meeting conditions. This audit normally requires a site visit where the CB meets with the client group and regulators.

  Cost of annual surveillance audit - $15,000 - $25,000

When a fishery is certified sustainable, there are specific conditions associated with the certification. These conditions relate to individual performance indicators within each of the MSC principles of stock, ecosystem and/or management. All major Atlantic Canadian fisheries are currently either certified or under assessment. Each of these certifications has conditions that require short to mid-term research initiatives.

The MSC undergoes regular program improvements through an established process that includes broad consultation. These program improvements affect both the certification and chain of custody schemes, The most significant change from these program reviews is Version 2.0 of the certification, which is due to be implemented April 1, 2015. The most significant changes are: new consideration given to Vulnerable Marine Ecosystems (VME's), illustration of the cumulative effect of bycatch fisheries, and updating requirements for performance indicators that utilize the Risk Based Framework (RBF).

Given that MSC certification is a requirement to sell to many EU buyers, these program improvements make it challenging for certificate holders, as regular improvement in management of the certified fishery must be demonstrated.

The following exhibit illustrates the certification status of NL adjacent resources, indicating the management areas of the fishery that are certified and those that are not.

Exhibit 4.3: MSC certification status for Atlantic fisheries

Species	Cerification Date	Status	Fishing Area
Sea scallop	March, 2010	Under re-assessment	St. Pierre Bank Eastern Scotian Shelf Browns and German Bank Georges Bank
Swordfish (harpoon)	June, 2010	Under re-assessment	NAFO 3, 4, 5 and 6
Yellowtail	October, 2010	Under re-assessment	3LNO
Northern shrimp	June, 2011	Certified	SFA 1 though 7
Striped shrimp	June, 2011	Certified	SFA 2 through 4
Swordfish (longline)	April, 2012	Certified	Canadian EEZ
Snow crab	April, 2013	Certified	2J3K, 3LNO, 3Ps
Atlantic halibut	May, 2013	Certified	3NOPs, 4VWX, 5Zc
Surfclam	July, 2013	Certified	Grand Bank and Banquereau
Herring	October, 2014	Certified	4R
Cod		In assessment	3Ps
Capelin		Not certified	Any area
Cod		Not certified	2GH, 2J3KL, 3MNLO, 4R3Pn
Herring		Not certified	2J3KL, 3MNLO, 3Pn, 3Ps
Lobster		Not certified	Any area
Mackerel		Not certified	Any area
Gulf shrimp		Not certified	SFA 8
Plaice		Not certified	Any area
Redfish		Not certified	Any area
Snow crab		Not certified	2GH, 3Pn, 4R
Turbot		Not certified	Any area
Witch		Not certified	Any area

Some fisheries have not commenced the MSC process because they are of low value, volume or the stock status of the fishery is poor that would result in the fishery not meeting certification requirements. For fisheries not in the MSC process, particularly recovering species such as cod, plaice and witch, a Fishery Improvement Project (FIP) can be developed. The FIP process identifies challenges that the fishery faces and identifies data gaps that require being addressed to improve the status of the fishery. Stakeholders must establish a prioritized list of actions to fill these gaps and monitor, on an ongoing basis, the action plan developed. A central registry for FIP's provides a summary of fisheries registered and details regarding the fishery and activities related to the FIP.

Outcome of NL MSC assessments: Of the 10 NL adjacent resource certifications, seven are specific to NL fisheries exclusively. Of these seven NL MSC assessments reviewed, there were 37 conditions imposed citing 17 performance indicators (PI's). The PI's that would require some form of research and/or analysis are summarized. Other conditions were related to management issues and did not require research activities to close out conditions.

- Define harvest control rules (PI 1.2.2).
- Provide information to determine risk posed to habitat (PI 2.4.3).
- Provide information to determine risk posed to both retained and discarded by-catch species (PI 2.1.1, 2.2.1 and 2.2.3).
- Define methods to support principles one and two (PI 3.2.1).
- Define research plan to meet management needs (PI 3.2.4)

SCIENCE GAP: There is no identified source of funding that can be used to conduct the scientific analysis required to enable fisheries to meet the conditions required to maintain certification under Marine Stewardship Council criterion.

5.0 RESOURCE PROSPECTS

5.1 Summary

The source information for determining the resource prospects was taken primarily from publications available from the Canadian Stock Advisory Secretariat and from NAFO Scientific Council Reports. These publications included science advisory reports, research documents, meeting proceeding and science responses. Where there was ambiguity found in different publications or clarity was required research scientists were contacted for clarification.

The following exhibits provide a synopsis of the primary fish stocks directly adjacent to NL, reflecting findings from recently published research. For resources that have adopted stock reference points, in compliance with the Canadian or NAFO's Precautionary Approach Framework, objective analysis of the prospects for those resources are provided. For stocks that are yet to develop reference points, a more subjective analysis of published findings is provided.

Exhibit 5.1: Summary for stocks that have reference points in place

Species	Area	LRP (000 t)	SSB (000 t)	Prospect
Atlantic Cod	2J3KL	660	185	↓ SSB growing. Maintain catches at current low level for continued growth
Atlantic Cod	3NO	60	25.2	↓ SSB growing - to be re-evaluated at 50% LRP. Stock has a rebuilding plan
Atlantic Cod	3Ps	-	-	↔ LRP defined as SSB in 1994. SSB index expressed relative to this, 2013 index value is approximately double the 1994 index
Atlantic Cod	4RS3Pn	116	< 25	↓ SSB considered to be well below the LRP – catches should be as low as possible
American Plaice	3LNO	50	38	↓ SSB growing, now 76% of LRP. Stock has a rebuilding plan. Could be above the LRP in the near-term with low catches
Yellowtail Flounder	3LNO	22.5	134.5	↑ SSB above LRP and upper stock reference point – stock very healthy
Atlantic Halibut	3NOPs + 4VWX5Zc	2	>8	↑ Despite increases in TAC the Atlantic halibut stock appears to be increasing
Witch Flounder	3NO	9.2	>20	↔ Estimates of biomass are variable, biomass index above LRP for 2011-13, stock under moratorium from 1994-2014 reopening in 2015, TAC 1000t
Redfish S. Fasciatus Redfish S. Mentella	SA 2 + 3K	29 116	8 16	↓ While these stocks are well below ↓ Their respective LRPs, biomass has been increasing in recent years. Maintain low catches to continue rebuilding
Redfish	3LN	41	191.5	↑ Scientists suggest a step-wise increase of TAC's to ensure SSB stays above Bmsy
Redfish S. Fasciatus Redfish S. Mentella	Units 1+2	148 233	65 19	↓ both stocks well below the LRP with S. ↓ Fasciatus rebuilding. Maintain low catches for S. Mentella to enable rebuilding
Northern Shrimp	Area 4 Area 5 Area 6	21.1 14.3 79.6	>100 63 187	↑ Upper Stock Reference = 56,300 t ↑ Upper Stock Reference = 38,000 t ↔ Upper Stock Reference = 212,200 t Stocks remain above the LRP and USR in Areas 4 and 5. More concern in Area 6 with stock below USR in 3 of 4 most recent years and with exploitation increasing.
Northern Shrimp	3LNO(Area 7)	19.3	11.8	↓ Fishery closed by NAFO in 2014, prospects for recovery not good
Northern Shrimp	4RST (Esquiman)	-	-	↑ LRP and SSB are expressed as an index, Current SSB index is 4-5 times higher than the LRP and almost double the USR.

Notes: LRP – Limit Reference Point
SSB – Spawning Stock Biomass
USR – Upper Stock Reference
↑ - SSB > USR (PA healthy zone)
↔ - LRP < SSB < USR (PA cautious zone)
↓ - SSB < LRP (PA critical Zone)

Exhibit 5.2: Summary for stocks that are yet to develop reference points

Species	Area	Prospect
Greenland Halibut	SA2+3KLMNO	↔ Stock has a Harvest Control Rule (HCR). Near-term TAC's to change by only ± 5%
Greenland Halibut	4RST	↔ Last full assessment showed stability, recent update showed decreasing indices
Atlantic Halibut	4RST	↑ Indices positive. Scientists believe TAC increases should be moderate. Industry want larger increases
Snow Crab	2HJ3KLNOPs	↓ Prospects for recruitment not good in most areas. More immediate concern in offshore 3K and all areas of 3Ps
Lobster	3KLP4R	↔ Recruit based fishery so landings reflect abundance. Recent increases in best fishing zones likely to continue
Capelin	2J3KLPs	↑ Recent success in the capelin fishery should continue in the mid-term
Capelin	4RST	↑ The fishery takes small proportion of biomass, however caution increasing TACs because of capelin's role as a forage species
Mackerel	SA 3+4	↓ Biomass at very low levels. Keep TACs low – not to exceed 800 t
Herring	4R	↓ Strong 2000 year class declining with no additional strong recruitment – no increase to 20,000 t TAC

Notes: ↑ - stock in good or healthy condition
↔ - stock in moderate condition
↓ - stock in poor condition

Additional information regarding each of the species listed is provided in Appendix XI, providing a description of the fishery, outcome of current scientific assessments, discussion of assessment methods used and a summary of the resource prospects. Further, management maps relating to snow crab and shrimp fisheries and NAFO areas are provided in Appendix XII.

The summary provided above indicates that 9 of the 27 species/stock combinations do not have precautionary approach frameworks developed. For some of these stocks this work is ongoing. In order to address Canada's obligations respecting the United Nations Fisheries Agreement and to address industry needs related to Certification of Fisheries, all fishery resources should be targeted for precautionary approach frameworks including the determination of reference points and harvest control rules (HCR).

SCIENCE GAP: Many stocks that are assessed in the waters around Newfoundland and Labrador are not yet associated with Precautionary Approach Frameworks including the determination of reference points and HCRs.

In addition, many of the stocks that are not described within the precautionary approach framework are those categorized as being data poor that are simply assessed using trends in catch, commercial effort or research vessel data. There are techniques employed in other areas (e.g. Maritimes Region, DFO) that are aimed at developing PA reference points for these types of data-poor stocks. This has not yet been completed for stocks in the waters around Newfoundland and Labrador.

SCIENCE GAP: There is no process for stocks in waters around Newfoundland and Labrador to address the precautionary approach requirements for data-poor stocks.

5.2 Short Term Prospects for Atlantic Cod, Snow Crab, Shrimp and Capelin

5.2.1 Introduction

Information used in this section was taken from DFO Canadian Science Advisory Secretariat Science Response 2014/049. Short-term Stock Prospects for cod, crab and shrimp in the Newfoundland and Labrador Region (Divisions 2J3KL). Information on capelin was taken from the most recent assessment.

There have been many observations indicating that bottom-water temperatures off the East Coast of Newfoundland and Labrador have been increasing since the mid-1990's. These conditions are expected to remain high or continue to increase (more gradually) for more than a decade to about 2030, based on the Aquatic Climate Change Adaptation Services Program (ACCASP).

Scientists agree that while the return to a warm regime should be favorable for Atlantic cod, there are other factors (e.g. abundance of a primary prey such as capelin) affecting stock growth and productivity. For snow crab, warm conditions are associated with low survival soon after settlement and weak subsequent recruitment. Effects of warming are most unclear for Northern Shrimp because variable recruitment dynamics which likely involves multiple factors interacting with temperature.

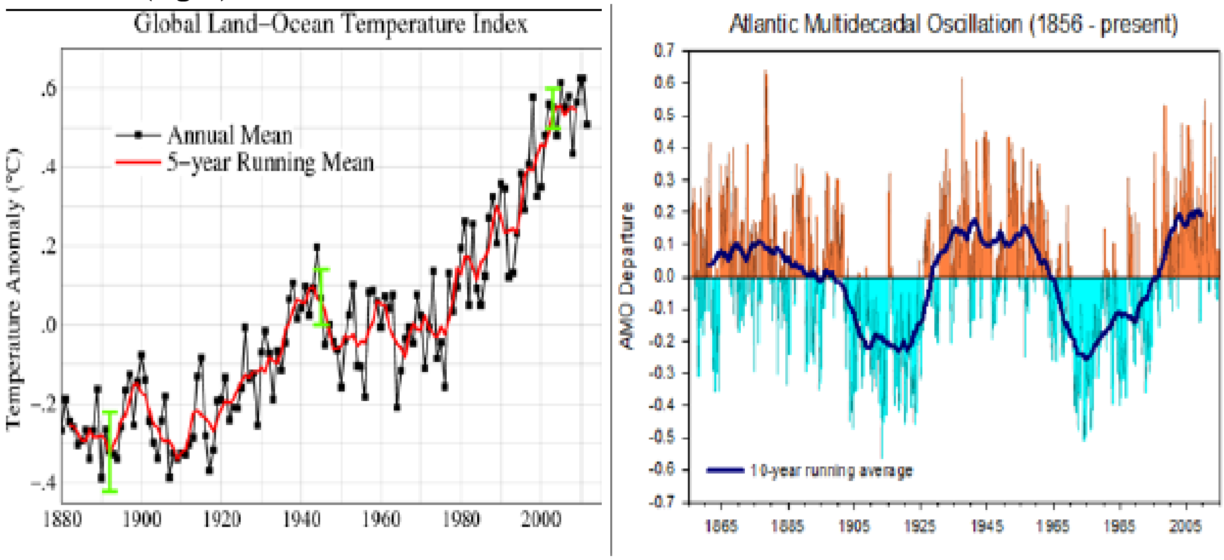
With very limited new analyses the report attained a consensus view of the resource prospects, based primarily on the most recent stock assessments and information previously peer-reviewed. The process also identified the main uncertainties and their potential consequences on resource prospects.

5.2.2 The Environment and Lower-trophic Levels

The recent warming trend in the climate system is most likely driven by an increase in temperature associated with both global climate warming and the warm phase of the Atlantic Multi-decadal Oscillation (AMO) The current warm phase of the AMO is expected to continue for another 1-2 decades before transitioning back to the cool phase (Exhibit 5.3).

Global rise in air temperatures have led to a general increase in regional sea surface and bottom temperatures since early to mid-1990's (Exhibit 5.3). In addition, extent of sea ice and the cold shelf water mass (cold intermediate layer) has been in decline since the early 1990's. The long-term trend indicates continuation of a warm regime. Although short-term projections of ocean climate conditions remain highly uncertain due to variability associated with large-scale atmospheric forcing, it will likely be above or close to normal in the next 3-5 years.

Exhibit 5.3: Global land-ocean temperature index (left) Atlantic Multi-Decadal Oscillation (right)



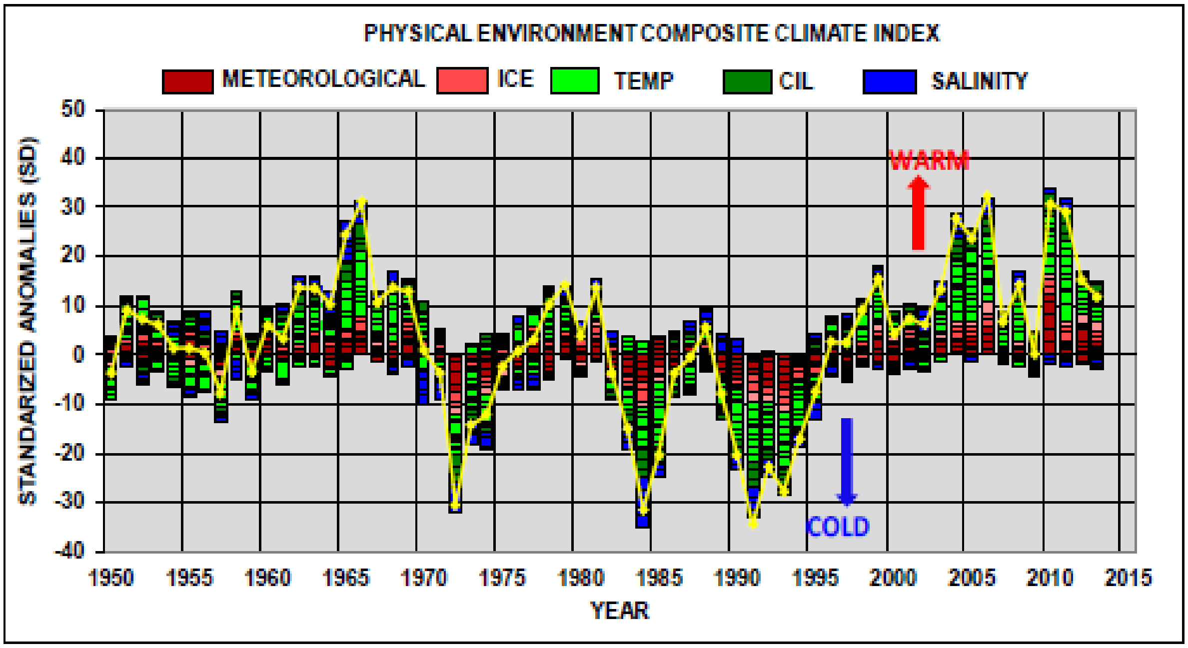
Source: Hansen, J. et al. 2006 (left), D. B.; Cid-Serrano, L. 2010 (right)

The composite index is a measure of the overall state of the Northwest Atlantic Ocean climate system with positive values representing warm-salty conditions and negative values representing cold-fresh conditions. The overall composite index clearly defines the cold/fresh conditions of the 1970s, 1980s and early 1990's, the recent warming and freshening trend that peaked in 2006 and the 3 years of relatively cooler conditions of 2007-09. In 2010, the composite index increased sharply to the 2nd highest in the 63-year time series. In 2011 it was very similar to 2010, the 4th highest in 63 years, but in 2012 it had decreased to the 8th highest (Exhibit 5.4).

Analysis of satellite ocean color data has detected shifts toward earlier timing and more intense spring blooms. These trends are expected to continue under the current warm regime. Recent changes have also been noted in timing and abundance of key zooplankton taxa that may also be indicative of changes in overall productivity.

Large-scale environmental trends and climate projections indicate global surface air temperature has increased ~0.2°C per decade in the past 30 years. Short-term statistical projections show that limited change from current conditions is expected until about 2015 - 2020 for both sea surface and bottom temperature based on patterns of variation in projected air temperature. Projections from a Canadian Regional Climate Model indicate that a long term increase of approximately 0.3°C/decade can be expected.

Exhibit 5.4: Composite climate index



Source: Colbourne, E. et al. 2013.

5.2.3 Ecosystem Structure and Trends

The NL Shelf marine ecosystem is organized in two major functional components, the northern Newfoundland and Labrador shelf and the Grand Bank proper, with the northern Grand Bank (nominally NAFO Div. 3L) acting as a transition zone between these two major regions. The marine ecosystem in NAFO Divs. 2J3KL mostly corresponds to the northern component, but also includes the transition into the Grand Bank ecosystem.

The fish community in Div. 2J3KL was historically dominated by groundfish species (e.g. Atlantic cod, American plaice, yellowtail, witch flounders and redfish), with capelin as its core forage-fish species. Anthropogenic impacts (e.g. overfishing, climate change), in conjunction with changing environmental conditions (e.g. AMO) led to a regime shift in the early-mid 1990's, which involved significant changes in community structure. The fish community became dominated by shellfish species like Northern shrimp, while traditional groundfish species and capelin declined to very low biomass levels.

Between the mid-1990's and early 2000s, the fish community showed a relatively stable structure, with shellfish (mostly Northern Shrimp) dominating the overall biomass. During this period, and with capelin at very low levels, Northern Shrimp became a key forage species for core fish predators. The cod diet was dominated by shrimp, and the fraction of shrimp in the turbot diet increased.

By the mid-late 2000s the community structure started to change. Fish functional groups began to show increases in biomass, and shellfish started to decline. Although showing positive trends, historically dominating groundfishes (e.g. Atlantic Cod, American Plaice) and capelin remain well below their pre-collapse levels, while Northern Shrimp is at or below the biomass levels observed in the mid-1990's.

If current trends persist, it could be expected that the fish community in NAFO Divs. 2J3KL would return to a groundfish-dominated structure. It remains uncertain how similar this emerging structure will be to the historical ecosystem, in terms of both species composition and overall biomass levels, or at what rate these changes would occur.

5.2.4 Stock Status and Resource Prospects for Snow Crab, Shrimp, Cod and Capelin

Snow Crab

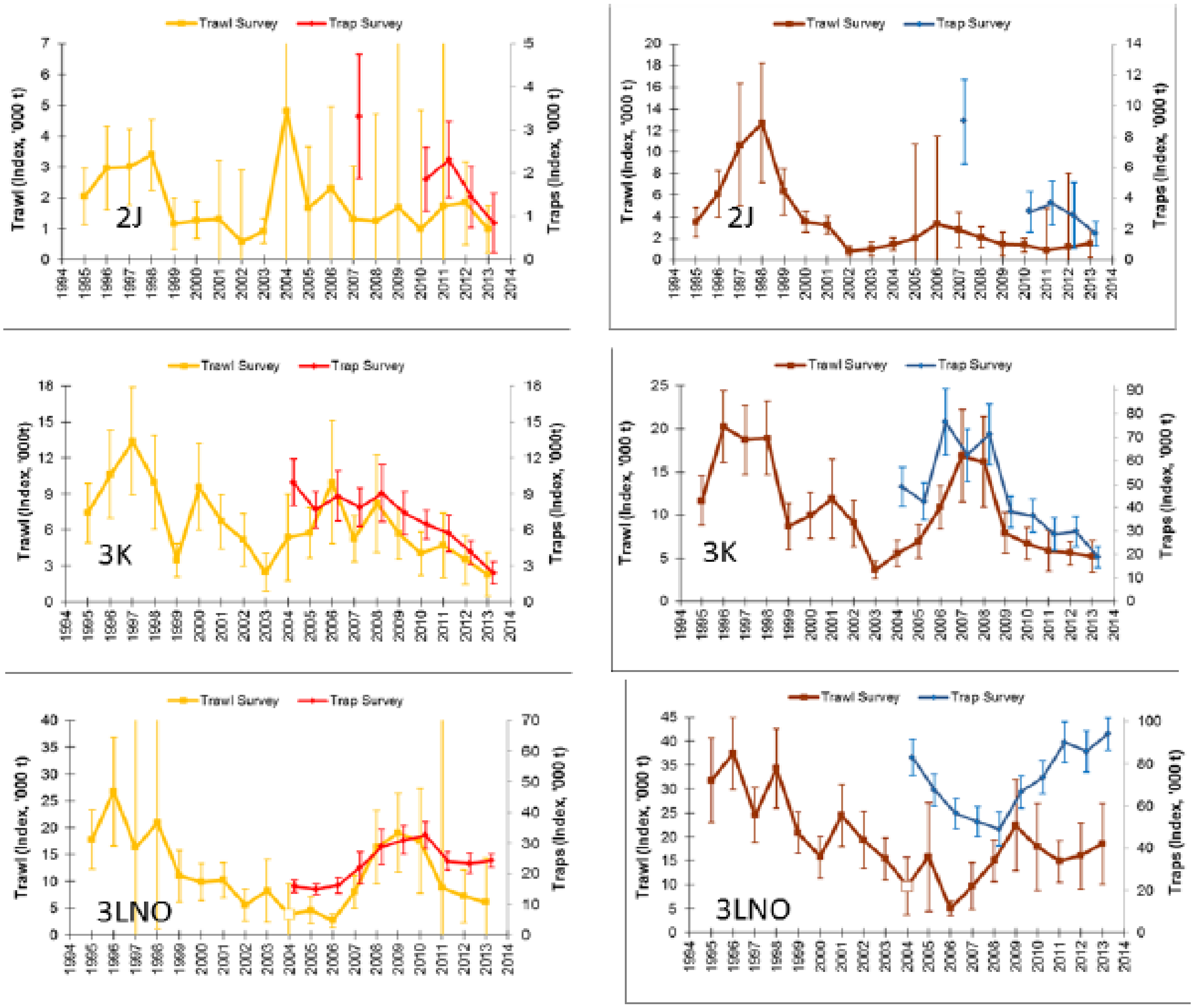
Stock Status: It is currently not possible to estimate absolute biomass. Survey indices suggest that the overall Div. 2J3KLNO exploitable biomass has changed little in recent years. However, it declined by about 74% in Div. 2J from 2006-2011 (Exhibit 5.5), while landings declined by 37%. Similarly, it declined by about 68% in offshore Div. 3K from 2008-2013, while landings declined by 50%. In contrast, the exploitable biomass has increased in Div. 3LNO. As a result Div. 3LNO has accounted for an increasing percentage of the overall 2J3KLNO exploitable biomass in recent years, from about 40% in 2008 to 75% in 2013. Div. 3NO is included in the Div. 3LNO management unit, but most of the Snow Crab resource is within Div. 3L.

The offshore Div. 3LNO trawl survey exploitable biomass index has been highly variable, but declined by almost an order of magnitude over a decade from the start of the survey series to 2006. The post-season trap and trawl surveys do not agree, with the trap survey exploitable biomass index declining by almost half over 4 years to 2008 (Exhibit 5.5). It is believed that the trend in the trap survey index better reflects the trend in the exploitable biomass because it is supported by the increasing fishery performance during that time. The trap survey suggests that the Div. 3LNO exploitable biomass has almost doubled since 2008. Meanwhile, landings have been maintained at a constant high level (about 24,000-29,000 t) over the past two decades.

Prospects:

- The overall exploitable biomass has changed little since the mid-2000's. However, both the trap and trawl surveys indicate that Div. 3LNO has accounted for an increased percentage in recent years, from about 40% in 2008 to 75% in 2013.
- Overall, recruitment is expected to decline in the short term (2-3 years).
- A recent warm oceanographic regime suggests weak recruitment in the long term.
- The exploitable biomass has recently declined (and is expected to remain low) in Divisions 2J and 3K, and a decline is expected in Divisions 3LNO in the near future.
- The nature and magnitude of the expected decline in Div. 3LNO and Div. 2J3KLNO overall, within the next 5 years, are unknown

Exhibit 5.5: Pre-recruit (left panels) and exploitable (right panels) biomass index from trawl and trap surveys



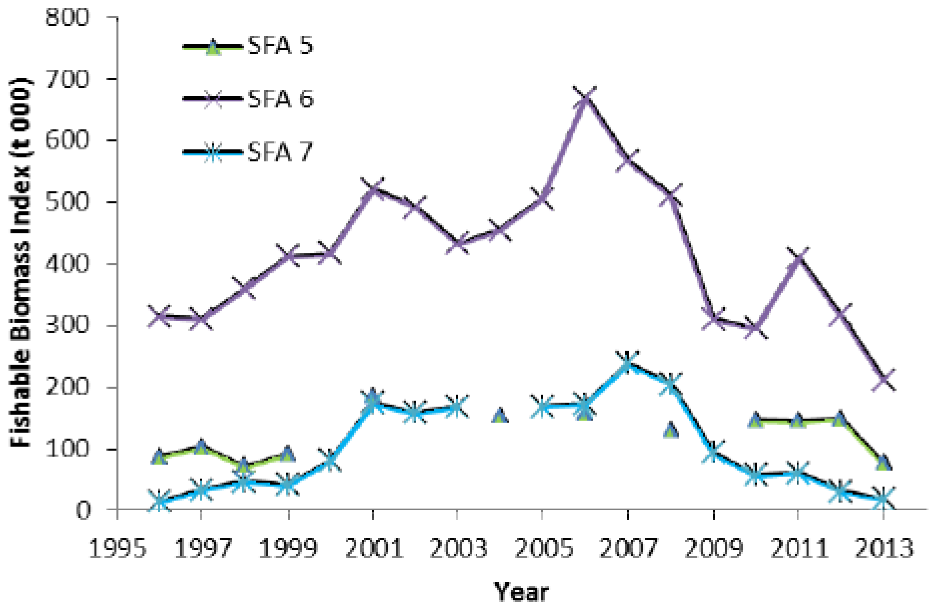
Shrimp

Stock Status: The Northern Shrimp resource is managed by Shrimp Fishing Areas (SFAs), which do not conform exactly to NAFO Divisions. SFA 5 (Div. 2HJ) is dominated by Div. 2H and it includes only a minor portion of the overall Div. 2J3KL resource. Most of the overall resource resides in SFA 6 (Div. 2J3K). The fishable biomass indices have declined substantially since 2006 (Exhibit 5.6). The rate of decline increased from north (SFA 5) to south (SFA 7; Div. 3L). The SFA 5 fishable biomass index decreased by 48% from 147,000 t in 2012 to 76,000 t in 2013 and is presently at the pre-2000 level. The SFA 6 fishable biomass index decreased by 68% from 670,000 t in 2006 to 212,000 t in 2013, the lowest level in the time series. The SFA 7 fishable biomass index decreased by 92% from 238,000 t in 2007 to 18,000 t in 2013, near the lowest level in the time series.

Female spawning stock biomass (SSB) is a part of the fishable biomass and is used to determine the status of the resource within the precautionary approach framework. The

SFA 5 resource is currently estimated to be in the healthy zone, with a 33 % chance of being in the cautious zone. The SFA 6 SSB is at its lowest level in the time series and remains in the cautious zone, but well below the 2012 point. NAFO Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for the biomass limit reference point or Blim (approximately 19 000 t) for Northern Shrimp in Div. 3LNO. The NAFO assessed SFA 7 resource has declined since 2007, and in 2012 the SSB point estimate was marginally above the Blim level, with a 43% chance of being below Blim. Recent data indicate the SSB was below the Blim level in 2013.

Exhibit 5.6: Northern shrimp fishable biomass index



A preliminary analysis of the shrimp annual surplus production rate in NAFO Divs. 2J3KL indicated that it has been reduced since the mid-2000s, particularly in the southern area (Div. 3L). Reduced shrimp production rates were associated with the recent warming trend, early timing of the phytoplankton bloom, increasing biomass of predatory fishes, and fishing, with typical lags in the range of 2-4 years. The underlying mechanisms behind these associations are not fully understood.

Prospects:

- Shrimp fishable biomass in NAFO Divs. 2HJ3KL has declined to its lowest level in the time-series.
- The severity of the decline increases from north (SFA 5: Div. 2HJ) to south (SFA 7: Div. 3L). Corresponding with this pattern, the resource is currently estimated to be in the healthy zone in SFA 5 (Div. 2HJ), in the cautious zone in SFA 6 (Div. 2J3K), and in the critical zone in SFA 7 (Div. 3L).
- Annual shrimp surplus-production rate appears to be reduced since the mid-2000s, particularly in Div. 3L.
- Reduced shrimp production rates were associated with the recent warming trend, early timing of the phytoplankton bloom, increasing biomass of predatory fishes, and fishing.

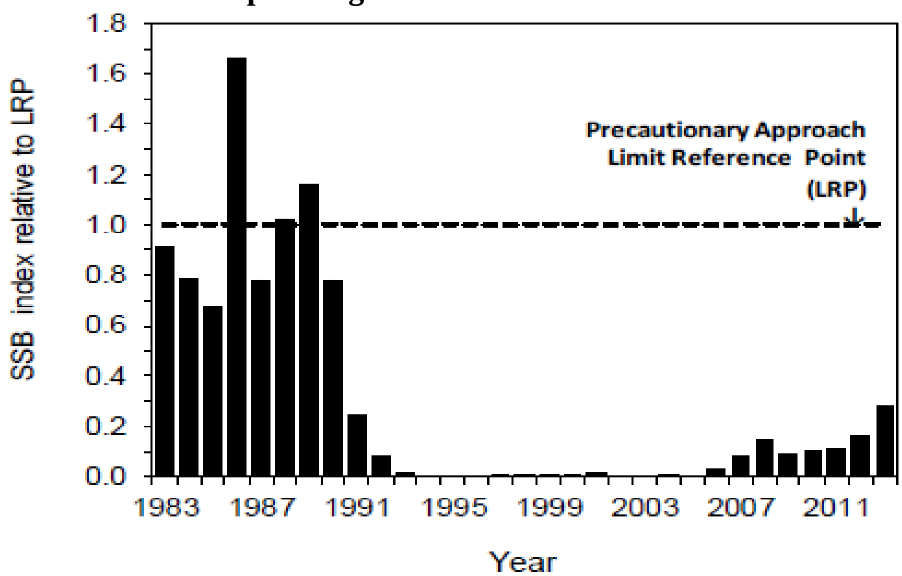
- The fishable biomass is expected to remain low or decline further over the next 5 years, based on the delayed response of shrimp production to recent and anticipated future unfavorable conditions.

Northern Cod

Stock status: The spawning stock biomass (SSB) index declined rapidly in the late 1980s and early 1990's and has been well below the LRP (Blim, or biomass Limit Reference Point; DFO, 2010) for more than two decades (Exhibit 5.7). The SSB index was low (<2% of the LRP) during 1993 to 2005 but shows an increasing trend after 2005. This trend has been linked to the increased availability of capelin. The three-year average SSB index during 2011-13 represents 18% of the LRP.

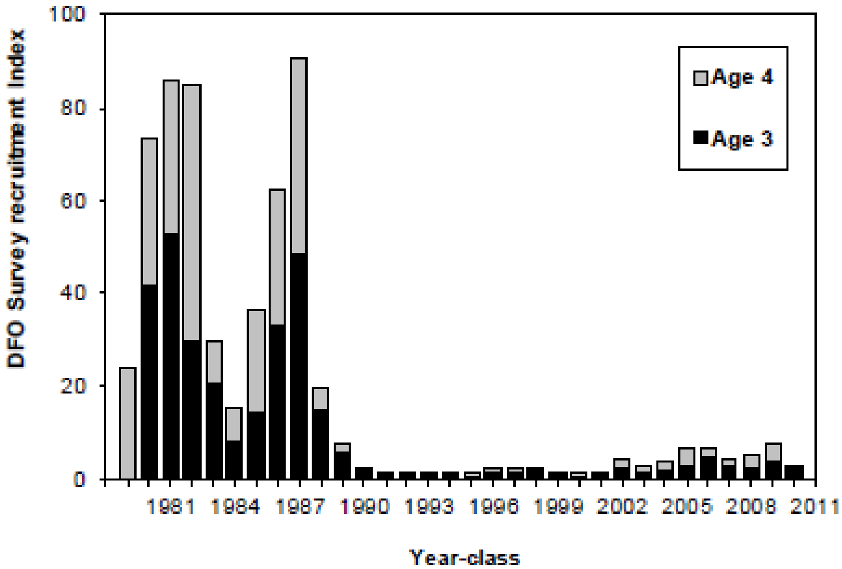
The SSB from DFO RV surveys and sentinel catch rates (inshore) do not show a clear trend during 2008-2012. Tagging results suggest that exploitation rates (% harvested) have been about 5% per annum. The lack of a clear upward trend in SSB indicates the stock has not been particularly productive during this period and has not generated much surplus production. However, on the positive side, survival has improved compared with the 1990's; older cod are now being observed offshore, the age structure has expanded, and the distribution of cod in the 2012 and 2013 DFO RV and Sentinel surveys shows some expansion northward in Divs. 3K and 2J.

Exhibit 5.7: Cod spawning stock biomass index -2J3KL



The number of recruits (ages 3 and 4) in the autumn RV survey in the 1990's has consistently been much lower than during the 1980s, but improved slightly in year-classes produced from 2002 to 2009 (Exhibit 5.8). Northern cod typically take about 5 years to reach maturity and recruits (ages 3-4) will contribute to the SSB and fishery 1-2 years later. There are no indications of major changes to SSB due to incoming recruitment (ages 3-4) in the next 1-2 years.

Exhibit 5.8: Cod recruitment index – 2J3KL



Prospects:

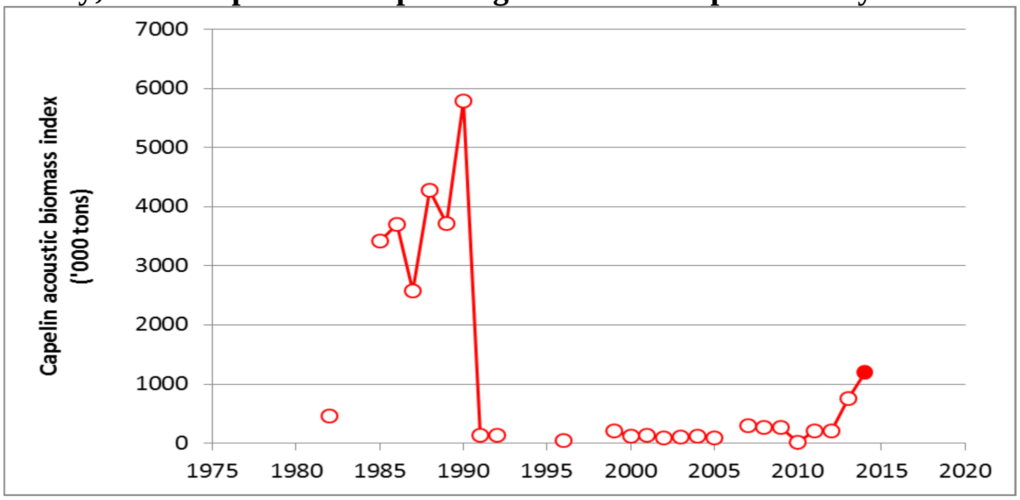
- Based upon the autumn DFO surveys the three year average SSB increased from 12% of the limit reference point (LRP) in 2010-2012 to 18% in 2011-13. The stock has shown some improvement after 2005 but has remained below the LRP (in the critical zone) since the early 1990's.
- There are no indications of major changes to SSB due to incoming recruitment (ages 3-4) in the next 1-2 years.
- Under productivity conditions observed during 2010-2012 (fishing mortality, natural mortality, and recruitment) the average SSB has been projected to remain stable, well below the LRP.
- No projections are available using 2013 survey results, but preliminary indications suggest improved survival and more abundant pre-recruits (ages 1 and 2). If these conditions persist then SSB could improve in 4-5 years (2018-2019), but would likely remain below the LRP.
- If the 2013 survey result was an overinflated estimate for both biomass and recruitment (year effect) the stock will continue to experience relatively high total mortality and will decline rather than experience growth.

Preliminary observations by CFER scientists suggest that the distribution of 2J3KL cod has been expanding during recent Celtic Explorer surveys. This is consistent with perspectives from fish harvesters who participate in the annual stewardship fishery. These harvesters contend that the high abundance and the current distribution of cod resemble historical patterns and is evidence that a significant recovery has and is taking place.

2J3KL Capelin:

Stock status. Fish harvesters report normal distribution and abundance in areas fished in recent years. In addition, in 2012 the DFO spring acoustic survey and the spring multi-species survey reported that capelin have shifted from the shelf break onto the shelf, along the coast, and further south, a pattern typical of the 1980's. Zooplankton abundance has also been above average in recent years, which is favorable for capelin growth, distribution and spawning. The recent hydro-acoustic estimates of capelin are the highest in over 20 years (exhibit 5.9)

Exhibit 5.9. Trend in the capelin acoustic biomass index from DFO spring capelin survey; the data point corresponding to 2014 is still preliminary.



Prospects:

- It would appear that given the various signals regarding capelin distribution and abundance it may be expected that recent success in the capelin fishery in NL should continue for the medium term.
- The current ecosystem shift back to that observed in the 1980's would suggest that recent improvement in capelin abundance should continue, similar to that of cod and other groundfish.

6.0 SCIENCE GAP ANALYSIS

6.1 Summary

There were several science gaps identified throughout this report. Additionally, there are other gaps that have been identified though the consultation process of this project. There have been gaps identified in areas that generally align with three themes:

- Fisheries science monitoring/stock assessment in Newfoundland and Labrador
- The Centre for Fisheries and Ecosystem Research at the Fisheries and Marine Institute
- Collaboration opportunities between science institutions and/or fishing industry

In addition there are a small number of gaps that do not fit into the above three themes. A summary of all gaps is as follows:

Fisheries Science/Stock Assessment

- Lack of science capacity related to stock assessment modeling
- Lack of assessment models for some key stocks (snow crab, shrimp, capelin).
- A number of stocks do not have Precautionary Approach Frameworks.
- There is no process for the implementation of PA Frameworks for data-poor stocks.
- Lack of Management Strategy Evaluation expertise for the determination of Harvest Control Rules (Capacity for this work not available at DFO).
- There is no analytical integration of ecosystem considerations into stock assessments.
- There is a lack of required multi-species data to fully implement ecosystem approaches.
- For some stocks there is not a complete record or estimation of total removals.
- There is a gap in coverage for the spring capelin acoustic survey.
- Additional work on study of long-term productivity of the ecosystem would be beneficial.

Centre for Fisheries and Ecosystem Research

- Ongoing funding for maintaining CFER operations and vessel charter is required.
- There could be additional collaboration between CFER and DFO on assessment modeling projects.
- CFER does not have research survey capacity in near-shore areas.

Collaborations between Science institutes and industry

- There is a requirement for a substantial stable funding source to facilitate collaboration between science institutes and/or fishing industry participants.
- No defined funding source for the science work required for emerging fisheries.
- No defined funding source for the science work required for certification of

fisheries.
- Collaboration should be encouraged related to work on Aquatic Invasive Species.

Other identified gaps

- Scholarships in the fisheries and ecosystem field of research.
- Industry participants are not utilized in a general way to collect data from commercial fisheries.

6.2 Scientific Assessments and Related Science Activities

As identified in earlier sections of this report, the Department of Fisheries and Oceans has the formal mandate for implementing scientific programs in the marine waters around Newfoundland and Labrador. This includes stock monitoring through the use of large and small research vessels and the completion of assessments of stock status for a variety of groundfish, shellfish and pelagic fishery resources. There is also a long list of other activities conducted by DFO in the delivery of their full scientific program (Appendix VII).

In the past several years the Marine Institute and fishing industry representatives and associations have also been participating in data collection programs and stock assessment processes. CFER at the Marine Institute, among other things, conducts large-vessel research surveys along the NE/South Coasts of NL, presents results of this work at DFO sponsored assessment meetings, and works on the development of stock assessment methodology. Industry also conducts surveys and participates in assessment meetings.

Results of stock assessments. Results of the assessments were examined for 27 species/stock combinations in areas around Newfoundland and Labrador (Divisions 2J3KLNOP4RST). Many of these stocks were assessed by DFO (NL, Quebec and Maritimes Regions) while the Scientific Council of NAFO assessed a smaller number. Results of these assessments were examined for:

- Resource prospects.
- Assessment modeling techniques utilized.
- The implementation of the precautionary approach frameworks.
- Ecosystem considerations.
- Species specific issues.

There is also a short discussion included here on the study of long-term productivity of the marine ecosystem.

Resource prospects. Regarding prospects, the status of the resources examined can be described as healthy or in the safe PA zone (9 stocks), in moderate condition or in the PA cautious zone (7 stocks), low or below the PA Limit Reference Point (LRP) but having a positive growth trajectory (6 stocks), and finally low or below the PA LRP, but not increasing (6 stocks).

The following table summarizes the results of the resource prospects for 27 stocks reviewed (NL snow crab is subdivided for the purposes of this table).

Exhibit 6.1: Precautionary approach status or subjective view of stock status of fisheries reviewed

Healthy or PA Safe Zone	Moderate or PA Cautious Zone	Low or PA critical zone - rebuilding	Low or PA Critical zone - no rebuilding
3LNO Yellowtail	3Ps Cod	2J3KL Cod	4RS3Pn Cod
3+4 Atl Halibut	3NO Witch flounder	3NO Cod	U1+2 Reds Mentella
3LN Redfish	SFA 5 Shrimp	3LNO Am Plaice	3L Shrimp
SFA 4 Shrimp	SFA 6 Shrimp	2+3K Reds Mentella	3+4 Mackerel
4R Shrimp	2+3 GL Halibut	2+3K Reds Fasciatus	4RHerring
4RST Atl Halibut	4RST GL Halibut	U1+2 Reds Fasciatus	2J3KPs Snow Crab
4RST Capelin	3LNO Snow crab		
	NL Lobster		
	2J3KLPs Capelin		

Note: There are 28 stock/areas in the table as NL Snow Crab in included for 3LNO and 2J3KPS separately

Assessment modeling. Assessment approaches for Canadian stocks are summarized in Section 3 of this report. This analysis indicates that while many stocks are assessed using analytical techniques there are still many stocks that are assessed using trends in research vessel catches or commercial catch per unit effort. There is work ongoing within the international science community (e.g. ICES Methods Working Group) related to the development of new techniques that utilize current models as well as the implementation of completely new assessment techniques.

SCIENCE GAP: Given retirements, other staff movements and current workloads there is currently a shortage of Scientists in Newfoundland and Labrador who are working on assessment modeling techniques.

Some of the stocks where stock status in determined using trends in research vessel or commercial catch data are very important to the Newfoundland and Labrador fishery sectors and by extension many rural areas of this province. These include: NL Snow crab, shrimp, lobster, and capelin fisheries. There is currently a collaborative project between DFO, CFER and the Northern Shrimp Research Foundation aimed at developing an analytical assessment model to be used for shrimp stocks. The development of suitable analytical models for assessment will enable researchers to better incorporate data from many sources that should result in more reliable estimates of stock status. Assessment models will also facilitate the development of precautionary approach frameworks and detailed rebuilding plans.

SCIENCE GAP: A number of key stocks (snow crab, shrimp, lobster and capelin) in Newfoundland and Labrador are not assessed using analytical assessment models/techniques.

Precautionary approach frameworks. The summary provided above indicates that 9 of the 28 species/stock combinations do not have precautionary approach frameworks developed. For some of these stocks this work is ongoing. In order to address Canada's obligations respecting the United Nations Fisheries Agreement and to address industry needs related to Certification of Fisheries, all fishery resources should be targeted for precautionary approach frameworks including the determination of reference points and predetermined harvest control rules (HCR).

SCIENCE GAP: There are many stocks that are assessed in the waters around Newfoundland and Labrador where various reference points have not been determined. This prohibits the implementation of Precautionary Approach Frameworks including the determination of HCRs.

In addition, many of the stocks that are not described within the precautionary approach framework are those categorized as being data poor that are simply assessed using trends in catch, commercial fishing effort or research vessel data. There are techniques employed in other areas (e.g. Maritimes Region, DFO) that are aimed at developing PA reference points for these types of data-poor stocks. This has not yet been completed for stocks in the waters around Newfoundland and Labrador.

SCIENCE GAP: There is no process for stocks in waters around Newfoundland and Labrador to address the precautionary approach requirements for data-poor stocks.

Management strategy evaluation and harvest control rules. Management strategy evaluation (MSE) was conducted for the development of harvest control rules (HCR) for the 2+3KLMNO Greenland halibut stock in 2010 and more recently for 3LN Redfish. This strategy requires a comprehensive and quite intensive computational process involving managers, stakeholders and experienced scientists. At the present time the Department of Fisheries and Oceans does not have the expertise to fully complete this process for other stocks. In fact the scientific experience/capacity to complete these evaluations is not broadly available internationally. There are a small number of scientists doing this type of work around the world.

SCIENCE GAP: Management strategy evaluations (MSE) for the analytical determination of Harvest control rules (HCR) have only been completed for 2 stocks in the NL area. Additional work in this regard is required. DFO currently does not have the scientific expertise to complete this analysis. There are only a small number of scientists world-wide who have the experience required for this type of work.

Ecosystem considerations. Most of the summary documents for various stocks assessments reviewed for this report contain information related to ecosystem considerations. This is true for Canadian assessment processes through CSAS as well as for those assessments conducted by the Scientific Council of NAFO. This is more fully described in Section 4 of this report. These ecosystem considerations often contain summaries of relevant data on temperature, habitat, predator/prey, etc. Although assessments attempt to evaluate impacts on stocks of significant changes in key indicators, no jurisdictions, including Canada, have truly integrated ecosystem considerations into analytical assessments.

SCIENCE GAP: Analytical assessments for stocks assessed in Newfoundland and Labrador do not formally integrate ecosystem considerations. It should be noted that this Science gap is also prevalent in virtually all international jurisdictions.

During most Research Vessel surveys conducted in Atlantic Canada there is data collected on key commercial species and many climate indicators are regularly measured. However there is less information collected on marginally commercial or non-commercial species. The collection of this data will be important to realize a full ecosystem approach for science and management.

SCIENCE GAP: For full Ecosystem-based science there is a lack of multi-species data and approaches compared with traditional single species approaches to science and management. There is also a lack of data collected on stomach contents that is normally used for predator/prey analysis.

Species Specific Issues.

Total removals of cod and mackerel. There are two issues that have been identified in assessment reports as causing difficulty in interpreting assessment results. With respect to discussions on 2J3KL cod as well as in the assessment report on Subarea 2+3 Mackerel it is noted that the total removals from each stock is not available.

This lack of a complete record of the total catch may inhibit scientists from completing specific assessment modeling techniques and causes uncertainty in the interpretation of assessment results. With respect to 2J3KL cod there is no estimate of recreational catches and for mackerel there is no estimate for direct sales between fish harvesters, the removals in the bait fishery or recreational catches. It should be noted that in other jurisdictions there are processes used for the estimation of total catches for those fisheries where total removals are not officially available.

SCIENCE GAP: In some cases there is no record of total annual removals from fisheries for some stocks. This gap is noted in cod and mackerel assessment documents, but may also be an issue for other stocks.

DFO capelin acoustic survey. In the report of the 2+3KL capelin assessment it is noted that the current spring acoustic survey only covers a portion of this stock. Further investigation revealed that the DFO spring capelin acoustic survey is conducted for a 25 day period and covers the 3L area as well as a small area in southern 3K. The 25 day time period includes 5 days for acoustic calibration and 20 days for the actual survey. It is likely that capelin distribution extends beyond this area surveyed into other areas in Division 3K.

SCIENCE GAP: The current DFO spring acoustic survey for 2+3KL capelin does not cover the entire distribution of this resource. The current survey covers 3L and a smaller area in southern 3K. Additional distribution may occur in other areas in 3K.

Long-term research into productivity of the ecosystem: The key influences on recruitment, growth and mortality rates for the major commercial fish stocks around NL are generally not well understood. Of particular importance are dynamics in response to population levels (e.g., spawning stock), fishing and climate dynamics that change at decadal and longer scales. As potentially important are the productivity dynamics of lower trophic levels, in particular that of the forage species, that directly support productivity in higher trophic levels and hence commercial fisheries.

The impacts of climate change are thought to be particularly relevant to changing stock productivity and sustainability, and may vary regionally and almost certainly by species. Food-web interactions may mediate the effects of changing fishery regimes, for example consumption rates of shrimp and crab by the northern cod may change as the cod stock increases in abundance and age composition. In addition, range expansions or contractions that differ among species are likely to occur with changing climate, with implications for food-webs, stock delineation and assessment.

The knowledge gaps about commercial fish productivity and the influences of climate change lead directly to issues in stock assessment and management. They are the opposite sides of the same coin. Without knowledge of productivity dynamics, it becomes problematic to specify stock assessment models that will inform management of sustainable fishery removals with reliable stock projections.

SCIENCE GAP: While DFO currently has scientists working on various components of the long-term productivity of the marine ecosystem, this is such an important issue that additional human resource capacity may prove to enhance the knowledge base in this area.

6.3 The Centre for Fisheries and Ecosystems Research (CFER)

The description of CFER is included in Section 2. This description outlines:

- Origin of the Centre
- Mandate and programs
- How CFER fulfills its roles
- Research vessels
- CFER's current activity
- CFER's Financial Summary

The most critical issue to be addressed regarding fisheries research at the Fisheries and Marine Institute is the creation of a long-term, sustainable funding source for CFER to continue its research program and to provide stability for research scientists, the graduate students and other staff at the Centre. To date, this issue of permanency and stability for personnel has been a problem in recruiting highly qualified people and will likely lead to challenges of retaining current personnel if not addressed. CFER is well positioned to build on its capacity in the area of fisheries population and stock analysis, which is a need in Canada as well as globally.

SCIENCE GAP: Funding for CFER, including operations and the large offshore vessel charter beyond spring 2016 have not yet been identified.

CFER scientists have completed or are currently working on projects related to stock assessment modeling techniques that could eventually be implemented by DFO scientists in completing stock assessments. It is therefore, beneficial to include DFO stock assessment researchers as collaborators.

SCIENCE GAP: There should be enhanced collaboration between CFER and DFO scientists respecting projects related to stock assessment techniques/modeling.

In addition to the ongoing research that CFER conducts, it would also be useful that CFER conduct research on near shore and mid shore resources. A vessel in the 100-125 foot range would be useful for surveys of snow crab, capelin, herring, Greenland halibut, mackerel, scallops, near-shore cod, as well as a variety of new or emerging fisheries such as whelk, sea cucumber, etc. Such a vessel would be able to operate throughout Newfoundland and Labrador. A vessel in this size range could be fully equipped with mapping and remote operated vehicle equipment and could be used for direct research as well as providing access for graduate students from CFER and other MUN programs. The Marine Institute currently has a vessel in the size category, the MV Anne Pierce, however it is understood that this vessel may soon need to be replaced. This vessel has been used for many MI programs outside of the CFER scientific mandate.

SCIENCE GAP: CFER currently does not have the capability to monitor/survey near-shore areas in Newfoundland and Labrador related to the study of snow crab, capelin, herring, halibut, mackerel, scallops, near-shore cod as well as emerging fisheries such as whelk, sea cucumber, etc.

6.4 Science-industry Collaboration

Traditionally information used for stock assessments or other biological studies were collected and analyzed exclusively by DFO. Over the past twenty years this has changed, with individual stakeholders, harvester associations, producer associations, and independent research bodies participating in science activities in collaboration with DFO. Most believe this collaboration fosters stewardship and has resulted in the establishment of DFO's Fisheries Science Collaborative Program (FSCP). This program provides access to federal funding, $1.5M annually, to facilitate industry-DFO collaborative work in Canada's marine area.

Recently the provincial government has funded the Centre for Fisheries Ecosystem Research (CFER) at the Marine Institute. This investment has led to additional collaboration between CFER and DFO-NL as well as with industry and institutional participants

The benefits of science-industry collaboration are clear and are well known to scientists and fishing industry organizations. The science community is comprised of experienced research scientists, fishery biologists and research technicians. They also have resources to collect data through research vessel surveys, sampling for age and length from commercial fisheries, analysis of commercial CPUE, catch monitoring and at-sea observer programs. On the other hand, the fishing industry have access to a large number of vessels using a variety of fishing gears as well as a wealth of knowledge regarding fishing areas and local fish distribution.

Fishery science/industry collaboration also leads to a greater understanding by industry participants of the complex process of fish stock assessment and various biological processes that underpin these analyses.

A large number of industry-science collaborations have occurred or are now occurring in waters adjacent to NL. Examples of the current collaborative projects are listed below:

- Sentinel surveys for cod in many areas (DFO/FFAW).
- Northern shrimp research survey (NSRF/DFO).
- Microsatellite analysis, genotyping, of redfish stocks (GEAC/DFO).
- Impacts of closed areas on fisheries (CFER/DFO/FFAW).
- Atlantic Halibut tagging in 4RST (CFER/DFO/FFAW).
- Life history and population ecology of cod/haddock in southern NL waters (CFER/DFO).
- Northern shrimp ageing project (CAPP/DFO)
- 2J3KL cod tagging Project (FFAW/DFO).
- Unit 2 redfish survey (GEAC/DFO)
- Post season snow crab surveys (FFAW/DFO)
- Analysis of OCI's Trackwell Electronic Logbook data (CFER/OCI)

SCIENCE GAP: While there is currently ongoing collaboration between science institutions and the fishing industry, funding for these collaborations comes from a variety of sources. Some of these sources are relatively stable, but there is no substantial single source of funding, to augment current ad-hoc funding levels, that can be used to facilitate collaborative work on an ongoing basis.

6.5 The Emerging Fisheries Policy (DFO)

Industry participants regularly seek ways to diversify their fishing enterprises by obtaining additional commercial fishing licences. More often this occurs with the "transfer" of licences from one harvester to another, or by the combining of enterprises. At times, non-traditional species provide an opportunity to expand fishing opportunities. The means of commericalization of these non-traditional species is through DFO's Emerging Fisheries Policy (EFP).

This policy was originally implemented by DFO in the mid 1990's and has been updated since that time. In fact, this policy is currently undergoing an additional review. The EFP clearly defines requirements that must be met and the procedures to follow before a new commercial fishery can be initiated. A cornerstone of the new policy is provision for the establishment of some level of scientific analysis by which stock responses to new fishing pressures can be assessed. The policy provides applicants with a transparent process to follow, it also gives DFO managers a procedure that can be applied fairly and consistently.

As a general rule, new fisheries development is completed in three stages:

- **Stage I (Feasibility)**: The preliminary feasibility stage. The objective of this stage is to: determine if harvestable quantities of the species/stock are known to be present in a particular fishing area, if the species/stock can be captured by a particular gear type, identify multi-species and habitat impacts, if markets exist and, the best approach for proceeding to Stage II.

- **Stage II (Exploratory)**: The commercial and stock assessment stage. This stage is reached when feasibility has been demonstrated. The objective of this stage is to determine whether a species/stock can sustain a commercially viable operation and to collect biological data in order to build a preliminary database on stock abundance and distribution.

- **Stage III (Commercial)**: The commercial fishery stage. This stage is reached once it has been determined that a species/stock can sustain, commercially and biologically, commercial fishing operation. A formal Integrated Fisheries Management Plan is introduced.

The above stages are often not as distinct as illustrated. In some cases it may be advantageous to combine stages I & II. In fact, it may be difficult from a practical perspective in some instances to separate them.

In NL there are a number of species/areas that have completed the three phases required under the emerging fishery policy and are now considered commercial fisheries.

Exhibit 6.2: Fisheries commercialized through emerging fishery policy

Species	Area	Year Commercialized
Sea Cucumber	3Ps	2013
Rock and Toad Crab	Multiple Areas	2007
Shrimp Beam Trawl	3Ps	2007
Sea Urchin	Multiple Areas	2007

There has also been recent interest expressed to DFO regarding an additional 13 species/area combinations. These are not listed here as there may be some proprietary information included as some of these requests have been made by individuals or small groups of fish harvesters.

DFO are tasked and staffed to complete monitoring or review of the scientific work commissioned by fishing industry participants. However, many of the science costs associated with the development of these new fisheries are the responsibility of fishing industry participants, individually or as a group. Clearly this could inhibit the development of many small-scale fisheries.

SCIENCE GAP: There is no identified source of funding that can be used to conduct the scientific assessments required to move emerging fisheries into the fully commercial stage.

6.6 Fisheries Certification

A description of fisheries certification, and in particular those assessed to the Marine Stewardship Council standard, is outlined in Section 4. Performance Indicators from those fisheries already certified result in the need for considerable scientific analysis. In addition, there are also substantial scientific requirements for all initial certifications. Up to this point in time all the scientific work required for the certification of any fishery has been the responsibility of the sponsoring industry sector, association or even an individual company. These costs have been rising over time and with a new MSC standard coming into play in 2015, the financial burden for industry can only grow.

The following information is a summary of the work required based on the performance indicators for currently certified fisheries. This provides the scope of some of the work required in the field. Research plans and research activity in support of habitat knowledge, or harvest control rules is clearly an area that has been a concern in current assessment certificates.

- **Harvest control rules (HCR's)–** In one specific case, three of the four conditions were issued as there was no HCR's that specify actions when stock biological limits are approached, or there were no decision rules to link quota allocations with harvest observations. The remaining condition was due to a lack of control mechanisms on a significant portion of the species. Research relating to developing and implementing HCR's can include:

  - ✓ Support primary stock research to define the stock reference points.
  - ✓ Support secondary research to determine the impact of other factors on stock abundance such as predator or prey abundance, environmental factors, and habitat classification.
  - ✓ Conduct modeling to assess the risks associated with setting specific HCR's.

- **Risk to habitat –** Four fisheries indicated more information was required to demonstrate the risk to the habitat. Of particular concern is mobile gear fisheries which directly impact habitat structures including trawling, raking and dredging. In the fisheries reviewed much of the research was available from various sources; however, in all instances either habitat research or secondary research and analysis had to be completed in order to close out the conditions. This included:

  - ✓ Description of the ecosystem elements in the fishery area focusing on benthic communities and tropic relationships.

- ✓ Bottom sediment mapping and surveys, which included submersible dives to observe.
- ✓ Documentation of sensitive habitat overlap and mitigation measures to avoid corals and sponges.
- ✓ Analysis of the fishery overlap with less sensitive habitats determined by maps of bottom sediments.
- ✓ Ecosystem studies, including benthic studies, which while a contribution to knowledge, did not specifically cover the target fishing area.
- ✓ Analysis of the fishery footprint and the percentage of bottom habitat impacted by trawling.
- ✓ Demonstration of the fishery impacts on Ecologically and Biologically Significant Areas (EBSA's).
- ✓ Demonstration of recovery potential of habitat for specific fishing gear.

➢ **Risk to by-catch species –** Two fisheries indicated there was not adequate stock information regarding primary by-catch species. The research and/or analysis required to address the conditions included:

- ✓ Primary research regarding the abundance of species and development of limit reference points and mitigation measures.
- ✓ Gathering and reporting non-target species capture.
- ✓ Demonstration of survivability of released species.
- ✓ Analysis of multi-species research, commercial by-catch and observer data to infer stock trends and document capture quantities, frequency and seasonality.

➢ **Fishery specific objectives:** There must be a published fishery management plan with specific short and long term objectives and strategies to achieve these objectives. Whereas many of these objectives are related to stock health, biodiversity and protection of the ecosystem, research in these fields supports this performance indicator.

➢ **Research plan:** The lack of a clearly defined research plan was a condition in four fisheries. While some research activity is specific to the fishery involved, there were common themes in the four assessments that had this condition.

- ✓ The most common shortcoming was the absence of a documented research plan that takes a strategic approach to research. In all assessments, it was acknowledged that research is being done and in some cases, very significant amounts, but there were identified gaps in research. These gaps were related to stock assessments, habitat or ecosystem information.

  To be acceptable and avoid conditions, the plan has to be in final approved form, be monitored annually with annual updates, where applicable, to the plan, and timely reporting of results. A robust research plan will have a gap analysis to match gaps identified in stock assessments or Integrated Fishery Management Plans (IFMP) that need to be placed in a comprehensive plan. The research plan should address uncertainties mentioned in any supporting documentation.

- ✓ Another common theme was the need for more research directed at ecosystem and habitat issues. One assessment went further and suggested that research, in general, appears to be more focused on supporting stock assessments, modeling and population issues than on the biodiversity and habitat issues. Therefore, there is need for an overriding plan to balance all research requirements.

- ✓ One assessment specified benthic habitat research was required, more extensive identification of habitat in deeper water, and demonstrating the effectiveness of conservation measures regarding habitat and sensitive species.

SCIENCE GAP: There is no identified source of funding that can be used to conduct the scientific analysis required to enable fisheries to meet the conditions to be certified as sustainable under Marine Stewardship Council criterion. Some of these gaps are related to stock assessment, habitat and ecosystems and by-catch recording and evaluation.

6.7 Aquatic Invasive Species

Aquatic invasive species (AIS) have already been responsible for significant devastation of some native fish species and fisheries in Canada. Invasive species thrive in the absence of their native predators and have the potential to drastically alter habitat, rendering it inhospitable for native species. Specifically relevant to NL, is the invasion and growth in abundance of green crabs as well as some species of tunicates. These species have little or no economic value, however, they negatively impact a variety of native species including clams, mussels and oysters.

DFO's new federal regulations to manage and control aquatic invasive species in Canada were posted on December 6, 2014 in the Canada Gazette, Part 1. The 30-day period for public comments has recently concluded.

There is also A Canadian Action Plan to Address the Threat of Aquatic Invasive Species, which was approved by the Canadian Council of Fisheries and Aquaculture Ministers. This plan outlines a national approach for managing AIS.

DFO has a funded program that looks at AIS issues and provides recommendations for management of species that fall into this category. This is an area where enhanced collaboration can assist in dealing with an emerging problem. There should be priority placed on any collaborative projects that are intended to deal with this issue.

SCIENCE GAP: While DFO currently have scientists who are responsible for work on Aquatic Invasive Species, it is noted here as there is a potential for enhanced collaboration between DFO/CFER and/or industry representatives on this expanding problem.

6.8 Scholarships in the Fisheries and Ecosystems Field

The Department of Fisheries and Aquaculture currently funds two scholarship programs.

- The Department of Fisheries and Aquaculture Fisheries Scholarship
- The Dr. Wilfred Templeman Memorial Scholarship

The Fisheries Scholarship is valued at $1,000 and is awarded to students graduating high school and pursing post-secondary education. Students who wish to apply for the scholarship must submit a 2,500 word essay describing what he or she feels is the biggest issue facing the province’s fishing industry and provide suggestions on how that issue would be best addressed. Students must also demonstrate strong academic standing and participation in extracurricular activities. The scholarship provides assistance with the costs of pursuing higher education and was created to encourage youth to become interested in the provincial fishery.

The provincial Government also created an award in honor of Dr. Wilfred Templeman, a pioneer of fisheries research in Newfoundland and Labrador (NL). This scholarship is available to full-time students pursuing a graduate program at Memorial University of Newfoundland, in which groundfish research is the main focus. Successful applicants will receive $2,500 per year for a maximum of two years to support research in a graduate degree program appropriately related to the stated goals of the scholarship.

While these scholarships are a positive development there is currently no scholarship program directly related to post-graduate Fisheries Science/Fish Stock Assessment areas of study. Having this type of scholarship fund available would enable CFER senior managers and scientists to identify early on exceptional fisheries and ecosystem students. This is important in attracting the best possible students into the fisheries and ecosystems and stock assessment line of study. Benefits that may be realized with a scholarship program include recognition among students, faculty and administrators of the Institute, the introduction of these students to career opportunities in the fisheries and ecosystem fields, and expansion of research capabilities within the province.

SCIENCE GAP: There are currently 2 scholarship programs funded by DFA that are directed towards graduating high-school students and students pursuing a graduate program at MUN, in which groundfish research is the main focus. However, there is currently no scholarship program directly related to post-graduate Fisheries Science/Fish Stock Assessment areas of study.

6.9 Data collection

DFO collects a large amount of fishery-dependent and independent data through its commercial fishery sampling program and their extensive research vessel program respectively. CFER also collects fishery-independent from its large vessel offshore surveys. There is also a considerable amount of fishery-dependent scientific data collected by at-sea observers. These observers serve an enforcement and science function. At times, however, the deployment schedule for observers is not optimum for science data collection. There is another source of data collection that is only used through specific programs – this is data collection by commercial fishery participants. Inshore fish harvesters and crew on offshore trawlers collect data from time-to-time on projects like the sentinel fishery, the post season crab survey or from the industry offshore surveys. However, there is no general data collection function that employs fish harvesters or crew on offshore trawlers.

Given the increased documentation needs for science, training fish harvesters and crew members of offshore vessels for data collection may provide an opportunity for cost-effective, reliable, and representative data for some fisheries research and management needs.

Fish harvester data collection programs would not replace the current fisheries observer programs but would supplement and strengthen them. Collaboration would be required between observers and industry data collectors so that the collection program would be considered valid by scientists, managers, and industry. Clear program objectives, strict collection protocols, and a system of checks will also be required.

SCIENCE GAP: Data collection in support of fisheries research is conducted regularly by DFO, CFER and the offshore observers; however there is no general data collection program that utilizes inshore fish harvesters or crew on offshore trawlers. This type of data collection could augment current programs and provide a large base for collection on required fishery-dependent data.

7.0 RECOMMENDATIONS

7.1 Introduction

Fisheries Investment Fund - Timing and approach. Funds in support of implementation of the Comprehensive Economic and Trade Agreement (CETA) are scheduled to be provided over a three year period, likely to commence in 2016 or 2017. There is consensus among those consulted that funding for science related issues should be distributed over a longer time frame than the implementation period. Many believe that a longer time frame will be more appropriate for many of the science initiatives that may require a period longer than 3 years to reach a useful and suitable conclusion. It was suggested that a period in the 5-10 year range will be much more appropriate that any period less than 5 years.

RECOMMENDATION: It is recommended that the funding for the science initiatives identified in this report be distributed over a 5-10 year period. It will be advantageous to have a time frame at the longer end of this range.

There are different processes that can be used to distribute funding allocated for any suite of suggested science initiatives. The simplest approach would be to set aside a specified amount from the Investment Fund to be allocated annually for science initiatives. If it is not possible to extend the funding time frame beyond the CETA implementation period the creation of a legacy fund would be an alternate approach that would enable funding for science to occur for an indefinite period of time. The downside of this approach is that within the current investment market any legacy fund would have to be quite large to generate sufficient cash flow to meet the annual science needs. For the purposes of this report it is assumed that a simple annual allocation will be made to fund initiatives.

Recommendations related to the use of the Fisheries Investment Fund are divided into three themes, similar to the themes outlined in the previous sections on science gaps. These three themes are:

- Fishery Science/Stock Assessment Modeling/Monitoring
- Centre for Aquatic and Ecosystem Research.
- Collaborations Between Science Institutes and Industry including Emerging Fisheries, Certification of Fisheries and Aquatic Invasive Species

There are also recommendations related to two other science gaps that do not easily align with any of the three themes described above.

- Scholarships for Fishery Science
- Data collection by Industry Participants

7.2 Fishery Science/Stock Assessment Modeling and Application

Stock assessments are conducted regularly to determine the status of a fish stock relative to biological reference points. An assessment normally includes an array of scientifically based outcomes that provides fisheries managers with the data necessary to make informed decisions that ensure the health and sustainability of the resource. Stock assessments are the core of existing fisheries science information. Much of the ecological research and developing scientific methodologies are designed and implemented to inform stock assessment and management. In NL, as well as other regions, there is a need for state-of-the-art integrated assessment models that utilize a variety of data sources from the commercial and science activity. This need is particularly acute for primary commercial species.

DFO has the mandate to conduct stock assessments for a variety of species directly, and participate in stock assessments conducted at the Scientific Council of NAFO. Researchers at CFER and several industry groups participate in many of these assessment processes. Regardless of where, when and how often individual assessments are being conducted, the workload is immense. This could lead to burnout within the current group of stock assessment experts and it also inhibits those in this field from working on the development of new or emerging approaches, as time is simply not available. There should be processes in place to recruit applied stock assessment personnel to assist with current workloads as well as assessment model development.

The availability of world-class stock assessment modeling expertise has all but disappeared from Atlantic Canada and in fact from many places around the globe. Where pockets of these skills do exist the demand for these skills outweighs the availability of these personnel to conduct modeling. There is increasing demand in Canada for these unique skills and capacity building in this field is required.

The issue of stock assessment capacity is not only an issue in Atlantic Canada. Recently, the National Oceanic and Atmospheric Administration (NOAA - USA) implemented a program to bring together government and academic scientists in support of education and training for the next generation of stock assessment scientists. This effort is called the STock Assessment Research and Training (START) Program. This program was initiated in response to a 2008 U.S. government mandated report that determined that future demand for stock assessment scientists will far outweigh the current supply and result in an anticipated shortage of 2 - 18 qualified stock assessment scientists per year over the next decade. The key recommendations to address shortages included:

- Increase number of faculty in the field of quantitative ecology.
- Increase graduate students and post- doctoral associate numbers in the field of quantitative ecology.
- Improve the quality of incoming graduate students (in the quantitative disciplines).

Capacity building in the fields of stock assessment and modeling would permit work to be completed on most of the Fisheries Science/Stock Assessment Modeling and Application gaps as well as the gap related to Long-Term Study of the Ecosystem identified in this report. Additional capacity can assist with:

- Identification and prioritization on an ongoing basis of information and analysis gaps for all fisheries assessments as well as work directed to address these gaps.
- Assist with the current workload related to applied fish stock assessments.
- Provide advisory capacity to industry in the interpretation and understanding of ranges of current and new assessment techniques including objectives, inputs and results.

Summary: There is an opportunity to address many institutional and commercial needs by increasing the human resource capability. The best method of doing so may be to enlist post-doctoral fellows to work with current DFO and CFER scientists and biologists who are currently engaged in many facets of stock assessment application and modeling. The recruited individuals could be fully immersed in the stock assessment culture by attending regional stock assessment meetings, participating in ICES stock assessment methods working groups, international symposia, and working collaboratively with other fishery institutions, academia and industry associations.

The post-docs targeted for this type of program will need the appropriate training in fish population dynamics, mathematics, statistics and computer programming. This approach could provide a pool of candidates with a broad set of stock assessment tools and experiences, who may become Newfoundland and Labrador's lead stock assessment experts in the future. With post-docs there is no need to provide guarantees of full-time employment, so there would be no requirement to book specific funds for the time period beyond the Fishery Investment Fund. In the meantime, there could be an ongoing integration of these recruited individuals into the ranks of DFO or CFER through the attrition of current staff or the implementation of new positions.

Currently the Fisheries and Marine Institute is developing a Master of Marine Studies (Statistical Fish Stock Assessment) Program. This initiative will provide potential candidates for a PhD program in Quantitative Fisheries Science which will eventually lead to a greater pool of post-doctoral fellows who could find their way into the scientific ranks of DFO or CFER.

KEY RECOMMENDATION. It is recommended that resources from the Fisheries Investment Fund be allocated for the hiring of post-doctoral fellows to immediately assist current stock assessment scientists and biologists and modelers while training to become the stock assessment experts of the future. The individuals selected for this initiative require training in fish population dynamics, mathematics, statistics and computer programming. The new Master of Marine Studies program at MI should also be supported.

FURTHER RECOMMENDATIONS: Most of this capacity should be directed at the stock assessment gaps, however it is recommended that a portion of this capacity should be directed at studying long-term productivity of the ecosystem.

It is also recommended that funding be divided between DFO and CFER.

Additionally it is recommended that Memorial University of Newfoundland and Labrador and the Fisheries and Marine Institute be encouraged to increase the number of faculty in the field of quantitative biology and ecology.

Multi-species data collection for ecosystem analysis. As noted in Section 6, during Research Vessel surveys conducted in Atlantic Canada there is minimal information collected on marginally commercial or non-commercial species. The collection of this data will be important to realize a full ecosystem approach for science and management. In addition, in the past DFO collected stomach content information for some species, but this type of data has only been collected sporadically in recent years. This type of work is important for ecosystem analysis.

RECOMMENDATION. It is recommended during research vessel surveys conducted by DFO and CFER that length data be collected on a variety of marginally commercial and non-commercial species.

It is further recommended that stomach content data be collected during RV surveys to provide information of predator/prey interactions.

These kinds of data collection and analysis come with considerable costs. It is recommended that these incremental cost be covered by the Fisheries Investment Fund.

Capelin acoustic survey gap. In 2013 DFO utilized approximately 280 research-vessel survey days in offshore areas and another approximately 80 survey days in the inshore and near-shore areas collecting fishery-independent data. CFER utilized another 30 days on their charter vessel to gather this same type of data. There are also industry surveys: one directed for shrimp in northern areas (47days) and the other for redfish on the south coast of Newfoundland (21 days).

DFO conducts an annual capelin hydro-acoustic survey on the Grand Banks. This survey is conducted in the spring of the year over a period of 25 days. Five of these days are used for acoustic calibration and 20 days are used for the survey itself. This survey covers 3L and a small area in southern 3K. The data collected from these surveys suggest the distribution of capelin may extend further into the more northern areas of 3K, beyond the extent of the current DFO survey plan for capelin. The offshore survey vessel operated by CFER has full hydro-acoustic capability and there are currently ongoing discussions between DFO and CFER with the objective of potentially filling part of this survey gap with the CFER charter vessel (RV Celtic Explorer). While this is a positive development, the number of days that may be diverted from the CFER at- sea program to deal with this issue will be too few to completely deal with this gap.

KEY RECOMMENDATION. It is recommended that the Fisheries Investment Fund be used to charter an additional 30 sea days of the Celtic Explorer from the Irish Marine Institute for the purpose of conducting a hydro-acoustic survey for capelin (and other species) in the areas of Division 3K not surveyed by the DFO acoustic survey.

OTHER RECOMMENDATIONS. In is also recommended that the survey plan for these additional days be determined through consultation between DFO and CFER.

Additionally it is recommended that the funds used for this purpose should cover charter costs as well as staff and equipment costs that will be incurred by both institutions participating in this survey.

7.3 Centre of Fisheries Ecosystem Research (CFER)

The key issue for the Fisheries and Marine Institute will be to secure long-term funding for CFER beyond spring, 2016. In many consultation sessions, the positive contribution of CFER in advancing fisheries knowledge has been highlighted. There is also an increasing level of collaboration occurring between DFO and CFER. As identified earlier, the issue of permanency and stability for personnel has been a problem in recruiting highly qualified people and will likely lead to challenges of retaining current personnel if not addressed. CFER is well positioned to build on its capacity in the area of fisheries population and stock analysis, which is a need in Canada and globally.

The issue of CFER's ability to conduct research in near-shore areas was raised during consultations. A vessel in the 100-125 foot range would be useful for surveys of snow crab, capelin, herring, Greenland halibut, mackerel, scallops, near-shore cod, as well as a variety of new or emerging fisheries such as whelk, sea cucumber, etc. The Marine Institute currently has ownership of a vessel in the size category, the MV Anne Pierce. This vessel has been used for many MI programs outside of the CFER scientific mandate. It is understood that this vessel is nearing the end of its operational life and will soon need to be replaced. A replacement vessel in this size range could be fully equipped with mapping and remote operated vehicle equipment and could be used for direct research as well as providing access for graduate students from CFER and other MUN programs.

KEY RECOMMENDATION. It is recommended that the Fisheries Investment Fund be used to provide the necessary funding to continue CFER's operation and large vessel charter for the term of the Investment Fund.

OTHER RECOMMENDATIONS. It is also recommended that CFER researchers expand collaboration with DFO researchers on projects regarding stock assessment techniques/modeling.

Additionally it is recommended that funding be provided to assist in the upgrade of the current or a new multi-tasked at-sea work platform to bring it to full science capacity to enable CFER to conduct research in near shore areas.

7.4 Collaborations between Science Institutes and Industry

General collaboration. This process of conducting scientific research is growing in Newfoundland and Labrador, in other areas of Canada as well as in many international jurisdictions. Funding to support collaborative research comes from a variety of sources in NL including DFO, DFA, use of fish allocations, cash contributions from industry associations, grants, etc. Many of these funding sources will remain, but in many cases collaborative research could benefit from an additional stable funding source that will enable the expansion of current initiatives, move forward with new initiatives, and alleviate some financial burden for industry groups. It is expected that many of the funding sources already employed to fund collaborative arrangements will continue, but there is no certainty regarding the duration or the level of funding from these sources.

The main benefit of supporting collaboration is obvious, that is to enable the completion of important scientific research that is of interest to industry and the scientific community. In the meantime, fishery science and industry collaboration also leads to a greater understanding by industry participants of the complex process of fish stock assessment and various biological process that underpin these analyses.

RECOMMENDATION. It is recommended that the Fisheries Investment Fund be used to provide an appropriate level of funding to support collaborative arrangements between fisheries science institutes and the fishing industry. This level of funding should be in the range of $1-1.5 million per year for the term of the Fisheries Investment Fund.

Process for funding collaboration: Currently DFA utilizes annual allocations in the range of $300-600K for the purpose of funding specific science projects using their Fisheries Research Grant Program. The projects funded have included collaborative work between industry and DFO and/or CFER, assistance to achieve the certification of fisheries and some of the funding required to provide the necessary science support for emerging fisheries.

Collaborative projects outlined in the report could be processed using the DFA Grant Program model. Eventual approval of projects will be made by a Fisheries Investment Steering Committee, or other oversight group instead of DFA's Minister as is the case with the current Fisheries Research Grant program.

The current procedures for the Fisheries Research Grant Program could be used for processing proposed collaborative projects that are generated through the Investment Fund. This will certainly increase the support-service requirements at DFA, therefore a small portion of the fund allocated for collaborations should be sub-allocated to hire additional resources to co-ordinate proposals and prepare documentation for approval and maintain a record of projects and funds expended.

The following outlines some possible program criteria. These criteria should give consideration to the timelines which may be imposed and the need to garner significant short-term benefits from the research conducted.

- Proposals should have a valid scientific sponsor.

- DFO-CFER collaborations, with no industry partner, should be eligible.
- Proposals should be completed within the time frame supported by the Fisheries Investment Fund.
- Proposals that contribute directly to stock assessment processes will be high priority.
- Proposals for ongoing time series outside the time frame of the investment fund should be low priority.
- Funding should be distributed among different industry groups.
- Funding should be distributed in various regions of Newfoundland and Labrador.

RECOMMENDATION. It is recommended that collaborative projects from the Fisheries Investment Fund be processed utilizing the DFA Fisheries Research Grant Program with projects being eventually approved by a Fisheries Investment Fund Steering Committee, or other oversight group.

It is further recommended that funding be made available to enable DFA to hire additional human resources to deal with increased workload related to this initiative.

Emerging fisheries: There has long been interest in Newfoundland and Labrador in emerging fisheries. The DFO policy developed to deal with these type of fisheries is implemented in three stages, with initial stages related to data collection and scientific assessment. DFO does complete a review of any science assessments conducted, but are not funded to actually complete these stock assessments. These are the responsibility of fishing industry participants. Occasionally there is funding from various sources that can assist in completion of the required science, but there is no dedicated source of funds that is targeted at emerging species. The burden of paying for the cost of these types of assessment may inhibit some fish harvesters from participating in any emerging fishery process.

At present there has been some level of interest in 13 new species/area combinations by various fishing industry representatives. These expressions of interest have been made by individuals or small groups of fish harvesters. These are not listed here because of privacy concerns.

RECOMMENDATION. It is recommended that the Fisheries Investment Fund be used to provide funding to support the completion of the scientific components of emerging fisheries. Projects of this type can be vetted and approved through the same process other collaborative arrangements as described above.

Certification of fisheries. Like emerging fisheries, DFO is not funded for completing the scientific work related to the certification of fisheries. Up to this point in time all the scientific work required for the certification of any fishery has been the responsibility of the sponsoring industry sector, association or even an individual fishing company. There is a considerable amount of science work for the certification of fisheries. This relates to both science work for fisheries that are required to maintain certification as well as certification for new fisheries. These costs have been rising over time and with a new MSC standard coming into play in 2015, the financial burden for industry will only grow.

Based on the performance indicators for currently certified fisheries the following work will be required for some fisheries to maintain their certifications. Of course this same type of work will also be required for new certifications.

- The definition of harvest control rules
- Description of risk to habitat
- Additional description on risk of by-catch
- There is a need for published management plans with well-defined short and long-term management objectives
- There is a requirement to have research plans developed for all certified fisheries

RECOMMENDATION. It is recommended that the Fisheries Investment Fund be used to provide funding to support the various science components required for the certification of fisheries. This type of work may include research related to: stock assessment, habitat and ecosystems and by-catch recording and evaluation. Certification projects, like emerging fishery projects can be vetted and approved through the same process as the collaborative arrangements described above.

Aquatic invasive species (AIS). The incidence of aquatic invasive species is a growing concern in Newfoundland and Labrador. Green crab and some types of tunicates have been observed to be expanding in NL waters in recent years. A discussion of AIS issues in Canada regularly occurs at the Canadian Council of Fisheries and Aquaculture Ministers. The Council has also developed an action plan which outlines a national approach to address this issue.

DFO has a funded program that looks at AIS issues and provides recommendations for management of species that fall into this category. This is an area where enhanced collaboration can assist in dealing with an emerging problem.

RECOMMENDATION. It is recommended that the Fisheries Investment Fund be used to support collaborative work between industry and scientific institutions (mainly DFO) in furthering knowledge related to the biology, distribution and eradication of AIS in NL waters.

7.5 Other Recommendations

Scholarship in fishery science. The current DFA scholarships are a positive development and DFA should be encouraged to continue this program. There is currently no scholarship program directly related to post-graduate Fisheries Science/Fish Stock Assessment areas of study. A program for masters and PhD candidates will be a positive development for CFER in attracting top candidates in the field of fisheries research.

A reasonable program could be used to provide scholarships for one PhD student and two Masters Students per year. The scholarship process should be competitive with potential candidates preparing and presenting a research proposal to a review board for evaluation. The value of these scholarships could be $30,000 for the PhD award and $20,000 per year for the Masters award with the awards possibly being renewable. The total cost of this program would be $70,000 per year.

RECOMMENDATION. It is recommended that $70,000 be allocated annually from the Fishery Investment Fund for the implementation of a Fisheries and Ecosystem Scholarship Fund. This would provide a single $30,000 scholarship for a PhD student and two $20,000 scholarships for Masters Students.

Data collection by industry participants. Fishery dependent and independent data collection for Fisheries Science activities already occurs through programs managed by DFO, CFER and through fishing industry associations. Training fishing industry participants as data collectors could augment the current data collection programs and provide for cost-effective, reliable, and representative data for specific research and management needs.

There would need to be a period of preparation for such a program to proceed. Training documentation will need to be developed, consultation between DFO managers and science, inshore fish harvesters, representatives from offshore sectors and the observer program managers will need to occur. While considerable preparation will be required this program may provide a useful and progressive approach to collecting fishery-dependent data.

RECOMMENDATION. It is recommended that the Fishery Investment Fund be used to investigate the feasibility of a fishing industry data collection program that could employ inshore fish harvesters and crewmen on offshore vessels to augment the collection of fishery-dependent data for use in annual stock assessments and related analyses

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APPENDIX II CONTACTS

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APPENDIX III ACRONYMS

ACCASP	Aquatic Climate Change Adaptation Services Program (DFO)
AFWG	Arctic Fisheries Working Group (ICES)
AIS	Aquatic Invasive Species
AMO	Atlantic Multi-decadal Oscillation
ASP	Association of Seafood Producers (NL)
ASPIC	A Stock Production Model Incorporating Covariates
AZMP	Atlantic Zone Monitoring Program (DFO)
BIO	Bedford Institute of Oceanography
Blim	Limit Reference Point for Biomass
BMSY	Biomass at which a stock produces Maximum Sustainable Yield
CAPP	Canadian Association of Prawn Producers
CBD	Convention on Biological Diversity
CCFAM	Canadian Council of Fisheries and Aquaculture Ministers
CCG	Canadian Coast Guard
CDCF	Centre for Development Cooperation in Fisheries (Norway)
CETA	Comprehensive Economic and Trade Agreement
CFER	Center for Ecosystem and Fisheries Research
CPUE	Catch Per Unit Effort
CSAR	Centre for Sustainable Aquatic Resources
CSAS	Canadian Science Advisory Secretariat (DFO)
DFA	Department of Fisheries and Aquaculture (NL)
DFO	Fisheries and Oceans Canada
DWG	Deepwater Group (NZ)
EEZ	Exclusive Economic Zone
ENGO	Environmental Non-Government Organizations
ESRF	Environmental Studies Research Fund (NRC)
FAO	Food and Agricultural Organization
FAWG	Fisheries Assessment Working Group (NZ)
FC	Fisheries Commission (NAFO)
FFAW	Fish, Food and Allied Workers
FMSY	Fishing mortality that produces the Maximum Sustainable Yield
FSCP	Fisheries Science Collaborative Program (DFO-FFAW)
GEAC	Groundfish Enterprise Allocation Council
HCR	Harvest Control Rule
ICES	International Council for the Exploration of the Sea
IGS	International Governance Strategy (DFO)
IFMP	Integrated Fishery Management Plan
IFREMER	Institut français de recherche pour l'exploitation de la mer
IML	Institute Maurice Lamontagne (DFO-Quebec)
IMR	Institute of Marine Research (Norway)
JNRFC	Joint Norwegian-Russian Fisheries Commission
LFA	Lobster Fishing Area
LRP	Limit Reference Point

MADMF	Massachusetts Department of Marine Fisheries
MPA	Marine Protected Area
MI	Marine Institute (NL)
MPI	Ministry for Primary Industries (NZ)
MRI	Marine Research Institute (Iceland)
MSC	Marine Stewardship Council
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
MTIF	Ministry of Trade, Industry, and Fisheries (Norway)
NAFO	Northwest Atlantid Fisheries Organization
NIWA	National Institute of Water and Atmospheric Research (NZ)
NEA	Northeast Arctic
NEAFC	North East Atlantic Fisheries Commission
NEFSC	Northeast Fisheries Science Center (USA)
NEREIDA	PotEntial VulneRable Marine Ecosystems-Impacts of Deep-seA Fisheries (NAFO)
NFT	NOAA Fisheries Toolbox
NMFS	National Marine Fisheries Service (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NRA	NAFO Regulatory Area
NRC	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council of Canada
NSRF	Northern Shrimp Research Foundation
NWWG	North-Western Working Group (ICES)
OCI	Ocean Choice International
PA	Precuationary Approach
RDC	Research and Development Corporation
RV	Research Vessel
SAIP	Stock Assessment Improvement Plan
SAM	State-space Assessment Model
SAR	Science Advisory Reports (CSAS)
SARA	Species at Risk Act
SARC	Stock Assessment Review Committee (USA)
SAW	Stock Assessment Workshops (USA)
SC	Scientific Council (NAFO)
SCAA	Statistical Catch at Age
SFA	Shrimp Fishing Area
SPA	Sequential Population Analysis
SPERA	Strategic Program for Ecosystem-Based Research and Advice (DFO)
SPM	St. Pierre and Miquelon
SPONL	Seafood Producers of Newfoundland and Labrador
SSB	Spawning Stock Biomass
STACFIS	Standing Committee on Fishery Science (NAFO SC)
TAC	Total Allowable Catch
TRAC	Transboundary Resources Assessment Committee
TRP	Target Reference Point
UNFA	United Nations Fisheries Agreement
UNGA	United Nations General Assembly
USR	Upper Stock Reference
VME	Vulnerable Marine Ecosystem
VIMS	Virginia Institute of Marine Science
VMS	Vessel Monitoring System
VPA	Virtual Population Analysis
WCSAM	World Conference on Stock Assessment Methods
WGNSSK	WG on the Assessment of Demersal Stocks in the North Sea and Skagerrak (ICES)
XSA	Extended Survivor Analysis

APPENDIX IV CFER PROJECTS

Projects led by George Rose

1. Hydronet: Development of Acoustic methods to monitor productivity of freshwater ecosystems
   Co-investigators: Dr. Daniel Boisclair (Univ. de Montreal); Manitoba Hydro
   Collaborators: Rodolphe Devillers (MUN), DFO FWI
   Grad students: Laura Wheeland (graduated MSc), Riley Pollom (MSc)
   Funded by NSERC Network Hydronet

2. CFN: Capture Fisheries Network: The impact of closed areas on fisheries
   Collaborators: Jon Fisher, FFAW, DFO National and NL (Darrell Mullowney and Corey Morris)
   Grad student: Kate Barley Kincaid (PhD)
   Funded by NSERC Network CFN

3. PSAT – satellite tagging of cod - migration, stock structure, behaviour, survey impact
   Co-investigator: Sherrylynn Rowe
   Funded by DFA, RDC

4. Trophic interactions among cod, shrimp, snow crab and capelin and productivity in NL waters
   Collaborators: Sherrylynn Rowe, Earl Dawe (DFO)
   Grad student: Darrell Mullowney (PhD)
   Funded by DFO NL, DFA

5. Otolith microchemistry to track migration, stock structure and behaviour of cod in NL waters
   Co-investigator: Sherrylynn Rowe
   Collaborators: Graham Layne and Glenn Piercey (MUN)
   Grad student: Victoria Neville (PhD)
   Funded by DFA

6. Northern cod acoustic-trawl spawning surveys, methods and design
   Co-investigators: Sherrylynn Rowe, Wade Hiscock, Gordon Adams
   Funded by DFA, RDC

7. North Atlantic bio-oceanographic dynamics
   Co-investigator: Sheena Fennell (NUI Galway)
   Collaborators: Dominique Robert, Louise Allcock and Anne Marie Power (NUI), Glenn Nolen (Irish MI)
   Funded by DFA, RDC, Irish Marine Institute, National University of Ireland

Projects led by Noel Cadigan

8. Quantifying maximum sustainable yield (MSY) reference points when productivity varies, and Marine Stewardship Council certification of NL fish stocks.
   Collaborator: Dr. J Concepción Loredo-Osti of the Dept Mathematics and Statistics, MUN, Year 1 postdoc: Yanjing He; Year 2 postdoc: Christoph Konrad
   Funding: DC Ignite grant (100K for 2 years; April 1, 2013 -March 31, 2015).

9. Invertebrate productivity and management targets under changing ocean conditions.
   Co-Investigator: Jon Fisher., Postdoc Stephanie Lelievre.
   Funded by Mitacs-Accelerate Graduate Research Internship Program (75K; July 2014 - February 2016), and internal CFER funds (postdoc salary November 2013 - June 2014).

10. An improved state-of-the-art stock assessment model for 3LNO American plaice.
    Co-Investigator: Jon Fisher
    Postdoc: Stephanie Lelievre.
    Funding: DFA grant (16.5K for one year – 2014)

11. Models for the variability in growth and maturation rates.
    Grad student: Zakiyah Mohammed (MSc)
    Funding: NSERC Discovery grant

12. Estimating regression parameters from highly stratified survey count data.
    Grad student: Shijia Wang (MSc)
    Funding: NSERC Discovery grant

13. Co-variability in year-class strength dynamics among Atlantic cod stocks around Newfoundland.
    Co-Investigator: Dominique Robert
    Grad student: Fred Tulk (MSc Thesis)
    Funding: NSERC Discovery (Noel and Dom)

Projects led by Dominique Robert

14. Halibut distribution, migrations and habitat use in the Gulf of St. Lawrence - satellite pop-up tags.
    Co-Investigator: Jon Fisher
    Collaborators: Martin Castonguay (DFO), Tim Loher (IPHC) and Jason Spingle (FFAW).
    Postdoctoral fellow: Hannah Murphy
    Funding: RDC and DFA

15. Gulf-wide conventional tagging survey to estimate exploitation rate in 4RST halibut stock.
    Collaborators: Noel Cadigan, Jon Fisher and Hannah Murphy (CFER), Yvan Lambert (lead) and Mathieu Desgagnés (DFO), Tim Loher and Ray Webster (IPHC), Brian

Johnson (CCFI), Erin Carruthers, Harvey Jarvis and Jason Spingle (FFAW).
Funding: NSERC, DFA, CCFI

16. Capelin larval growth dynamics in relation to year-class strength.
Collaborators: Chris Dawe and Mark Santos (CASD), Fran Mowbray and Pierre Pepin (DFO).
Postdoctoral fellows: Ilhan Yandi, Hannah Murphy
Funding: NSERC Discovery (Dom), DFO

17. Herring larval diet and effect of preferred prey abundance on population dynamics.
Collaborators, Christina Bourne and Pierre Pepin (DFO), Carissa Currie (MSc thesis)
Funding: NSERC Discovery (Dom)

18. Assessment of bottom up control of 2J3KL capelin at different stages of the ontogeny.
Collaborators: Fran Mowbray and Pierre Pepin (DFO)
Grad students: Timothée Govare (MSc) and Daigo Kamada (PhD)
Funding: NSERC Discovery

19. Phenology of capelin spawning-larval emergence in Trinity Bay using acoustics-plankton hauls.
Collaborators: MSc student TBR, Gord Adams
Funding: NSERC Discovery

20. A meta-analysis on the links between larval feeding success, growth and survival in marine and freshwater fish, across systems and taxa
Collaborators: Akinori Takasuka (Japanese Fisheries Research Agency), Jun Shoji (Hiroshima University), Pierre Pepin (DFO) and several others.

21. The role of Gulf Stream eddies in the transport and production of zooplankton and fish larvae.
Collaborators: Hannah Murphy and George Rose (CFER); Anne Marie Power, Louise Allcock and Sheena Fennell (NUI Galway)
Funding: CFER, Irish Marine Institute, National University of Ireland

Projects led by Jon Fisher:

22. Impact of changing ocean conditions on deep water fisheries distributions.
Grad student Brynn Devine (PhD)
Funding: RDC OSIRA, NSERC

23. Quantitative food web modeling of changes in species interactions within a key Newfoundland and Labrador fishery ecosystem.
Grad student Kyle Krumsick (PhD)
Funding: RDC OSIRA, NSERC

24. Southern Newfoundland under changing ocean conditions: diets and spatial

distributions of emerging and re-emerging gadoids within NAFO division 3Ps.
Collaborators Mariano Koen-Alonso (DFO), Dominique Robert
Grad student Hilary Rockwood (MSc)
Funding: RDC OSIRA, NSERC

25. Integrated analyses of Northwest Atlantic pelagic ecosystem structure across a strong thermal front along the Flemish Cap Line. This study is using data from the CFER CE survey and the DFO AZMP survey from 2012 to 2014.
Collaborators: Dominique Robert and George Rose (CFER), Pierre Pepin (DFO).
Funding: NSERC, RDC

26. The application of macro-ecological techniques to fisheries ecology; spatial downscaling of predator-prey interactions predicted from macro-ecological patterns; understanding the spatial structure of regime shifts.
Collaborators: Ken Frank (BIO), Brian Petrie (BIO), William Leggett (Queen's U)
Funding: NSERC

27. A habitat template approach to the identification of areas of differential fisheries productivity in Newfoundland and Labrador waters.
Collaborators: DFO NL scientists, Charles Hannah (DFO IOS), Vlad Kostylev (BIO)
Grad student Brynn Devine

28. Northwest Atlantic marine ecosystem responses to warm conditions in 2011/2012: changes in groundfish distributions and communities. Oceanographic and fisheries survey data from five regions to examine responses of fish to recent changes in water temperatures.
Collaborators: Nancy Shackell (BIO, lead), Catherine Johnson, Daniel Duplisea, Phillip Grayson, Mariano Koen-Alonso, John Hare, James Manning.
Funding: DFO Aquatic Climate Change Adaptation Services Program.

29. Fishery dependent landings data: spatial distributions, environmental influences and bycatch avoidance. This project has amalgamated OCI's Trackwell Electronic Logbook data into an Access database, for use by CFER science and OCI.
Collaborators: Gudjon Thorbjornsson (OCI), Victoria Turbrett (2014 research assistant)
Funding: RDC

30. Spatial analysis of demersal fish communities to support ecosystem based management.
Collaborators: Danny Ings, Pierre Pepin (leads)
Grad student Brynn Devine
Funding: DFO Strategic Program for Ecosystem-based Research and Advice (SPERA)

31. Assessment of the potential risks of seismic surveys to affect snow crab resources.
Collaborators: Corey Morris (DFO, lead), many from DFO NL Science, FFAW, LGL.

Funding: Environmental Studies Research Fund (in progress, pending funding negotiations)

Projects led by Sherrylynn Rowe:

32. Incidence and impacts of parasitic nematodes in Atlantic cod stocks surrounding NL.
    Collaborators: John Brattey (DFO), Jason Spingle and Robyn Saunders (FFAW)
    Grad student: Laura Carmanico (MSc thesis)
    Funding: IBES and RDC

33. Role of MPAs in enhancing lobster populations and fisheries.
    Collaborators: Gordon Janes (Eastport Peninsula Lobster Protection Committee), Christoph Konrad (CFER), Elizabeth Coughlan, Blair Thorne, and Rick Rideout (DFO), Jackie Baker (FFAW)
    Grad student: Victoria Howse (MSc thesis)
    Funding: NSERC

34. Northern cod diet and productivity under changing environmental conditions and stock status.
    Collaborators: George Rose, Rick Rideout (DFO)
    Grad student: David Woodland (MSc thesis)
    Funding: NSERC

35. Life history and population ecology of cod and haddock in southern NL waters.
    Collaborators: Joanne Morgan and Rick Rideout (DFO)
    Grad student: Bob Rogers (MSc thesis)
    Funding: DFA, RDC

36. Size-based individual variation in susceptibility of Atlantic cod to capture by survey gear.
    Co-investigators: George Rose, Wade Hiscock, Gordon Adams
    Funding: DFA, RDC

Projects led by scientists external to CFER:

37. Advancements to State Space Models for Fisheries Science.
    Canadian Statistical Sciences Institute (200K for 3 years; April 1, 2014. End: March 31, 2017)
    Lead Investigator: Joanna Mills Flemming - Dalhousie University
    Collaborators: Noel Cadigan – CFER, David Campbell - Simon Fraser University (SFU), Eva Cantoni - University of Geneva, Chris Field - Dalhousie University, Anders Nielsen - Technical University of Denmark, Rick Routledge SFU, Håvard Rue - Norwegian University of Science and Technology, Steven Cooke - Carleton University, Daniel Duplisea - Fisheries and Oceans Canada, Scott Hinch - University of British Columbia, Aaron MacNeil – Australian Institute of Marine Science, Boris Worm - Dalhousie University.

38. Comparison of interactions between capelin and Arctic cod among North Atlantic

systems.
Lead investigator: Fran Mowbray (DFO, lead)
Co-investigators: Dominque Robert, Padmini Dalpadado and Harald Gjøsæter (IMR, Norway)
Funding: DFO and Norwegian IMR

39. Development of an index of abundance for capelin in the Gulf of St. Lawrence. This project will use a combination of bottom trawl and acoustic data from R/V surveys in the Gulf
Lead investigators: Martin Castonguay, Ian McQuinn (IML DFO)
Collaborators: Domique Robert and Fran Mowbray (NL DFO)
Funding: DFO through its SPERA program

40. Productivity of freshwater ecosystems impacted by Hydro-power
Lead investigator: Daniel Boisclair (University of Montreal), Manitoba Hydro
Co-investigator: George Rose

41. Cod spawning and the use of spawning closures as a tool for the management of fish stocks.
Lead investigator: Rick Rideout (DFO NL)
Co-investigators: Sherrylynn Rowe, Joanne Morgan, Brian Healey, and Don Power (DFO), Jöel Vigneau (IFREMER)
Funding: DFO IGS Programme

APPENDIX V FFAW PROJECTS

1. Post season Snow Crab Pot Survey – 2J3KLNOPs4R
   Total Cost - $2,214,000 (Use of Fish: $2,000,000)
   Contributors: FFAW (cash and in-kind), DFA, DFO-FSCP

2. Data collection from the Lobster Fishery. These are voluntary log book and at-sea sampling programs for the east and south coasts which began in 2004. These programs collect information on catch and effort, provide a recruitment index from modified traps and include detailed biological sampling. 244 lobster harvesters, from all LFAs have participated in the voluntary science logbook program.
   Total cost - $280,000
   Contributors – FFAW (in kind), DFA, DFO-FSCP

3. 2J3KL cod tagging project
   Total cost (not including tag returns) - $61,000
   Contributors – FFAW (cash and in-kind), DFA. DFO-FSCP

4. 4R Crab survey
   Total cost - $61,000 (Use of Fish: $19,000)
   Contributors – FFAW (in-kind), DFO FSCP

5. Cod condition: The 4R cod tagging program (project 7 below), Cod Reproductive Potential-CRP (Project 6 below), and Cod Condition programs are all contributions to northern Gulf cod research programs, funded through FSCP-QC and DFA. All programs provide critical information for the cod assessments. Length, weight, sex, maturity stage, gonad, liver, and stomach content weight are recorded and tissue and otolith samples are taken during the mobile and fixed gear sentinel programs. Data and samples are sent to DFO in Mont-Joli.
   Total cost - $24,800
   Contributors – DFA, DFO-FSCP

6. CRP (see project 5 above).
   Total cost - $64,100
   Contributors – FFAW (in-kind), DFA, DFO-FCSP

7. Cod tagging in Division 4R (see project 5 above).
   Total cost - $69,400
   Contributors – FFAW (in-kind), DFA, DFO FCSP

8. Lobster in 4R. Similar to the data collection for 4R to the work described above in project 2.
   Total cost - $145,900
   Contributors – FFAW (cash, in-kind), DFO-FSCP

9. 2J3KL cod sentinel
Total cost - $1,223,000
Contributors – FFAW (cash and in-kind), DFO

10. 4R cod sentinel
Total cost - $656,800
Contributors – FFAW (cash and in-kind), DFO

11. Atlantic Halibut tagging: This tagging program involves two components: a satellite tagging program, led by CFER, and a conventional (t-bar) tagging program, led by FFAW. The goal of the conventional tagging program was to design a systematic field program in 4R which could be used to estimate exploitation rates for the 4RST stock.
Total cost - $33,800
Contributors – DFA, Other

12. Traceability. The NL program is currently focused on lobster and halibut. The program began in 2011 with a small pilot project in Harbour Breton in Lobster Fishing Area (LFA) 11. In 2014, 269 harvesters were onboard from LFAs 12, 13, 14A and 14B, with even more joining on in 2015 as the project moves into LFA 11. This involves the placement of traceability tags.
Total cost - $255,000
Contributors – FFAW (cash), DFA, Other

13. 3Ps cod tagging
Total cost - $33,400
Contributors – DFA

14. Eastport MPA. This program provides administrative and logistical support for the DFO Science MPA research program.
Total Cost- $17,800
Contributors – DFO

15. Connaigre Bay Aquaculture. The objective of the fixed station survey is to provide a baseline assessment of commercial snow crab and lobster stocks in the bay prior to the development of finfish aquaculture sites in the bay.
Total Cost - $32,100
Contributors – FFAW (in-kind), DFO

16. NSERC Lobster: This project, led by Remy Rochette (UNB Saint John), is part of the larger NSERC Capture Fisheries Network with the long term objective of understanding lobster meta-population dynamics, specifically this research program aims to understand movement and connectivity among local populations. Within NL, 44 lobster harvesters participated in the Lobster Node program in 2013.
Total cost - $119,700
Contributors - NSREC

APPENDIX VI OFFSHORE PROJECTS

1. Northern shrimp survey of SFA4, the Eastern Assessment Zone, and the Western Assessment Zone. A stratified random survey has been conducted annually since 2005. Annual budgeted expenditures of the Northern Shrimp research Foundation (NSRF) are in the order of $1.6 million

2. Northern shrimp aging project. At a cost in the order of $50,000, the NSRF is supporting and coordinating the engagement of a university laboratory to age shrimp sampled from the NSRF and DFO research vessel surveys conducted in 2014.

3. Northern shrimp modeling project. At a cost in the order of $200,000, the NSRF will support and help coordinate the engagement of a post-doctoral candidate, who will work with a panel of experts to develop a robust shrimp assessment model.

4. 2J3KL cod offshore tagging project. At a cost in excess of [$350,000] annually, a multi-year project has been proposed by which GEAC will tag thousands of cod (conventional tags, acoustic tags, satellite tags) in 2J, 3K and 3L designed primarily to identify relative exploitation rates and migration patterns for offshore cod components of this stock complex.

5. Unit 2 redfish survey. A stratified random survey, managed by the Groundfish Enterprise Allocation Council (GEAC), has been conducted since 1997, initially annual and now biennially. Budgeted expenditures of the 2014 survey were in the order of $250,000. Comparison trawling will occur in 2015, at a cost in the order of $115,000.

6. Unit 2 redfish species identification projects. At a cost greater than $100,000, GEAC has conducted systematic sampling and analysis (including anal fin ray counts supported by generic analysis) to identify and analyze species composition in the RV survey and in the commercial fishery, temporally and spatially (by area and depth).

7. Redfish aging project. At a cost in the order of $30,000, GEAC has supported an otolith aging project leading to the development of age/length keys for various redfish stocks in Atlantic Canada.

8. Redfish model development project. At a cost in the order of $100,000 (still on-going), GEAC is coordinating the development of a statistical catch at age model for Units 1+2 redfish.

9. 2+3 Greenland Halibut modeling. At a cost in the order of $50,000, GEAC coordinated an international effort in preparation for a Management Strategy Evaluation.

10. 4X5 Pollock modeling. At a cost in the order of $75,000, GEAC supported and coordinated a Management Strategy Evaluation process.

11. Northern shrimp survey of SFA4, the Eastern Assessment Zone, and the Western Assessment Zone. A stratified random survey has been conducted annually since 2005. Annual budgeted expenditures of the Northern Shrimp research Foundation (NSRF) are in the order of $1.6 million

12. Northern shrimp aging project. At a cost in the order of $50,000, the NSRF is supporting and coordinating the engagement of a university laboratory to age shrimp sampled from the NSRF and DFO research vessel surveys conducted in 2014.

13. Northern shrimp modeling project. At a cost in the order of $200,000, the NSRF will support and help coordinate the engagement of a post-doctoral candidate, who will work with a panel of experts to develop a robust shrimp assessment model.

14. Unit 2 redfish survey. A stratified random survey, managed by the Groundfish Enterprise Allocation Council (GEAC), has been conducted since 1997, initially annual and now biennially. Budgeted expenditures of the 2014 survey were in the order of $250,000. Comparison trawling will occur in 2015, at a cost in the order of $115,000.

APPENDIX VII DFO-NL PROGRAMS

Aquatic Resources Division

- Research, data collection and monitoring
  - ✓ Multispecies surveys conducted throughout the year on the *CCGS Teleost* and *CCGS Alfred Needler*
  - ✓ Near-shore survey program on the *CCGS Vladykov*
  - ✓ Port sampling program
  - ✓ Offshore observer program
  - ✓ Sentinel cod survey - service contract with the FFAW
  - ✓ DFO-Northern Shrimp Research Foundation (NSRF) northern shrimp survey – Section 10 collaborative agreement
  - ✓ Post season crab survey – Section 10 collaborative agreement and Fisheries Science Collaborative Program (FSCP) supported.
  - ✓ DFO-Groundfish Enterprise Allocation Council (GEAC) Unit 2 redfish survey - Section 10 collaborative agreement
  - ✓ Cod tagging studies - FSCP funded projects (service contracts) to FFAW, Petty Harbour Cooperative and Fogo Island Cooperative
  - ✓ Lobster CPUE project - FSCP funded service contract with the FFAW
  - ✓ Cod condition and reproductive potential studies - FSCP funded service contract with the FFAW
  - ✓ SARA program
  - ✓ Salmonid program
  - ✓ Aquaculture research program
  - ✓ Marine mammals surveys and research

- Resource/stock assessments for domestic and international (NAFO) advice provision:
  - ✓ Groundfish
  - ✓ Invertebrates
  - ✓ Marine mammals
  - ✓ Pelagic fish
  - ✓ SARA species

Environmental Sciences Division: Monitoring, Research and Advice activities

- Ecosystem Research – Ecosystem interactions in the offshore environment, also includes ecosystem modelling, and the production of ecosystem overviews.
- Marine Habitat Research – effects of development on coastal ecosystems
- Freshwater Habitat Research – effects of development on FW ecosystems
- Productivity Research – ecosystem interactions amongst juvenile species (mostly cod), includes the juvenile work in Terra Nova
- Biological Effects – Effects of seismic on commercial species (both finfish and

invertebrates

- Benthic Ecology – Fishing effects on benthic communities, corals and sponges work, and VME work.
- Aquatic Invasive Species – Early warning monitoring, research into effects of species established and risk assessment for expected species
- Marine Protective Area research, monitoring and advice.
- Monitor and report Ocean ‘climate and primary productivity’ conditions in the NL region:
    - ✓ Conduct Atlantic Zone Monitoring Program (AZMP) within waters of Newfoundland and Labrador.
    - ✓ Head-lands thermograph program
    - ✓ Station-27 long term time series
- Model near and far shore ocean climate
    - ✓ Large area ocean modelling in support of ocean forecasting (BREA, ESRF, CSA)
    - ✓ Regional modelling - FVCOM modelling
- Remote satellite sensing and products.
- Provide instrumentation and technical/data support to internal clients undertaking field measurements and sampling:
    - ✓ AZMP surveys
    - ✓ Multi-species surveys
    - ✓ Freshwater/ Salmonids thermographs
    - ✓ Near and offshore oceanographic moorings (BPO,OSNAP, CCG, SCH)
    - ✓ Acoustic tagging
    - ✓ Argo
    - ✓ Other clients as required or requested
- Conduct research using several DFO and other funding programs (ACCASP, IGS, SPERA, ESRF, SWOT, BREA)
- Provide leadership and participation in national and international organizations (AZMP, CONCEPTS, CHONE, ICES, NAFO, and GODAE).
- Science advice provision to regional, national and international management organizations for all of the above

Canadian Hydrographic Service Division

- Data collection and nautical products production
    - ✓ Hydrographic Survey, CSL Harlequin in Conception Bay, Fortune Bay, Hermitage Bay, and Burgeo. Bathymetry, acoustic backscatter, used for nautical chart production and DFO Science
    - ✓ Tides and water levels, Conception Bay, Fortune Bay, Hermitage Bay, and Burgeo. Tidal data for the areas stated.
    - ✓ GPS data, Conception Bay, Fortune Bay, Hermitage Bay, and Burgeo. GPS data for various sites in the area stated used for refinement of the Continuous Vertical Datum Model in the areas stated.
    - ✓ Sailing Direction Revisory Survey, Island of Newfoundland. Collection of Harbour and Port information and data used for sailing direction booklet continuous maintenance.

- ✓ Tidal Gauge Maintenance Island of Newfoundland, Sites at; Port Aux Basques, Bonavista, St. Lawrence, Argentia, and St. John's.
- ✓ Goose Bay- Lake Melville Surveys, collaboration with MUN and UNB to collect data in Goose Bay-Lake Melville.
- ✓ Nautical Publications, Sailing Directions booklet New Editions East Coat Newfoundland and North Labrador.
- ✓ Nautical Chart Production areas:
    - Voisey Bay Labrador
    - Corner Brook
    - Trinity Bay

APPENDIX VIII DFO-NL COLLABORATIONS

ACRDP: Aquaculture Collaborative Research and Development Program

- The potential of using Newfoundland stock cunners to control sea lice on infected Atlantic salmon smolts: tank trials.
- Comparison of the health and condition of cultured mussels from deep water and shallow water sites in Newfoundland with reference to environmental conditions, condition index, physiological stress and lipid biochemistry.
- Determination of the potential spatial overlap and interaction between commercial fisheries (American Lobster, snow crab) and finfish aquaculture activities in Connaigre Bay, Newfoundland.
- An Evaluation of the seasonal abundance, prevalence and species diversity of sea lice on non-salmonid marine fish species from Bay D'Espoir Newfoundland with specific reference to areas neighbouring Atlantic salmon cage sites.

Section 10 allocations (use of fish)

- Post Season Crab Survey 2013/2014 with FFAW
- Northern Shrimp Research Foundation (NSRF) SFA 4 survey
- Unit 2 Redfish Survey with GEAC

Environmental Studies Research Fund (ESRF): administered by Natural Resources Canada

- Mid-Labrador Marine Mega fauna and Acoustic Surveys on the Labrador Coast.

- Development ,validation and Implementation of an Operational Ocean Forecasting System for the Grand Bank and Orphan Basin for Daily operational Delivery at the Canadian Meteorological Centre.

Torngat Joint Fisheries Board Collaborative Project

- Satellite Tracking of Ringed Seals Project in Lake Melville region.

Academia Collaborations

Memorial University; Marine Institute; College of the North Atlantic; Dalhousie; Laval; McGill; Queen's; University of New Brunswick; University of Manitoba; Waterloo; Carleton; University of Alberta; UQAM; INRS; University of PEI; Guelph; Canadian Rivers Institute; ArcticNet; HydroNet; University of Norway; University of Oslo; University of Wales; Virginia Tech; University of Alaska Fairbanks; University of Oregon; University of Patagonia; University of Portsmouth; Canadian Museum of

Nature.

Non –Government Organizations Collaborations

Atlantic Salmon Federation; Salmonid Association of Eastern Newfoundland; ACAP Humber Arm; Rivers and Fisheries Trusts of Scotland; Bird Studies Canada; Trout Unlimited Canada; Friends of Shoal Harbour River; Norris Arm and Area Economic Development Committee; Arctic Fishery Alliance; Canadian Scientific Submersible Facility - World Wildlife Fund.

Government Collaborations

Government of Newfoundland and Labrador; Government of Nunavut.

Industry Collaborations

Fish Food and Allied Workers (FFAW); Nalcor Energy; NL Aquaculture Industry Association; VALE INCO; North Atlantic Aquaponics; AMEC Earth and Environmental Ltd.; Cold Ocean Salmon Inc.; Norlantic Processors Ltd.; Atlantic Rivers Outfitting Company; Northern Harvest; 1512513 Alberta Inc;. One Ocean; SMRU Ltd.; Vonin Canada; Petty Harbour Co-op; Fogo Island Co-op, C-Core.

First Nations Collaborations

Qalipu Mi'kmaq; Miawpukek First Nation; Nunatukavut Community Council; Nunatsiavut Government; Innu Nation.

Inter-Departmental Collaborations

Parks Canada; Environment Canada; Canadian Food Inspection Agency; Department of Foreign Affairs and International Trade; Transportation Safety Board; Department of National Defense; Transport Canada; NR Can; NCR-Institute of Oceans Technology.

Inter- Regional /Inter-Sectorial Collaborations

Maritimes Region; Gulf Region; Central and Arctic Region; Pacific Region; Quebec Region; FAM; EFM; CCG; SCH; Oceans.

International collaborations

NAFO; NOAA; Woods Hole Oceanographic Institute; ICES; IFREMER (France); US Geological Survey; Institute of Marine Research (Norway) ; Instituto Investigaciones Marinas (Spain); Instituto Espanol de Oceanografia (Spain); NASCO; National Oceanography Centre (UK); NIWA (New Zealand); Ecosystems Research; Norwegian Institute for Nature Research; AZTi tecnalia; National Oceanography Centre(UK); Greenland Institute of Marine Resources; Scottish Oceanographic Institute; PINRO (Russia); Argentinean Research Council.

APPENDIX IX DFA RESEARCH GRANT PROGRAM (2010/11-2014/15)

Proponent	Project	2010/11	2011/12	2012/13	2013/14	2014/15	Other Partners	Total Per Project
MI - Rose	Fishery Closures in EBFM Areas - NSERC	$30,000.00	$25,000.00	$25,000.00	$25,000.00		MUN, NSERC	$105,000.00
MI - Rose	Popup Tags - Atlantic Cod	$50,000.00		$50,000.00	$76,000.00			$176,000.00
MI - Rose	Otolith Morphology and elemental Fingerprinting - Atlantic Cod	$50,000.00	$50,000.00				NSERC	$100,000.00
MI - Rose	Cod Acoustic Data and Analyses	$20,000.00						$20,000.00
MI - Rose	Inshore tagging and spawning (3KL and 3Ps)		$50,000.00					$50,000.00
MI - Rose	Cod Performance		$75,000.00				MUN, DFO	$75,000.00
MI - CSAR	Assessment of 3Ps Atlantic hagfish fishery 2011-2012			$25,000.00	$24,960.00	$24,970.00		$74,930.00
MI - CCFI	Shrimp trawl Interactions with Snow Crab			$10,647.00				$10,647.00
MI - **CFER**	Abundance & life history of haddock in southern Newfoundland waters				$25,000.00	$17,000.00		$42,000.00
MI - CFER	DFA contribution to CFER				$66,712.00			$66,712.00
MI- CFER	American plaice 3LNO study				$16,500.00			$16,500.00
DFO Science	Nearshore 2J3KL Cod Survey	$40,000.00	$75,000.00				FFAW	$115,000.00
DFO Science	Migration and Mortality Study	$30,000.00					FFAW	$30,000.00
DFO Science	3Ps Cod Tagging Project			$20,000.00			FFAW	$20,000.00
FFAW	Joint Project - Northern Gulf Cod Science Program (Cod Reproductive Potential, Cod Tagging and Cod Condition)	$50,000.00		$50,000.00	$50,000.00	$115,975.88	DFO Science (Quebec)	$265,975.88
	2J3KL cod tagging project				$20,000.00		DFO	$20,000.00
	Lobster Science Project		$29,675.00	$15,000.00	$15,000.00		DFO	$59,675.00
	Industry-DFO Post-Season Snow Crab Survey		$37,335.39	$50,000.00	$40,000.00		DFO	$127,335.39
FFAW	Fisheries Stewardship Initiative*	$50,000.00					DFO, ACOA, PFHCB	$50,000.00
FFAW	Effects of Grey Seals and Cod Quality and Abundance		$28,550.00				DFO, MUN	$28,550.00
FFAW	Abundance & Spatial Distrubution of 4R Cod	$24,517.78	$22,299.99	$21,075.85				$67,893.62
FFAW	3Ps Cod Tagging Project			$100,952.00			DFO	$100,952.00
FFAW	Lobster and Crab Trap Survey in Connaigre Bay			$18,370.00	$15,383.00		COS, DFO	$33,753.00
FFAW	Tagging of halibut in 4R				$23,778.75	$27,530.00	DFO Quebec	$51,308.75
DFA	DFA Fisheries Scholarship	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00		$5,000.00
MUN	Dr. Wilfred Templeman Memorial Scholarship	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$2,500.00		$22,500.00
MUN - OSC	Sea cucumber- Stress resistance and diet influence				$15,000.00			$15,000.00
NSRF	Scientific gear manual for northern shrimp survey in 2G/0B				$10,725.00		DFO, Pisces, Steve Walsh	$10,725.00
	Northern shrimp research survey in NAFO Divisions 2G/0B			$25,000.00			DFO	$25,000.00
ASP	Snow Crab Productivity reference Points				$10,000.00	$10,000.00	CFER	$20,000.00
GEAC	Cod/Redfish Species Identification Project	$25,000.00						$25,000.00
WWF	Cod Fisheries Improvement Project	$50,000.00	$40,000.00				Icewater, DFA	$90,000.00
Icewater	MSC Pre-assessment of Northern (2J3KL) Cod	$7,000.00					Icewater, DFA, OCI, FFAW, DFO	$7,000.00
UPEI	Lobster Science Workshop		$3,000.00					$3,000.00
U of Maine	Lobster Science Symposium			$1,000.00				$1,000.00
ACPG Innovation	Conference: GSL Shrimp: The Challenges of a Responsible			$10,000.00			FFAW, DFO	$10,000.00
Ocean Learning Partnership	Ocean Education Initiative for Schools		$25,000.00					$25,000.00
	Total Per Year	**$432,517.78**	**$466,860.38**	**$428,044.85**	**$440,058.75**	**$199,975.88**		**$1,966,457.64**

CORE BUDGET for 2014/15= $300,000

APPENDIX X ASSESSMENTS OTHER JURISDICTIONS

1 New England, USA

Assessment process for New England stocks: A formal scientific peer- review process is in place for evaluating and presenting stock assessment results to managers, known as Regional Stock Assessment Workshops or "SAW". Assessments are prepared by SAW working groups, federally led assessments, or Atlantic States Maine Fisheries Commission technical assessment committees, state led assessments, and are peer reviewed by an independent panel of stock assessment experts called the Stock Assessment Review Committee (SARC).

The SARC panel is tasked with determining the adequacy of the assessments in providing a scientific basis for management, and it may accept or reject an assessment. Following the peer review meeting, each SARC panelist provides a written review and the panel provides an overall written summary of the proceedings. SARC panelist reports are typically completed about five weeks after the peer review meeting.

Documentation includes a Stock Assessment Report, a Stock Assessment Summary Report and the SARC panelist reports. After the peer review takes place, final SAW assessment reports are published by the NFSC Fisheries Service office and details regarding the SAW are also made publicly available. Final published SAW reports reflect the written decisions and conclusions of the SARC panel regarding each of the assessment Terms of Reference.

Since 1998, a Trans-boundary Resources Assessment Committee (TRAC) has reviewed stock assessments for shared resources across the USA-Canada boundary in the Gulf of Maine-Georges Bank region. This includes the stocks of cod, haddock, and yellowtail flounder on eastern Georges Bank. TRAC is the scientific arm of the Trans-boundary Management Guidance Committee (TMGC), and TRAC advice to the TMGC is provided in the TRAC Status Reports. NMFS and DFO appoint one person each to act as TRAC co-chairs, who administer the TRAC review process. Publications and review meetings are all made publicly available.

Key cod stock assessments in New England area: The following provides a broad overview of the methodology and challenges regarding cod stock assessments in northeastern US trans-boundary areas.

The evaluation of cod in eastern Georges Bank (NAFO area 5Zjm) was based on an age structured Virtual Population Analysis (VPA), which used commercial fishery catch data and abundance indices from three bottom trawl RV survey series including NMFS spring, NMFS fall, and DFO. Two VPA model formulations were attempted, based on a previous benchmark assessment, one of which used a higher natural mortality estimate for the older cod. The assessment noted large changes in the survey catches in 1993-94, and noted that inability to plausibly explain these survey catchability changes caused increased uncertainty in this assessment. The conclusion was that resource productivity is currently very poor because of low recent recruitment and low weights at age, and that despite the assessment uncertainties, all results indicate that low catches are needed to promote rebuilding.

Cod in the Gulf of Maine area (5Y) assessed in August 2014, with the main conclusions of a Stock Assessment Workshop being that the stock is in poor condition, it is overfished, and that overfishing is still occurring. Gulf of Maine cod survey indices are at time series lows. VPA type models, using different estimates for natural mortality, showed that spawning stock biomass (SSB) in 2013 is the lowest ever estimated and is 3-4% of the target SSB reference point. Fishing mortality is near all-time highs despite the fact that fishery catches are at the lowest levels in the time series. It also noted that the past two Gulf of Maine cod assessments have overestimated spawning stock size and underestimated fishing mortality. The New England Fishery Management Council have since voted to reduce the total allowable cod catch limit from 1,550 t to 386 t for the fishing season beginning May 1, 2015.

2 Iceland

Assessment process: Iceland's MRI is an active participant in the work of ICES and its advisory Committee on Fisheries Management. The survey and stock assessment findings of the MRI are subject to review by ICES before the TAC recommendations are made to the Icelandic ministry. Surveys of demersal fishes and invertebrates are done at various times of the year in Icelandic waters and the results are used in the stock assessments as the basis for the annual TAC recommendations. Acoustic methods are used to survey the herring, capelin and oceanic redfish stocks for the same purpose.

The Icelandic cod stock assessment, as well as other Icelandic stocks, are reviewed by the ICES North-Western WG. This WG which last met in late April 2014, also assesses various stocks around the Faroe Islands and Greenland, as well as oceanic redfish, which extend into NAFO waters. Icelandic scientists also participate in other international fisheries fora, such as NAFO Scientific Council.

Cod stock assessment: The cod in Icelandic waters are assessed as a single stock. The data used in the ICES assessment of the Icelandic cod stock in 2013 are landings-at-age and two age-structured survey indices. Landings-at-age data as well as survey indices are considered reliable.

The analytical assessment is based on landings and survey data using a forward-based statistical catch-at-age model. The assessment results are that the spawning stock of the Icelandic cod is increasing and is higher than it has been since the early 1960's. Fishing mortality has declined significantly in the last decade and is presently at a historical low, and below likely candidate reference points for fishing mortality. ICES noted that *"this assessment is considered very consistent"*.

Increases in water temperature after 1996 have had considerable effects on the spatial distribution of fish species in Icelandic waters with many species now encountered further north. This includes increased abundance of haddock, mackerel, whiting, and some flatfish species in the area north of Iceland. However, cold-water species like

Greenland halibut and northern shrimp have become less abundant around Iceland.

Despite the increased spawning stock biomass and the warmer conditions, during the last 20 years the Icelandic cod stock has not produced a large year class and the average number of age 3 cod at this time is below the average of previous periods. Even with the lower recruitment, the reduction in fishing mortality has resulted in almost double the Spawning Stock Biomass (SSB); however, this increase in the SSB has not resulted in a significant increase in recruitment in recent years ICES NWWG 2014.

3 Norway

Assessment process: IMR is involved in the work of ICES and its advisory Committee on Fisheries Management. On the basis of stock assessments and quota recommendations from ICES, IMR provides science-based advice to the annual fisheries negotiations between Norway and other parties including EU, Russia, the Faroe Islands and Greenland, as well as to Norway's national quota allocation process. IMR also provides annual advice to the North East Atlantic Fisheries Commission (NEAFC), and its scientists participate in the work of NAFO Scientific Council in the Northwest Atlantic fisheries.

The North Sea cod stock is assessed by ICES, in its Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). This WG met most recently in May 2014. The Arctic Fisheries Working Group AFWG) of ICES assesses and provides advice on the stocks of Northeast Arctic (NEA) cod, haddock, saithe, and Greenland halibut, Barents Sea capelin and redfish, as well as Norwegian coastal cod. AFWG first met in 1959 and is the longest running ICES group still in existence, having met most recently in April 2014. Scientists mainly from Norway and Russia attend each meeting, but scientists from EU countries and Canada also attend.

The AFWG advice for Norwegian Coastal cod and Northeast Arctic saithe is used by Norway. The AFWG advice provided on NEA cod, haddock, Greenland halibut, and Barents Sea capelin is used by the Joint Norwegian-Russian Fisheries Commission (JNRFC). The JNFRC has developed a harvest control rule for the NEA cod stock; ICES has evaluated the rule and considered it to be in accordance with the precautionary approach.

Cod stock assessments: Catches from the NEA cod stock increased to about 966 kt in 2013, with Russia and Norway taking around 435 kt each. The catch advice for 2014 given by ICES was 993 kt based on the agreed harvest control rule, and this was the quota established by JNRFC for 2014. The 2014 assessment of NEA cod by ICES AFWG is based on the analysis of surveys and the XSA population model, including estimates of cod cannibalism. There are three survey indices used in the assessment: a joint Norway-Russia Barents Sea winter survey (bottom trawl and acoustics), an acoustic survey of spawning stock in the Lofoten area, and a Russian autumn bottom trawl survey. In addition, a Russian CPUE series from bottom trawlers was also used as an index of abundance.

The 2014 assessment indicates that the spawning stock biomass of NEA cod in 2014 is estimated to be 1,800 kt, which is one of the highest values in the series. The limit reference point for SSB (Blim) is 220 kt, and a precautionary reference point Bpa is set at 460 kt. Total stock biomass in 2014 is estimated to be about 3,100 kt which is close to the highest level observed since the 1940's but 15% lower than in 2013. The estimated fishing mortality in 2013 is below the PA reference point, but somewhat higher than in 2008-2012. Estimates of recruitment for the 2011-2013 year classes are above average.

Norwegian coastal cod are assessed separately from the northeast Arctic stock, also by ICES AFWG. The stock is assessed using VPA methods, with commercial landings at age and an index of abundance at age from a trawl-acoustic survey. The assessment in 2014 indicates that spawning biomass and recruitment has remained close to the lowest observed over the last decade. Fishing mortality has also been stable over the same period. There is a rebuilding plan for this stock, which was developed and reviewed by ICES in 2010, and implemented by Norway for 2011 onwards.

North Sea cod is assessed in the ICES WGNSSK, using a state-space model (SAM). The 2014 assessment by ICES WGNSSK uses commercial catch at age data along with two bottom trawl survey indices of abundance. Reliable, individual, disaggregated commercial fishery data were not available for the analysis of CPUE. Recent catches have been around 33 kt. The results of the 2014 assessment indicate that the stock has begun to recover from the low levels in early 2000's, at which time recruitment was impaired and the biological dynamics of the stock difficult to predict. Fishing mortality rates have reduced from 2000 and in combination with the stronger 2005 and 2009 year classes, the stock has increased since 2006. The reduction in fishing mortality, now well below Fpa, is allowing the recent series of poor recruitments to make an improved contribution to the stock. The low average age of the spawning stock reduces its reproductive capacity as first-time spawners reproduce less successfully than older fish, a factor that has contributed to the continued low recruitment.

In December 2008 the European Commission and Norway agreed on a management plan that aimed to be consistent with the precautionary approach. An evaluation of the effectiveness of the plan in 2011 concluded that for North Sea cod, although there has been a gradual reduction in fishing mortality (F) and discards in recent years, the plans have not controlled F as envisaged, and that following the current regime is unlikely to result in fishing at MSY level by 2015.

4 New Zealand

Stock assessment process: For fish stocks managed within the MPI Quota Management System, as well as other important New Zealand fisheries, the objectives are:

- To assess, based on scientific information, the status of fisheries and fish stocks relative to MSY- compatible reference points and other relevant indicators of stock status.
- To conduct projections of stock size under alternative management scenarios.
- Top review results from relevant research projects.

Fisheries Assessment Working Groups (FAWG's) evaluate relevant research, determine the status of fisheries and fish stocks and evaluate the consequences of alternative future management scenarios. They do not make management recommendations or decisions, this responsibility lies with MPI fisheries managers and the Minister. The Working Groups, including FAWG's, consist of an MPI fisheries science chair, research providers (either the primary researcher or a designated substitute), other scientists not conducting analytical assessments who act in a peer review capacity, representatives of relevant MPI fisheries management teams, and any interested party who agrees to the standards of participation.

Meetings take place as required, generally January-April and July-November for FAWG's and throughout the year for other Working Groups. Stock status summary reports are produced which include the assessment model and options used, reference points for the stock, and status of the stock relative to targets, limits, and whether or not overfishing is occurring. The summary reports also rank the quality of research and science information based on a Science Information Standard developed within MPI for New Zealand fisheries.

Hoki assessment: Hoki, also known in some places as blue grenadier or blue hake, is the largest fishery by volume in New Zealand, with recent catches around the TAC of 130 kt. The fishery operates year round in several areas, generally in depths of 300-800 m. A stock assessment in 2014 was carried out using research time series of abundance indices (trawl and acoustic surveys), proportions at age data from the commercial fisheries and trawl surveys, and biological data.

The New Zealand-developed stock assessment software, CASAL, was used. This is an age-based analytical assessment, which uses Bayesian estimation, and was similar to that in the 2013 assessment. Various approaches were examined within the model to estimate natural mortality. Two key outputs from the assessment model are B0, the average spawning stock biomass that would have occurred over the period of the fishery had there been no fishing, and the year-class strengths of the population. The assessment, including data inputs and the model, was subject to an independent peer review using internationally recognized reviewers in February 2014.

The model partitioned the population into two stocks, east and west, and four areas, Chatham Rise, West Coast South Island, Sub-Antarctic, and Cook Strait. It is assumed that the adult fish of the two stocks do not mix. The assessment model uses an annual cycle, dividing the fishing year into five time steps, and includes fish migrations. Five indices of abundance are used, including two acoustic surveys and three trawl surveys. These cover different parts of the stocks at different times of the year.

NZ has set various PA reference points for biomass as follows:

- Target: 35–50% B0
- Soft Limit: 20% B0.
- Hard Limit: 10% B0.

For both stocks, the results show the biomass in 2014 to be about 60% of B0, and thus the stocks were described as Virtually Certain (> 99%) to be at or above the lower end of the target range, and Exceptionally Unlikely (< 1%) to be below either the Soft or Hard Limit. Spawning stock biomass has increased in recent years in both stocks, and overfishing is unlikely to be occurring in either stock. If the year classes recruit to the stocks as estimated by the model, and assuming the 2013-14 catch levels continue, the biomass of the western stock is expected to increase slowly over the next five years, while the biomass of the eastern stock is expected to remain more or less constant over the next five years.

Exhibit X.1. Summary of some stock assessments for other jurisdictions.

Jurisdiction	Species/stock	Recent Catch or TAC (t)	# RV survey series	Assessment method	Stock status
New England	Cod Gulf of Maine	TAC 386 in 2015	3	Various VPA methods	Lowest ever estimated
Iceland	Icelandic cod	236,000	2	Statistical catch at age model	Highest since 1960's
Norway	NEA cod	966,000	3	XSA model, including cannibalism estimate	Near record high, ~ 9 times above LRP
New Zealand	Hoki (2 stocks)	130,000	5	Age-based, Bayesian approach	High, stable or increasing, well above LRP

APPENDIX XI   RESOURCE PROSPECTS

This appendix includes supporting information for each of the resource prospects outlined in the body of the report. Information on the fishery, resource status and resource prospects for each stock are included below.

1.0 Stocks Assessed by DFO Newfoundland and Labrador Region

1.1 Cod in Divisions 2J3KL

The most recent Stock Status Report for this stock was published in 2013. There was a stock status update completed in March of 2014 with the next full assessment scheduled for March 2015.

The Fishery: Catches of northern cod increased during the 1960's to a peak of over 800,000 t in 1968 (Exhibit A1), declined steadily to a low of 140,000 t in 1978, increased to about 240,000 t through much of the 1980's, and then declined rapidly in the early 1990's in advance of a moratorium on directed fishing in 1992.

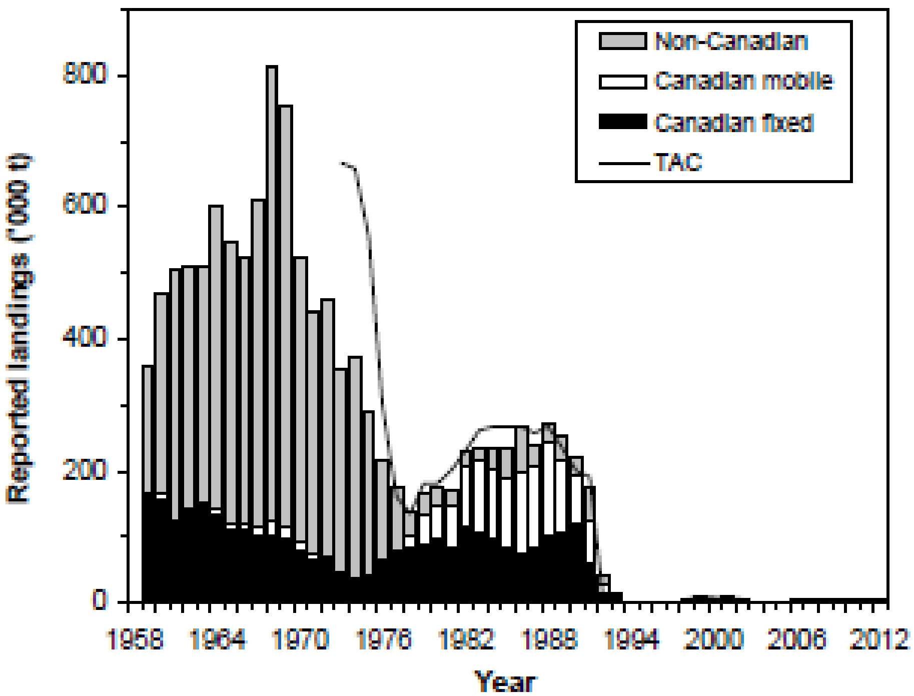


Exhibit A1. Northern Cod landings from 1959-201 (Source DFO).

Landings during 1993-1997 came from by-catches, food/recreational fisheries, and DFO-industry sentinel surveys that started in 1995. In addition, landings from 1998 to 2002 also came from a limited index/commercial inshore fishery restricted to fixed gear and small vessels (<65'). The directed commercial and recreational fisheries were closed in April 2003; most of the landings in 2003 came from an unusual mortality event in Smith Sound, Trinity Bay. During 2004 and 2005, substantial by-catches (>600 t) of cod were taken in the inshore, mostly in Div. 3KL, in the Winter Flounder fishery.

A stewardship fishery and a recreational fishery for cod were re-opened in the inshore in 2006 and continued in 2007-2013 (Exhibit A2). Reported landings in 2013 were 4,299 t. This comprised 4,001 t in the stewardship fishery, 275 t in the sentinel surveys, and 23 t taken as by-catch, but excludes recreational fishery removals. Catches outside the Canadian EEZ (200 mile limit) during 2013 are not yet available, but have generally been <300 t during the past five years. Currently, there is no requirement to report recreational landings, providing uncertainty in total removal estimates. However, analysis of proxy data, tag returns, suggests that removals of commercial size fish from recreational fisheries during 2013 were approximately 37% of the removals from the stewardship fishery or approximately 1,500 t for an estimate of total removals for 2013 of 5,800t.

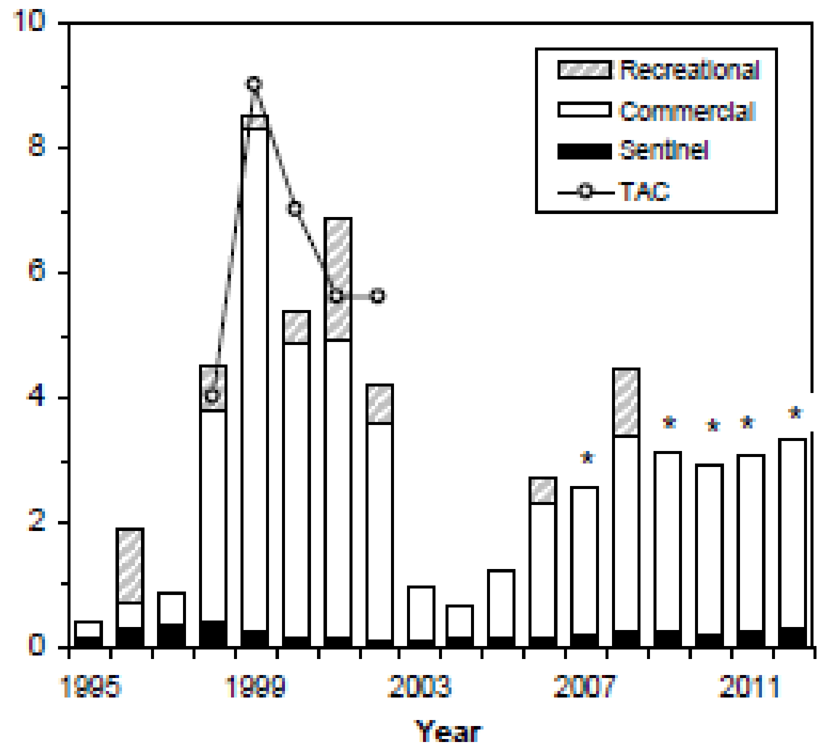


Exhibit A2. Northern Cod landings from 1995 to 2012 (Source DFO).

Resource Status: The abundance and biomass indices from the autumn RV surveys have been low since the start of the moratorium in 1992. The abundance index increased during 2005-09 and the biomass index increased during 2005-08; these increasing trends did not persist during 2009-11 but have resumed during 2011-13 surveys. The spring research vessel survey index for Div. 3L is more variable than the autumn index for Div. 2J3KL but is generally consistent in terms of trends. The research vessel surveys in 2012 show an expansion of fish into southern Div. 2J and northern Div. 3K and continuing low abundance in central and southern Div. 3L.

A conservation limit reference point (LRP) has been established at 600,000 t and is defined as the average spawning stock biomass (SSB) during the 1980s. The SSB index from the autumn RV survey declined rapidly in the late 1980s and early 1990's and remained very low for two decades after the 1992 moratorium. The SSB index has been variable since 2006 but shows an increasing trend. The SSB was only 1% of the LRP in 2005 and increased to an average of 12% for the 2010-2012 period. The average SSB index during 2011-13 represents 18% of the LRP and the index value for 2013 is 28% of the LRP. The stock has remained below the LRP (in the critical zone) since the early 1990's. These increasing trends in the SSB are encouraging; however the spawning stock remains well below that of the 1980's.

Total mortality rate from DFO surveys averaged 0.27 during 2011-13, which corresponds to 24% mortality per year. During 2010-12 total mortality averaged 0.46 which corresponds to 37% mortality per year. In recent (2011-13) surveys, several cohorts have shown increasing numbers among older ages that is not biologically possible. This indicates that one or more of the 2011-13 surveys may be influenced by a year effect. Consequently, stock trends and total mortality estimates in the most recent three years are uncertain.

Information from recaptures of cod tagged in various inshore regions of 3KL during 1997-2013 was used to estimate average annual exploitation (harvest) rates. No cod were tagged in the offshore during 2009-13, but most tagging was conducted during July-October when migrant offshore cod may be inshore. Exploitation rates were consistently low for cod tagged in central and southern areas, ranging between 2% and 5% during 2012 and 2013.

Sentinel survey catch rates increased in the northern, central, and southern areas in 2013. Catch rates are well above the respective time series (1995-2013) average in the northern and central areas, but close to average in the southern area. Recent catch rates are much lower in the southern area compared with the northern and central areas. Information from the Sentinel survey and autumn DFO RV survey in 2013 is generally consistent. Information from the Sentinel survey and autumn DFO RV survey in 2013 is generally consistent. Both indicate some improvement in stock status, particularly in 2J and 3K. There are no indications of exceptional changes to SSB due to incoming recruitment (ages 3-4) in the next 1-2 years. In keeping with the DFO decision-making framework incorporating the precautionary approach, removals should remain low to promote continued stock growth.

Prospects: The increasing trend in SSB is an encouraging sign for this stock. In addition, exploitation rates from the survey data as well as tagging are quite low. However, survey variability in the past three years makes the stock trends and total mortality rates derived from these data somewhat uncertain. There is no expectation that SSB will increase in the next 1-2 years due to incoming recruitment, but maintaining the removals from this stock at the current low levels should promote stock growth in the mid to long-term.

1.2 Cod in Division 3Ps

The most recent Stock Status Report for this stock was published in 2013. However, another assessment was completed in October 2014, but the results from this exercise are not yet published. Information will be available in December 2014 or January 2015. Assessments for this stock are conducted annually.

The Fishery: The stock was heavily exploited in the 1960's and early 1970's by non-Canadian fleets, mainly from Spain, with catches peaking at 87,000 t in 1961. After the extension of jurisdiction in 1977, landings increased to peak at almost 59,000 t in 1987 due to increased landings by France. Landings then decreased sharply to a level of about 40,000 t during 1998-91 before decreasing further to 36,000 t in 1992 (Exhibit A3). A moratorium was imposed in August 1993 after only 15,000 t had been landed. Although offshore landings fluctuated, the inshore fixed gear fishery reported landings around 20,000 t each year prior to the moratorium.

The fishery reopened in May 1997 with a TAC of 10,000 t, and increased to 30,000 t by 1999. In 2000 the management year was changed to begin on 1 April. The TAC for the most recent four management years was set at 11,500 t. Reported landings by both Canada and France have been substantially below the TAC since the 2009/10 season, and the proportion of the TAC taken has been decreasing. During the 2012/13 season, less than half (42%) of the 11,500 t TAC was landed.

Prior to 2009/10, the TAC has been almost fully subscribed with the exception of the initial four years of TAC regulation. Industry participants have indicated multiple reasons contributing to the recent reduction in landings, mainly relating to economic factors, but reduced availability has been a concern for some areas at certain times of year. Of the 4,798 t landed during the 2012/13 season, 4,038 t was taken by Canada (including 14 t from sentinel surveys), and 760 t was landed by France. Provisional data (as of October 3, 2013) indicate landings during the ongoing 2013/14 management year were 1,512 t, 8 t of which was landed by France. Although incomplete, these landings at the time of the assessment were relatively low, and suggested that much of the 2013/14 TAC of 11,500 t would not be caught. The level of total removals is uncertain. It is likely that historical landings have been biased both upwards, due to misreporting of catch by area and/or species, and downwards, due to discarding. In addition, commercial catch accounting procedures pre and post-moratorium are quite different, with current measures likely to provide improved estimates of removals due to improved monitoring and reporting systems.

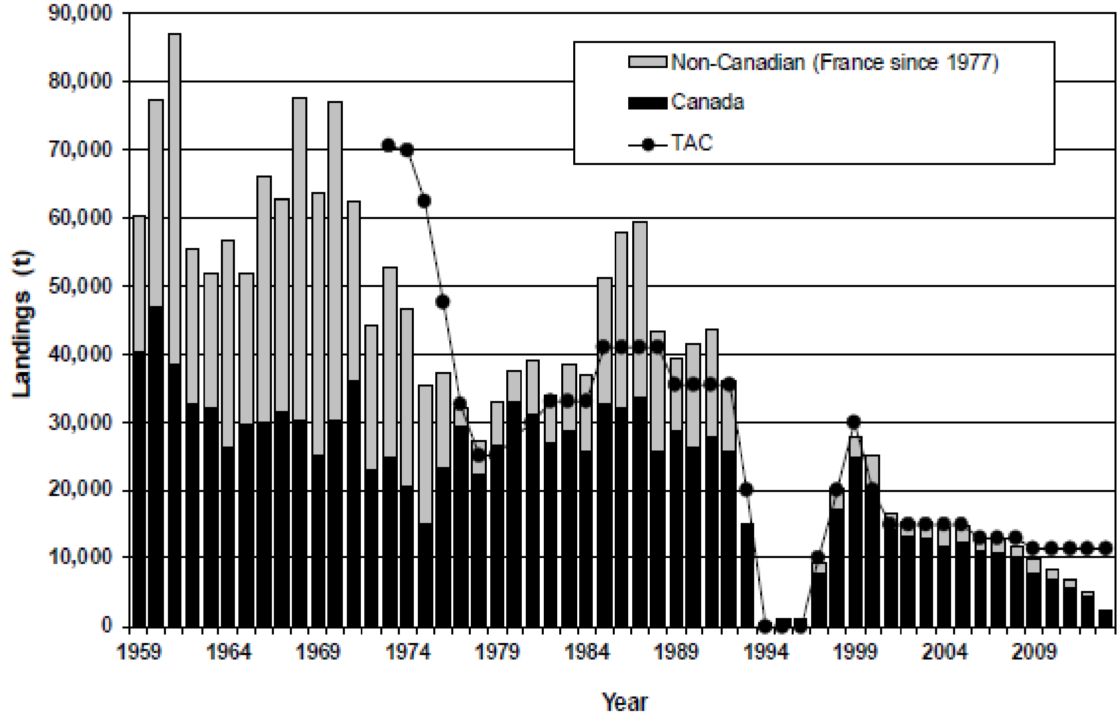


Exhibit A3. Catches of 3Ps cod from 1959 to 2013 (Source DFO)

Resource Status: Sentinel gillnet catch rates have been very low since 1999, and in 2012 the gillnet index was near the lowest in the time-series. Sentinel line trawl catch rates from the past four years have also been below average. Gillnet catch rates from logbooks of vessels <35' have been stable since 1999, though the 2012 estimate is the lowest in the time-series. Line trawl catch rates decreased over the 2006-10 period, and have subsequently been relatively stable near the time-series average. Although at-sea observer coverage is relatively low for most years and areas, 1.5% for fixed gear and 14% for mobile gears, catch rates from gillnets, line trawls and otter trawls generally support that recent values are among the lowest in the time-series (1997- 2012).

Average annual exploitation rates based on various size groups of cod tagged and released in Placentia Bay have been variable over 2009-12. In 2011, estimates ranged from 7%-14% but increased to 11%-21% in 2012, even though the full TAC was not taken in either year. Total mortality rates reflect mortality due to all causes, including fishing. Estimated total mortality from a cohort model has been decreasing since 2006, with an average 2010-12 value of 0.44, 36% annual mortality. Current mortality rates are near the time-series average when less than half of the 2012/13 TAC was taken. Recent recruitment, 2004-09 cohorts, has improved; particularly the 2006 cohort that is estimated to be well above the time-series, 1983-2012, average, and preliminary indications are that the 2011 cohort is the strongest in the time-series.

The basis for a LRP for this stock is $B_{recovery,}$ which is defined as the lowest observed SSB from which there has been a sustained recovery. The 1994 value of SSB has been identified as the limit reference level for this stock. Over 2009-13, SSB has increased considerably. The 2013 estimate is approximately twice the level of the LRP, and is near the time-series, 1983-2013, maximum. The probability of being below the LRP in 2013 is very low (<0.01). Three-year projections were conducted assuming future mortality rates will be within ±20% of current values, 2010-12 average. Projection scenarios indicate that the 2014 SSB will remain stable or increase slightly from the 2013 estimate. However, by 2016, results indicate SSB will increase to about 3-4 times the LRP. The particularly large increase in SSB projected from 2015 to 2016 is highly uncertain, being influenced by the very large preliminary estimate for the 2011 year-class.

Prospects: The exploitation rates on this stock in recent years have been very low. This is in part due to the full TAC not being taken in the recent past. The 2013 estimate of SSB is twice the level of the LRP. Incoming good recruitment will result in further increases in the SSB and by 2016 the SSB will be 3-4 times the LRP. Continued low exploitation as well as expected positive recruitment for this stock should result in continued growth in the SSB in the mid to long-term.

1.3 Snow Crab in Newfoundland and Labrador

The most recent Stock Status Report for this stock was published in 2014. The next assessment is scheduled for 2015.

The Fishery: The fishery began in Trinity Bay (Crab Management Area 6A) in 1967. Initially, crabs were taken as gillnet by-catch but within several years a directed trap fishery developed in inshore areas along the northeast coast of Div. 3KL. The minimum legal mesh size of traps is 135 mm (5 ¼”), to allow small male and female crabs to escape. Under-sized crabs and new-shelled that are retained in the traps are returned to the sea and an unknown proportion dies.

Until the early 1980’s, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981 fishing was restricted to the NAFO Division adjacent to where the license holder resided. During 1982-87 there were major declines in the resource in traditional areas in Div. 3K and 3L while new fisheries started in Div. 2J, Div. 3Ps, and offshore Div. 3K. A snow crab fishery began in Div. 4R in 1993. Licenses supplemental to ground fishing were issued in Div. 3K and Div. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990’s. Since 1989 there has been a further expansion in the offshore. Temporary permits for inshore vessels <35’ introduced in 1995, were converted to licenses in 2003. There are now several fleet sectors and an estimated 2,800 license holders.

In the late 1980’s quota control was initiated in all management areas of each Division. Current management measures include trap limits, individual quotas, trip limits, male only retention, fishing areas within Divisions, and differing seasons. The fishery has started earlier in recent years and is now prosecuted predominately in the spring, resulting in reduced incidence of soft-shelled crabs and improved landed quality. A protocol was initiated in 2004 that results in closure of localized areas when the threshold level of soft-shelled crabs within the legal-sized catch exceeds 20%. In Div. 3L, the closure threshold was reduced to 15% in 2009. Mandatory use of the electronic Vessel Monitoring System (VMS) was fully implemented in offshore fleets in 2004, to ensure compliance with regulations regarding area fished.

Landings for Div. 2HJ3KLNOP4R increased steadily from 1989 to peak at 69,100 t in 1999, largely due to expansion of the fishery to offshore areas (Exhibit A4). They decreased by 20% to 55,400 t in 2000 and changed little until they decreased to 44,000 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Total landings have remained at 50,000–53,000 t since 2007. However, Div. 3LNO has accounted for a steadily increasing percentage in recent years, from about half in 2009 to two-thirds in the past two years.

Fishing effort has increased since the 1980's and has been broadly distributed in recent years. The fishery is sometimes delayed in certain areas and years due to ice conditions (Div. 2J and 3K) and price disputes. Severe ice conditions can affect the spatial distribution of fishing effort and fishery performance.

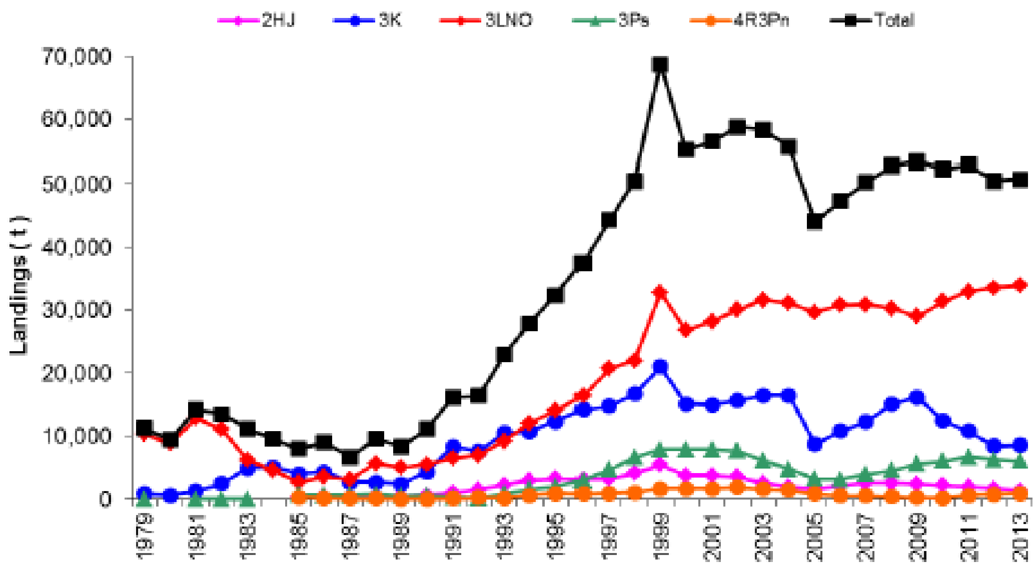


Exhibit A4. NL Snow crab landings from 1979 to 2013 (Source DFO).

Resource Status: The total landings have remained at 50,000–53,000 t since 2007. The overall exploitable biomass has changed little since the mid-2000's. However, both the trap and trawl surveys indicate that Div. 3LNO has accounted for an increased percentage in recent years, from about 40 % in 2008 to 75% in 2013. Overall, recruitment is expected to decline in the short term, 2-3 years. In addition, a recent warm oceanographic regime suggests weak recruitment in the long term.

A summary of available information for each of the primary management areas is provided.

Divisions 2HJ

- Landings decreased by 45 % since 2008, to 1,380 t and the TAC has not been taken in the past 3 years.
- The CPUE declined steadily by half from 2008 to 2011, was unchanged in 2012,

and increased in 2013.

- The exploitable biomass, as indicated by the post-season trawl survey, declined steadily from 2006 to 2011 and has changed little since.
- Recruitment declined from 2006 to 2011 and changed little since; prospects are uncertain in the short term (2-3 years).
- The post-season trawl survey pre-recruit index has changed little since 2005.
- A recent warm oceanographic regime suggests weak recruitment in the long term.
- The exploitation rate index increased steadily from 2007 to 2012 before decreasing in 2013.
- The pre-recruit fishing mortality rate index was at its highest level since 2004 during 2011 and 2012 but decreased by more than half in 2013.
- The percentage of the catch handled and released in the fishery decreased from 35 % in 2012 to 20 % in 2013, implying a decrease in pre-recruit mortality.
- Maintaining current level of fishery removals would likely have little effect on the exploitation rate in 2014.

Division 3K Offshore

- Landings most recently peaked at 13,300 t in 2009 but declined by 51 % to 6,500 t in 2012 before increasing to 6,600 t in 2013.
- Effort most recently peaked in 2009 and has since declined by 33 %.
- The CPUE declined by half from 2008 to 2011 and increased slightly since 2012.
- The exploitable biomass, as indicated by the post-season trap and trawl surveys, declined by more than two thirds since 2008.
- Recruitment declined after 2008 and prospects remain poor in the short term (2-3 years).
- Post-season pre-recruit biomass indices from both trap and trawl surveys have decreased by about 70 % since 2008.
- A recent warm oceanographic regime suggests weak recruitment in the long term.
- The trawl survey-based exploitation rate index was at its highest level since 2004 in 2010-2011. It decreased in 2012 before increasing again in 2013.
- The pre-recruit fishing mortality rate index increased from 2007 to 2011 but decreased in 2012 before increasing again in 2013.
- The percentage of the catch handled and released in the fishery decreased from about 20 % in 2012 to about 10 % in 2013, implying a decrease in pre-recruit mortality.
- Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate in 2014.

Division 3K Inshore

- Landings declined by 34 % from 2,900 t in 2009 to 1,900 t in 2012 and 2013.
- Effort increased by 70 % from 2008 to 2011 before declining by 40 % to 2013.
- CPUE declined by more than half from 2008 to 2011, and increased over the

past two years.

- The exploitable biomass, as indicated by the post-season trap survey, decreased from 2007 to 2009 and has since fluctuated.
- Recruitment prospects are poor in the short term (2-3 years).
- The post-season trap survey pre-recruit biomass index decreased by more than half in 2013, to its lowest level in the time series.
- The post-season trap survey-based exploitation rate index has changed little throughout the time series.
- Data are insufficient to estimate the pre-recruit fishing mortality rate index.
- Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2014.

Divisions 3LNO Offshore

- Landings decreased by 11 % from 24,500 t in 2006 to 21,900 t in 2009 and then increased by 20 % to 26,300 t in 2013.
- Effort increased by 83 % from 2000 to 2008 and has since declined by 32 %.
- VMS-based CPUE declined to its lowest level in 2008, and has since increased steadily to its highest level in the time series.
- The indices of exploitable biomass from post-season trap and trawl surveys diverged during 2009 to 2011 with the trap index increasing and the trawl index declining. However both indices have since increased slightly.
- Biological data from several sources indicate that recruitment will likely decrease in the short term.
- A recent warm oceanographic regime suggests weak recruitment in the long term.
- The exploitation rate index decreased marginally in 2013.
- The pre-recruit fishing mortality rate index decreased from 2008 to 2011, increased in 2012 and changed little in 2013.
- The percentage of the catch handled and released in the fishery decreased from about 20 % in 2008 to 9 % in 2013, implying a decrease in pre- recruit mortality.
- Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2014.

Division 3L Inshore

- Landings increased by 19 % from 6,100 t in 2005 to 7,300 t in 2010, and have since changed little, at 7,600 t in 2013.
- Effort increased from 2008 to 2010 and has since declined steadily.
- CPUE increased sharply since 2011 to its highest level.
- The post-season trap survey index suggests that the exploitable biomass increased steadily since 2008 to its highest level in the time series, with considerable variability among management areas.
- Recruitment has declined slightly since 2010, although there is considerable

variability among management areas, and is expected to decline further in the short-term (2- 3 years).

- The post-season trap survey pre-recruit biomass index decreased in 2013.
- The post-season trap survey-based exploitation rate index has changed little over the time series, with considerable variability among management areas.
- Maintaining the current level of fishery removals would likely result in little change in the exploitation rate in 2014.

Subdivision 3Ps Offshore

- Landings almost doubled from 2,300 t in 2006 to a peak of 4,200 t in 2011, before declining by 16 % to 3,500 t in 2013.
- Effort increased by 76 % from 2008 to a record high level in 2013.
- CPUE increased from 2005 to 2009 and has steadily declined since, to about its previous lowest level.
- The exploitable biomass, as indicated by both the spring trawl survey and the post- season trap survey indices, increased steadily from 2006 to 2009 before declining rapidly to its lowest level in 2013.
- Recruitment has recently declined and is expected to decline further in the short term (2- 3 years).
- Pre-recruit biomass indices from both trap and trawl surveys declined rapidly from 2009 to their lowest levels in 2013.
- A recent warm oceanographic regime suggests weak recruitment in the long term.
- The spring trawl survey-based exploitation rate index more than doubled from 2009- 2012, before doubling again in 2013.
- The pre-recruit fishing mortality rate index has increased steadily since 2009 to about its previous highest level.
- Maintaining the current level of fishery removals would increase the exploitation rate in 2014.

Subdivision 3Ps Inshore

- Landings more than tripled from 700 t in 2005 to 2,500 t in 2011 and remained at that level since.
- Effort declined substantially in 2005 and has since varied without trend.
- CPUE increased steadily from 2005 to 2010, changed little in 2011–2012, then decreased slightly in 2013.
- The exploitable biomass, as indicated by the post-season trap survey index, increased substantially between 2006 and 2010, changed little in 2011-2012, then decreased by half in 2013.
- Recruitment decreased substantially in 2013 and is expected to remain low in the short term (2-3 years).
- The pre-recruit biomass has been declining since 2007.
- The post-season trap survey-based exploitation rate index has changed little in

the past six years.

- Maintaining the current level of fishery removals would increase the exploitation rate in 2014.

Division 4R Offshore

- Landings declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, and increased to 300 t in 2013.
- Effort increased by almost a factor of 7 since 2010.
- The TAC has not been taken since 2002.
- VMS-based CPUE declined from 2004 to its lowest level in 2009 before increasing to its highest value in the time series in 2013.
- The exploitable biomass remains low relative to other areas.
- Recruitment prospects are uncertain in the short term (2-3 years).
- A recent warm oceanographic regime suggests weak recruitment in the long term.
- The effect of maintaining the current level of removals on the exploitation rate in 2014 is unknown.

Division 4R Inshore

- Landings declined by 80% from 930 t in 2003 to a historical low of 160 t in 2010 and have since more than tripled to 600 t in 2013.
- Effort declined by 69% from 2004 to 2010 and doubled in 2011 before declining by 34% to 2013.
- The TAC has not been taken since 2002.
- CPUE increased sharply since 2010 to a record high level in 2013.
- The exploitable biomass, as indicated by the post-season trap survey index, fluctuated from 2006 to 2010, was three times as large in 2011, and changed little in 2012 before decreasing in 2013.
- Recruitment prospects are unfavorable in the short term (2-3 years). The trap survey pre-recruit biomass index more than doubled in 2009 and changed little until it decreased substantially to remain below pre-2009 level during 2012-2013.
- The post-season trap survey-based exploitation rate index decreased in 2012 and changed little in 2013.
- Maintaining the current level of fishery removals would increase the exploitation rate in 2014.

Prospects: The general trend of the warming environmental conditions is not positive related to recruitment for snow crab. In many of the management unit resource status summaries prepared by DFO the following phrase is used: "*A recent warm oceanographic regime suggests weak recruitment in the long term*." In addition there has also been a change in the percentage of exploitable biomass in Divisions 3LNO from 40% in 2008 to 75% in 2013, indicating a reduction in the availability of crabs to the fishery in areas outside 3LNO. The fishing areas of most immediate concern in the next

2-3 years are offshore 3K and inshore and offshore 3Ps.

1.4 Shrimp in SFA's 4-6

The most recent Stock Status Report available for this stock was published in 2013. There was a stock update completed in February, 2014. The next full assessment for this stock will occur in February, 2015**.**

The Fishery: The fishery for Northern Shrimp off the coast of Labrador began in the mid-1970s, primarily in the Hopedale and Cartwright, SFA 5, channels. Annual catches increased steadily from less than 2,700 t in 1977 to about 4,100 t in 1981 but subsequently declined to 1,000 t in 1983 and 1984 due to poor markets and high operating costs (Exhibit A5). Economic conditions improved thereafter, and catches from SFAs 5 and 6 increased to about 7,800 t in 1987. In 1988, fishing effort became more widespread as vessels ventured into Div. 2G, SFA 4, where both catch rate and size of shrimp proved to be very attractive to the industry. Additional commercial concentrations of shrimp were located within SFA 6 in a small area east of St. Anthony Basin and in the Funk Island Deep. Catches in both 1988 and 1989 approached 17,000 t and remained in the 14,000-20,000 t range from 1990 to 1993.

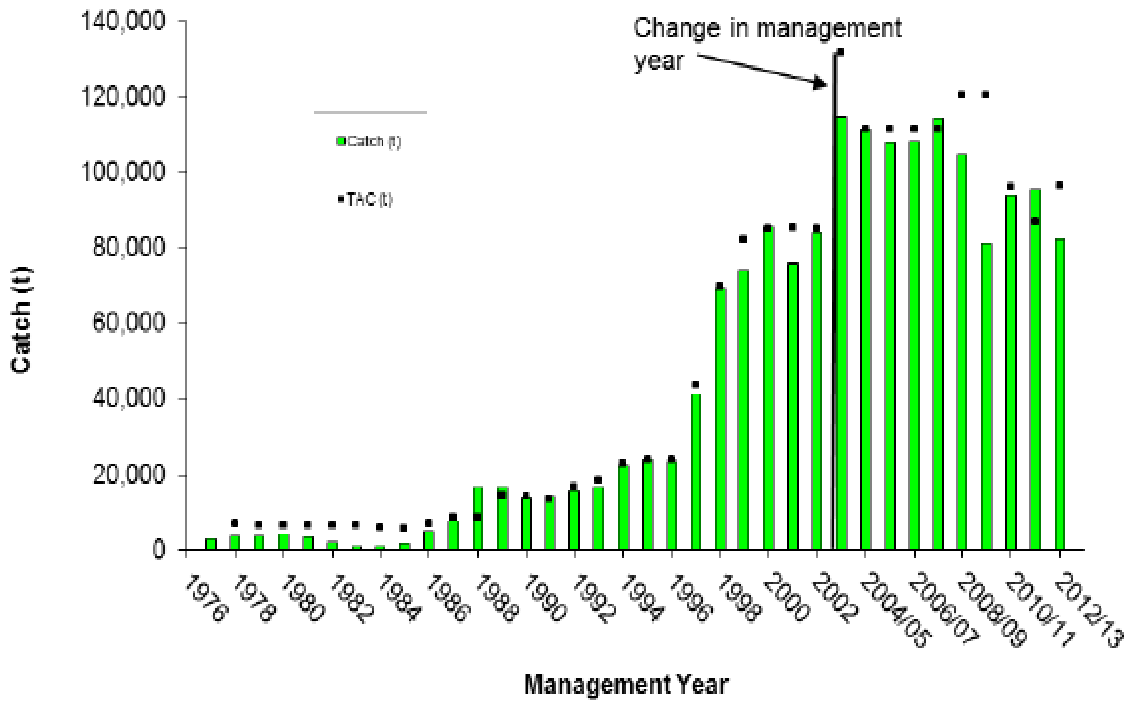


Exhibit A5. Northern shrimp landings from 1976 to 2013 (Source DFO).

Exploratory fisheries along the slope of the shelf in SFAs 4, 5, and 6 in 1992 and 1993 revealed commercial concentrations of shrimp in those areas, as well. Catches from 1994 to 1996 averaged 23,000 t increasing to 85,000 t by 2000, following increases in TAC within SFA 6 where the resource was considered to be healthy and exploitation low. The increases after 1996 were primarily reserved for the development of a small-vessel fleet

(< 100') comprising more than 260 vessels currently.

The overall TAC increased by 25,000 t in 2003. During that year industry was granted a change in management year from calendar (January 1–December 31) to fiscal (April 1-March 31). To facilitate this change, an additional 20,229 t interim quota was allocated to the large vessel fleet and the 2003/2004 management period became 15 months in length. The 2004/2005 management year was 12 months in duration and total allocations equaled 111,552 t. This TAC was maintained until 2008-09 when it was increased to 120,344 t. This TAC was maintained through to 2009/2010; however, due to operational and commercial constraints, it was not taken.

Under the Integrated Fishery Management Plan PA framework, the SFA 6 TAC was decreased by 28 % to 61,632 t resulting in an overall TAC of 96,252 t for the 2010/2011 management year. Resource status declined further in 2010/2011 therefore the SFA 6 TAC was reduced by 15 % to 52,387 t resulting in an overall TAC of 87,007 t for the 2011/2012 management year. Resource status in SFA 6 improved in 2011, therefore, the 2012/2013 SFA 6 TAC was increased to 60,245 t; resource indices remained high in SFA 4 therefore the TAC in SFA 4 was increased to 13,018 t resulting in an overall SFAs 4-6 TAC of 96,563 t for the 2012/2013 management year. It was anticipated that this TAC will be taken by March 31, 2013. The TAC remained the same for the 2013-14 management year, but was reduced to 84,137 t for the 2014-15 management year.

Resource Status: Shrimp and Capelin are key forage species in Divisions 2J3KL (SFAs 5, 6, and 7). Capelin abundance is at very low levels while some groundfish are increasing. Together this may increase predation pressure on shrimp. Resource status was updated based on a DFO fall multi-species research vessel (RV) bottom trawl survey series (1996-2013), which provided information on shrimp distribution, abundance, biomass, recruitment, and size in the Div. 2J portion of SFA 5 and Hawke Channel + Div. 3K (SFA 6). Trends in fishery performance were also inferred from fishery catch per unit effort (CPUE) and fishing patterns. The Northern Shrimp Research Foundation (NSRF) in partnership with DFO conducted annual shrimp based research surveys in Div. 2G (SFA 4) during 2005-13. The resource decreased from a peak in 2006 to near 1996 levels in the south (SFA 6); remained near average on the mid-Labrador Shelf (SFA 5) and increased in the north (SFA 4).

SFA 6 (Hawke Channel and NAFO Division 3K).

- Catch decreased from a peak of 81,000 t in 2007/2008 to 46,000 t in 2009/2010; remaining near 60,000 t since.
- The TAC gradually increased to a high of 85,725 t in 2008/09 and 2009/10.
- There were TAC reductions in 2010/11 and 2011/12, after which resource status improved and the TAC was increased to 60,245 t for the 2012/13 and 2013/14 fishing seasons and was reduced to 48,196 for the 2014-15 fishing season.
- The preliminary catch for the 2013/14 fishing season was 51,855 t, 86 % of the TAC, as of 14 February, 2014. It is anticipated that the 2013/14 TAC will be taken.
- Recruitment prospects are uncertain.

- In the long term, the exploitation rate index has varied around 15 %.
- The exploitation rate decreased from 2004/2005 to 2009/2010 and increased in the following two years.
- The resource is currently in the cautious zone, well below last year's point in the cautious zone.
- Biomass indices (fishable and female SSB) are at all-time lows.
- The exploitation rate index, based on maintaining and taking the current TAC, will be 28 % in 2014/15.
- This is well above any previous estimates for this resource.

SFA 5 (Hopedale and Cartwright Channels)

- Catches increased from about 15,000 t during 1997–2002 to around 23,000 t in more recent years.
- The TAC doubled from 7,650t during 1994-96 to 15,300 t during 1997 -2002.
- The TAC remained the same, at 23,300 t, from 2003/04 to 2013/14. The preliminary catch for the 2013/14 fishing season was 20,953 t, 90 % of the TAC, as of 14 February, 2014. The TAC for the 2014-15 management season was reduced to 20,970 t.
- It is anticipated that the 2013/14 TAC will be taken.
- Recruitment prospects are uncertain.
- Exploitation rate has varied without trend around 15 % over most of the time series.
- The resource is currently in the healthy zone with a 33 % chance of being in the cautious zone.
- Biomass indices (fishable and female SSB) have recently decreased to the levels of pre-2000.
- The exploitation rate index, based on maintaining and taking the current TAC, will be 31 % in 2014/15; well above any previous estimates for this resource.

SFA 4 (NAFO Division 2G)

- Catches increased from approximately 10,000 t over the period 2005/2006 to 2011/2012 to approximately 13,000 t in 2012/2013.
- The preliminary catch for the 2013/14 fishing season was 13,918 t, 93 % of the TAC, as of 14 February, 2014 (Figure 11).
- It is anticipated that the 2013/14 TAC 0f 14,971 t will be taken.
- The TAC for the 2014-15 fishing season remained unchanged from 2013-14.
- Recruitment prospects are uncertain.
- Annual female total mortality oscillated between about 40-50 % over the period 1999-2008.
- Exploitation rate has been between 6 and 9 % since 2007/2008 and the current estimate is 7 %.
- The resource is currently in the healthy zone with a 10 % chance of being in the cautious zone.

- Biomass indices (fishable and female SSB) have changed little since 2008.
- The exploitation rate index for 2014/15, based on taking the current TAC, will be 10%.

Prospects: The resource in SFA 6 is decreasing and is currently in the cautious zone of the PA framework. Biomass indices are at an all-time low and recruitment prospects are uncertain. The average exploitation rate in the long term has been about 15% and if the TAC is taken in 2014-15 this will rise to 28%. Further reductions in this stock can be expected in the mid to long term.

The resource in SFA 5 is currently in the healthy zone, however there is a 33% chance it is actually in the cautious zone. Biomass indices have currently declined to pre-2000 levels and the expected exploitation rate for 2014-15 of 31% will be well above any previous estimate for this resource. Further reductions for this stock can be expected, however reductions may not occur as rapidly as in SFA 6.

The resource in SFA 4 is currently well into the healthy zone and biomass levels have not changed much since 2008. The exploitation rate index for 2014-15 will be low at 10%. It appears that catches for this stock can be maintained in the medium term.

1.5 Lobster in Newfoundland and Labrador

The most recent Stock Status report for this resource was published in 2013. The timing of the next assessment is not yet available on the CSAS website.

The Fishery: The history of the American Lobster fishery in Newfoundland dates back to the early 1870’s (Exhibit A6). The fishery is prosecuted from small open boats. Traps are set close to shore, at depths generally less than 20 m. Effort was uncontrolled up to 1976, at which point a limited-entry licensing policy was implemented, and trap numbers were regulated. The minimum legal size was increased from 81 mm carapace length (CL) to 82.5 mm CL in 1998. Following the implementation of the 1998-2002 management plan, there was a 25% reduction in licenses in the Newfoundland lobster fishery. Reductions in trap limits, season lengths and licenses issued were put in place as deemed necessary by fishery managers.

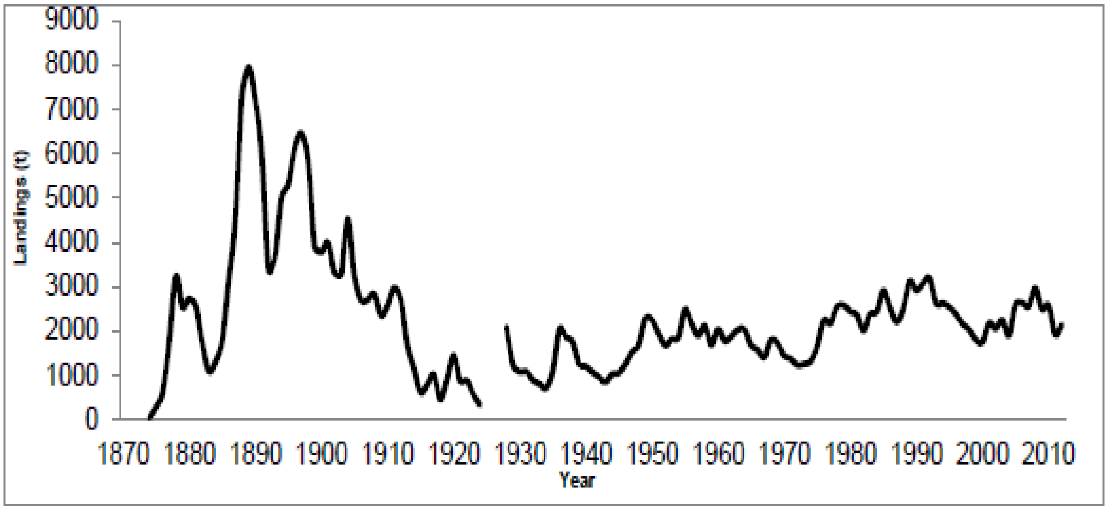


Exhibit A6. Trends in lobster landings in Newfoundland & Labrador (Source DFO)

In recent years, a lobster enterprise retirement program and the Atlantic lobster sustainability measures program were implemented. Together these programs have led to license and trap limit reductions in the Newfoundland lobster fishery, particularly in the South and West Coast regions. There are currently about 2,700 licenses with trap limits varying from 100 to 300 per licensed fisher, depending on LFA. Traps must possess vents which allow undersize lobster to escape. Regulations prohibit the retention of undersize animals, as well as egg-bearing and v-notched females. Reported landings do not account for local sales, poaching, and handling mortalities that can occur prior to the sale of the catch. The extent of local sales, in particular, can be considerable and varies by location and year. Reported landings peaked at almost 8000 t in 1889.

Early documentation indicates that all lobsters captured were landed and processed by small canning operations that existed around the coast. A stock collapse occurred in the mid-1920's, after which the fishery was closed for three years, from 1925 to 1927. The fishery reopened in 1928, and reported landings reached over 2000 t, but dropped sharply the following year. In the early 1930's, regulations were introduced to protect undersized and egg-bearing animals.

The fishery has always been a recruit-based fishery, therefore reported landings reflect abundance. Reported landings are going down in the Northeast and Avalon and going up on the South and West Coasts. Total reported landings for Newfoundland have fluctuated between 1000t and 3000 t since the 1960's.

Resource Status: The Newfoundland lobster assessment was completed for four assessment regions which are a geographical grouping of LFAs into Northeast (LFAs 3-6), Avalon (LFAs 7-10), South Coast (LFAs 11-12) and West Coast (LFAs 13-14). The total reported landings for Newfoundland have remained relatively stable since the 1960's. Reported landings increased by 70% from 1760 t in 2000 to 3000 t in 2008 before declining by 28% to 2150 t in 2012 resulting from a decrease in the Northeast and Avalon regions and an increase in the South and West Coasts.

The reported landings for lobster have become spatially concentrated in recent years. The contribution of the most productive LFA (11) to the reported landings has increased from less than 15% in the early 1990's to around 45% in the last three years. Nominal effort, based on active fishers, trap limits and fishing days, has decreased by 31% since 2008, due to license retirements, fewer active fishers, shorter seasons, and trap limit reductions. CPUE has changed little over the time period for which data are available, 2004-12. It appears that the survival fraction has increased, since 2008, in all regions except for the Northeast. It also appears that the survival fraction in the South and West Coast regions is lower than the Northeast and Avalon regions.

Northeast Region (LFAs 3-6)

- Reported landings have declined from about 750 t in the early 1990's to 140 t in 2012.
- The greatest declines have occurred in LFA 4.
- Nominal effort has decreased by 33% since 2008 due to fewer active fishers.
- Mean CPUE has changed little since 2004 in all LFAs.
- Lobster survival has gradually decreased from a peak in 2008, based on molt class ratios for males and females.

Avalon Region (LFAs 7–10)

- Reported landings have declined from about 460 t in the early 1990's to about 50 t in 2012.
- The greatest declines have occurred in LFA 10, the most productive LFA in this region.
- Nominal effort has decreased by 46% since 2008 due to fewer active fishers and shorter seasons.
- Mean CPUE has changed little since 2005 in LFAs 8-10 whereas it gradually increased in LFA.
- Lobster survival gradually increased from 2008 to 2011 before declining slightly in 2012, based on molt class ratios for males and females.

South Coast Region (LFAs 11–12)

- Reported landings increased from about 400 t in the early 1990's to peak at 1300 t in 2010.
- They decreased to 990 t in 2011 and then increased to 1100 t in 2012.
- The greatest increase occurred in LFA 11, the LFA with the highest reported landings in all years.
- Nominal effort has decreased by 23% since 2008 due to license retirements, fewer active fishers, shorter seasons and trap limit reductions.
- Mean CPUE has increased slightly since 2004 in both LFAs.
- Lobster survival was lowest in 2005-08 based on molt class ratios for males and females.
- It increased in 2009 and declined gradually to 2011 before increasing sharply

in 2012 to the highest levels in the time series.

West Coast Region (LFAs 13–14)

- Reported landings increased from about 750 t in 2000 to 1400 t in 2008 before declining to about 770 t in 2011 and increasing to about 880 t in 2012.
- Nominal effort has decreased by 29% since 2008 due to license retirements, fewer active fishers, and trap limit reductions.
- Mean CPUE has varied without trend since 2004 in all LFAs with the highest mean CPUE in LFA 13.
- Lobster survival gradually increased since 2007, based on molt class ratios for males and females, with a sharper increase for females than males in 2012.

Prospects: The fishery for lobster in Newfoundland and Labrador has always been a recruit-based fishery, therefore reported landings reflect abundance. Reported landings are going down in the Northeast and Avalon and going up on the South and West Coasts. There is no evidence to suggest landings will vary significant from current levels in the near term.

1.6 Capelin in Newfoundland and Labrador

The most recent Stock Status Report for this stock was published in 2013. The next assessment is scheduled for February 2015.

The Fishery: Historically, Capelin were fished on beaches for domestic use including food, bait, and fertilizer and had an annual harvest of ~25,000 t. A directed foreign offshore fishery began in the early 1970's and was closed in Div. 3L in 1979 and in Div. 2J3K in 1992. The peak offshore catch of 250,000 t occurred in 1976 (Exhibit A7). During the late 1970s, an inshore fishery for roe-bearing female capelin commenced. Throughout the 1980's, the inshore fishery usually started by mid-June in the south and finished in mid-July in the north. Since the early 1990's the inshore fishery has operated mainly in July and at times, especially in Div. 3K, in early August. Peak inshore landings of approximately 80,000 t occurred in 1988-1990. The TAC was close to being caught in 2011-2012. Preliminary landings in 2011 and 2012 were 20,104 t and 22,298 t, respectively, against a Total Allowable Catch (TAC) in Div. 3KL of 22,579 t.

The inshore fishery has been prosecuted using traps, purse seines, and, to a lesser extent, beach seines. Since 1998, modified beach seines, called "tuck seines", have been deployed because capelin stayed in deep water and were unavailable to capelin traps and beach seines. The use of tuck seines or capelin traps has varied from location to location. The majority of the inshore landings in recent years come from purse seines and tuck seines.

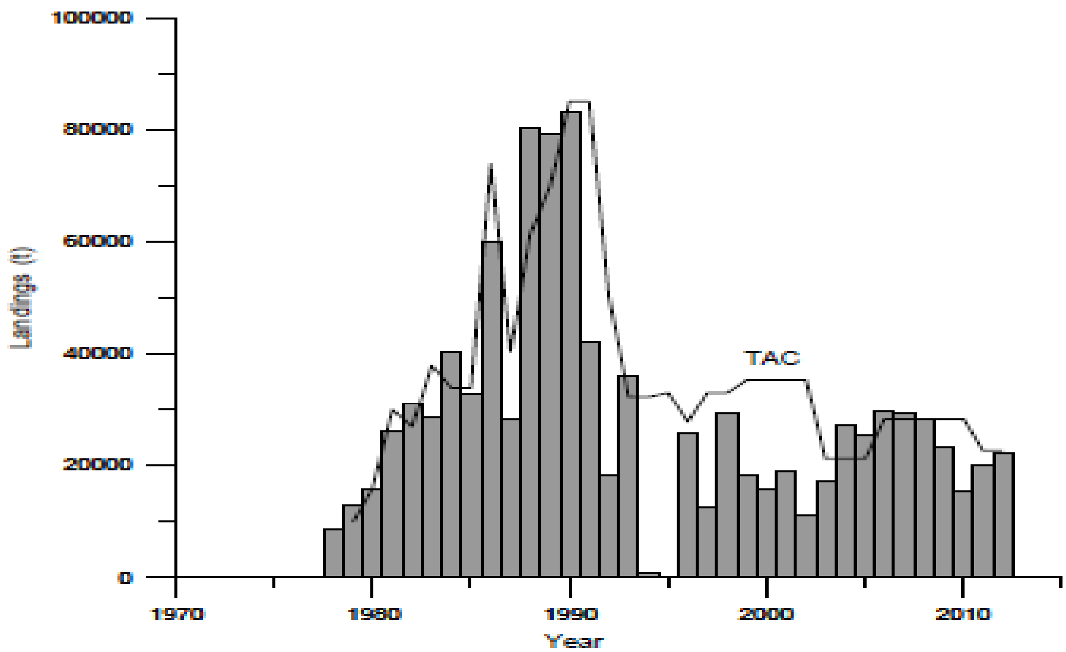


Exhibit A7. Trends in capelin landings in Divisions 3KL (Source DFO)

The primary market for frozen roe-bearing female capelin in Japan is limited and the demand for quality is high. Inshore TAC's have been tied to market constraints until the late 1990's. Discarding at sea and dumping of capelin, predominantly males that are unsuitable for the Japanese market, were major concerns in the 1980s'. In recent years, several management measures and access to other markets have mitigated these concerns. Monitoring capelin quality prior to opening the fishery and relatively short fisheries, two to three days, have significantly reduced at-sea discarding. A condition of provincial processing licenses requiring full utilization of capelin has been in effect since 2006. This license requirement coupled with identification of new markets has permitted for near full utilization of landed capelin.

In 1994 and 1995, the average size of female capelin in most areas was too small to meet a conservation criterion of 50 count/kg (sea run) in the capelin management plan. As a result, the fishery either did not open or opened for only a short time and catches were low. In 1996, this size criterion was removed. Landings from 1996-2003 were less than the TAC as a result of reduced fishing effort due to low prices, small females, and lack of interest by processors. Interest in the capelin fishery has steadily increased since 2004 coincident with a closure of the Barents Sea capelin fishery. The Barents Sea fishery reopened in 2009.

In the capelin IFMP for 2003-2005, there was a 40% reduction in TACs attributed to uncertainty around the status of capelin at the time and its role in cod recovery. In the capelin IFMP for 2006-2008, TACs were increased by 33%; at the time there were indications that capelin status was improving based on observations of capelin in northern portions of the stock area, an increase in the size of spawners, and indications of more and earlier beach spawning. TACs were lowered by 20% for 2011 and 2012.

Capelin landings in Notre Dame Bay and White Bay for 2012 have returned to levels prior to 2010; however, landings in Conception Bay remain at relatively low levels. Capelin landings in St. Mary's Bay and along the Southern Shore have been negligible since the 1990's. A sustained reduction in the spawning area of the stock may mean recruitment is becoming more dependent on spawning sites located in a smaller portion of the stock area.

Resource Status: Fish harvesters report normal distribution and abundance in areas fished in recent years. Autumn capelin distribution contracted southerly in the early 1990's. In 2011-2012 there was an expansion northward into Div. 2J. In spring 2011 and 2012 capelin were widely distributed. In 2012 the DFO spring acoustic survey, an independent acoustic study, and the spring multi-species survey reported that capelin have shifted from the shelf break onto the shelf, along the coast, and further south, a pattern typical of the 1980's.

Capelins vertical distribution continues to exhibit less day-night migration, remaining closer to the bottom than in the 1980s; however, capelin inhabited more shallow depths in 2011-2012. The mean lengths and ages of capelin sampled during the commercial fishery in 2010 and 2011 increased from a low in 2009 but remained smaller and younger than estimates in the 1980s. The proportion of age two's maturing in recent years, 37-79%, has been higher than in the 1980s, less than 5%.

Since the 1990's spawning times have been delayed by as much as four weeks. Peak spawning at Bryants Cove and Bellevue Beach from 2010 to 2012 was in early to mid-July almost three weeks later than in the 1980s. Larval densities from the Trinity Bay September 0-group index since 2003 have been lower than during the mid-1980s, and the mean length of larvae has been smaller. Recruitment based on the spring acoustic survey has remained low since the 1980s. Five recruitment indices covering the year classes since 2003 have generally been coherent and indicate that the 2010 and 2011 year classes are comparable to the relatively large 2007 year class. There is uncertainty concerning the relative size of the 2012 year class. The 2011 and 2012 estimates of abundance from the spring acoustic survey in Div. 3L are higher than the 2010 estimate and similar to those of 2007-2009, an order of magnitude below estimates of the 1980s.

Zooplankton abundance has been above average in recent years and favorable for capelin growth, distribution and spawning. The current impact of predators on capelin is not well understood. However, the biomass of piscivores, fish eating birds/animals, since 2005 has been generally higher during than the previous decade but remains lower than the 1980's.

Prospects: Fish harvesters report normal distribution and abundance in areas fished in recent years. In addition, in 2012 the DFO spring acoustic survey and the spring multi-species survey reported that capelin have shifted from the shelf break onto the shelf, along the coast, and further south, a pattern typical of the 1980's. Zooplankton abundance has also been above average in recent years, which is favourable for capelin growth, distribution and spawning. It would appear that given these various signals it may be expected that recent success in the capelin fishery in NL should continue for the medium term.

1.7 Redfish in Subarea 2 + Division 3K

The latest information on the stock status was published in 2012. This most recent report related to Redfish reference points. The timing for the next assessment of this stock is not yet posted on the CSAS website.

The Fishery: Three species of redfish can be found in the Northwest Atlantic: *Sebastes mentella* and *S. fasciatus*, which dominate commercial fisheries, and *S. marinus* which is much less abundant. *S. marinus* can be distinguished from the two other species by its colour, eye size and the size of the bony protrusion on its lower jaw; however, *S. mentella* and *S. fasciatus* are visually similar. Three characteristics are used to discriminate *S. mentella* from *S. fasciatus* in the Northwest Atlantic: 1) the number of soft rays in the anal fin, 2) extrinsic gas bladder muscle passage patterns, and 3) genotype at the liver malate dehydrogenase locus. In the Gulf of St. Lawrence and the Laurentian Channel, the occurrence of hybrid individuals has also been confirmed. Modern genetic methods use DNA microsatellite discrimination.

In the Northwest Atlantic, redfish distribution ranges from the Gulf of Maine, northwards off Nova Scotia and the southern Newfoundland Banks, in the Gulf of St. Lawrence and along the continental slope and deep channels from the southwestern Grand Bank to areas as far north as Baffin Island. Redfish are also present in the area of Flemish Cap and west of Greenland.

Sebastes mentella and *S. fasciatus* are distributed according to a gradient in the Northwest Atlantic. *S. mentella* is the dominant species in Baffin Bay and in Labrador waters, while *S. fasciatus* dominates in the Gulf of Maine and in basins and on the continental slopes of the western part of the Scotian Shelf. The distribution of both species overlaps in the Gulf of St. Lawrence, the Laurentian Channel, off southern Newfoundland and in the southern Labrador Sea. The distribution of the two species is also characterized by an area of introgressive hybridization which is geographically circumscribed to the Gulf of St. Lawrence and Laurentian Channel, and to a lesser extent to the Flemish Cap area.

This stock has been under moratorium since the mid-1990's.

Resource Status: A production assessment model was used for the determination of stock status and limit reference points for Subarea 2+3K *Sebastes mentella* and *Sebastes fasciatus* stocks. DFO has conducted an autumn survey in 2J3K in this region since 1978 which provided the biomass index used. Species were separated by using anatomical characteristics. Mixed species catch data from 1959 is available from NAFO.

For *Sebastes fasciatus* the production model suggests that median biomass declined by about 50% from 1960 to 1980 then continued to decline rapidly over the next 10 years. The stock had collapsed by over 99% of its earlier abundance to its lowest level in the mid-1990's, but has subsequently shown improvement.

For *Sebastes mentella* the production model suggests that median biomass was reduced by 50% in a steady continuous trend from 1960 to the mid-1980s, and then declined rapidly over a 10-year period to the mid- 1990's. Since then biomass has remained stable at a low level until the mid-2000s when a period of marginal increase is evident.

The estimates for various biomass levels from these analyses are associated with high variability. These redfish stocks are associated with episodic recruitment as well as issues with catchability of the survey trawl. There are also challenges related to large changes in survey estimates between years that are difficult to explain.

Prospects: The limit reference point (LRP) for the 2+3K *Sebastes fasciatus* is 29,000 t with the 2011 biomass estimated to be 8,000 t or 28% of the LRP. For *Sebastes mentella* the LRP is 116,000 t with an associated 2011 biomass estimate of 16,000 t (14% of the LRP). While there has been some improvement in the estimated biomass for these two redfish stocks in recent years, both stocks are still well below the LRP and catches should remain at their lowest possible level in the mid-term.

1.8 Redfish in Unit 1 and Unit 2

The latest information on the stock status for this stock was published in 2012. This report, related to redfish reference points was published by the NL, Maritimes and Quebec regions. The timing for the next assessment of this stock is not yet posted on the CSAS website.

The Fishery: Three species of redfish can be found in the Northwest Atlantic, *Sebastes mentella* and *S. fasciatus*, which dominate commercial fisheries, and *S. marinus* which is much less abundant. In the Northwest Atlantic, redfish distribution ranges from the Gulf of Maine, northwards off Nova Scotia and the southern Newfoundland Banks, in the Gulf of St. Lawrence and along the continental slope and deep channels from the southwestern Grand Bank to areas as far north as Baffin Island. Redfish are also present in the area of Flemish Cap and west of Greenland.

Currently the two species, *Sebastes fasciatus* and *S. mentella*, are assessed separately and that Units 1 and 2 are grouped as a single biological unit for each of the two species and assessed as such. DFO now explicitly takes into consideration the spatial structuring of the populations in the assessment and in the development of conservation and management strategies.

A directed redfish fishery developed in the Gulf of St. Lawrence and in the Laurentian Channel outside the Gulf by the late fifties. The redfish fishery in the Gulf of St. Lawrence (Unit 1) has been characterized by two periods of high landings: the first at the beginning of the 1970's and the second in the 1990's. For the period 1960-1969, landings averaged 46,000 t annually and increased to 82,000 t for the 1970-1976 period. Landings peaked in 1973 at 136,000 t. Average annual landings were lower at 37,000 t for the period 1977-1994. In 1995, the directed fishery was closed as a result of low stock abundance and the absence of significant recruitment. The directed fishery has remained closed since then. However, a small index fishery established in 1998 has been prosecuted with an allocation of 2000 t (1000 t in 1998). From 2004 to 2008 the average annual landings of the index fishery and by-catch in Unit 1 reached 626 t for a total allowable catch (TAC) of 2,000 t. For 2009, preliminary data indicate landings of 600 t for an allocation of 2000 t.

On the south coast of Newfoundland (Unit 2) from 1960 to 1969, annual landings averaged 27,000 t, and increased to an average of 40,000 t for the period 1970-1976 due mainly to increased catches by non-Canadian fleets. Subsequent to the establishment of the 200-mile limit, landings were lower with an average of 18,000 t for the period 1977-1994. Landings further decreased to an average of 10,500 t between 1995 and 2003, following reductions in TAC. From 2004 to 2008, landings in Unit 2 averaged 5,250 t compared to a mean annual TAC of 8,333 t. Industry reported that market conditions had a major effect on catches falling short of the TAC. In 2009 preliminary data indicated landings of 5,132 t from a TAC of 8,500 t.

Resource Status: A production assessment model was used for the determination of stock status and limit reference points for the Unit 1+2 Se*bastes mentella* and *Sebastes fasciatus* stocks. For Unit 1, the DFO summer survey from 1990 was used as the biomass index. Species were separated in the survey using anatomical and genetic characteristics. The index is in Teleost-Campelen swept area equivalents. The Groundfish Enterprise Allocation Council (GEAC) summer survey from 2000 was used as the biomass index for this region. The GEAC survey was converted to swept-area Campelen biomass equivalents. Species were separated by the same method used for Unit 1. Mixed species catch data from 1960 is available from NAFO.

Unit 1+2 *Sebastes fasciatus* levels are very low presently at only a small fraction of the estimated 1960 biomass levels. The stock is estimated to be growing in recent years but without a large recruitment event it would still take considerable time for the stock to grow to a desired healthy level.

Unit 1+2 *Sebastes mentella* is estimated to have declined to only very small proportion of its 1960 biomass. This stock biomass is still decreasing. Current removals are taken in a Unit 2 directed fishery (TAC currently 8,500 t for redfish combined species) and an index fishery in Unit 1 (TAC currently 2,000 for redfish combined species). A large proportion of the redfish catch in Unit 1+2 is reported to be *S. fasciatus*.

The estimates for various biomass levels from these analyses are associated with high variability. These redfish stocks are associated with episodic recruitment as well as issues with catchability of the survey trawl. There are also challenges related to large changes in survey estimates between years that are difficult to explain

Prospects: The LRP for the Unit 1+2 *Sebastes fasciatus* is 148,000 t with the 2011 biomass estimated to be 65,000 t or 44% of the LRP. For *Sebastes mentella* the LRP is 233,000 t with an associated 2011 biomass estimate of 19,000 t, 8% of the LRP. While there has been some improvement in the biomass estimated for the *Sebastes fasciatus* stock in recent years, the same is not true for the *Sebastes mentella* stock, which still shows a declining trend. Given that both stocks are still well below the LRP and the biomass for *Sebastes mentella* is still declining, catches should remain at their lowest possible in the mid-term.

2.0 Stocks Assessed by DFO in other Regions

All stocks except Atlantic halibut in Divs. 3NOPs4VWX5Zc were assessed by the Quebec Region. The Atlantic halibut stock was assessed by the Maritimes Region.

2.1 Cod in Divisions 3Pn4RS

The last Stock Status Report for this stock was published in 2012 with an update on indicators of stock status published in 2014. The next full assessment of this stock will occur in February, 2015.

The Fishery: Landings associated with this stock for the 1974-1993 period were from fixed and mobile gear fisheries carried out by Canadian fleets, as well as from foreign fleets using mobile gear. The first TAC was introduced in 1977 and was set at 55 000 t. Since the reopening of the fishery in 1997, following the first moratorium between 1994 and 1996, all landings have been from fixed gear harvest methods including handlines, longlines and gillnets. Fishery management followed the calendar year until 1998, after which the management year was May 15 of the current year to May 14 of the following year.

Cod landings in the northern Gulf of St. Lawrence exceeded 100,000 t in 1983 (Exhibit A8). Landings then declined continuously until 1993. During the decline, vessels using mobile gear generally caught their allocation, whereas those using fixed gear failed to do so. The fishery was under moratorium from 1994 to 1996. It reopened in 1997 and catches and TAC's have varied between 2,000 to 7,500 t since, except in 2003 when the fishery was closed again. Currently, it is the only Atlantic coast cod stock where the directed fishery is only conducted with fixed gear. In 2002, a new management zone was established in 4R off St. George's Bay to protect the spawning stock. In this area, the groundfish fishery is prohibited between April 1 and June 15. Preliminary landings reported for 2013 total 1,250 t for a TAC of 1,500 t. These landings do not include recreational fishery catches, estimated to be 80 t, because they are not known precisely.

Logbooks have been mandatory since 1997 for cod-directed commercial fishing boats under 35 feet in NAFO Divisions 3Pn and 4R, and for boats under 45 feet since 1999 in NAFO Division 4S. Logbook data are analyzed to assess the performance of fixed gear commercial fleets. Landings from these fleets represent around 70% of the annual landings in the cod-directed fishery. For all areas combined, gillnet and longline commercial catch rates were fairly stable until 2002. Catch rates have increased after the 2003 moratorium for both gear types and the maximum value was observed in 2004 for gillnets and in 2006 for longlines. Catch rates decreased from 2004 to 2009 for both gear types since 2006. The 2011 values increased and are below the series average. The more noticeable increase for gillnets in 2011 was due to high catch rates in 4S.

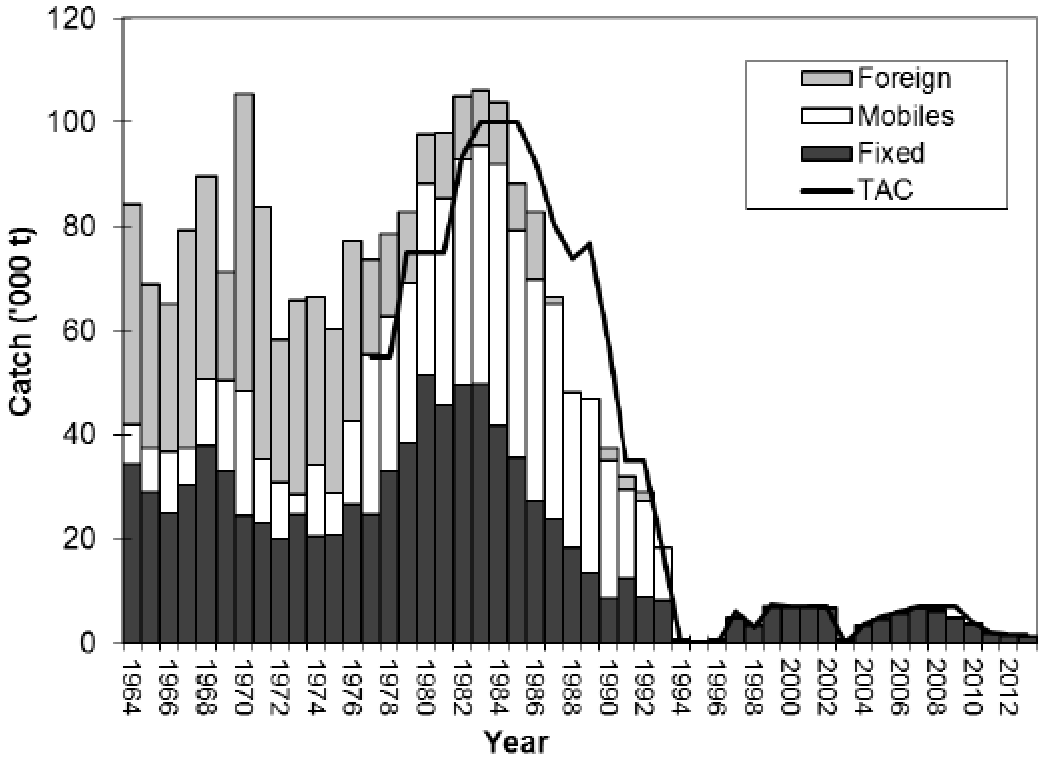


Exhibit A8. Trends in landings for Cod in Divisions 4RS3Pn (Source DFO).

Resource Status: The fixed gear sentinel fisheries program provides abundance indices derived from gillnets and longlines. Catch per unit effort (CPUE) data have represented an index of annual trends of cod abundance since 1995. The longline abundance index in 3Pn,4RS showed a general upward trend starting in 1997 and peaking in 2006. It then decreased until 2010 to a level below the series average. The index increased in 2011 to a level near the series average. The 2013 CPUE increased to a value above the 1993–2012 series average.

The gillnet abundance index for 4R and 4S varied at low levels between 1995 and 2002 and more than doubled in 2003 and peaked in 2006. It remained high and well above the average until 2008 and then decreased to a level below average in 2009 and 2010. This index shows a strong and significant increase in 2011. This increase is largely attributable to very high catch rates on the Lower North Shore, in the northeastern part of Division 4S. The gillnet CPUE decreased in 2013, but still remained above the series average.

The July mobile gear sentinel fisheries survey index shows no trend between 1995 and 2011. The average number of cod per tow varied between 17 and 43 individuals. However, the mean number of cod per tow in 2011 is the highest in the series. The 2013 mobile sentinel results are near the series average.

The DFO trawl survey indicates a sharp decline in cod abundance between 1991 and 1993, followed by an increase until 2000. The increase corresponds to the period of the first moratorium (1994 to 1996). Abundance then fluctuated with little trend from 2001 to 2011. Two years showed abnormal values; a low value in 2002 and a high value in 2003.

These annual effects were observed for other species in these surveys. The 2013 index values are equal to the 1990 to 2012 series average.

According to an assessment model, the abundance of individuals ages 3+ declined from 559 million in 1980 to 31 million in 1994, then it slowly increased to 55 million individuals in 2009 and dropped to 41 million in 2012. The number of spawners decreased from 200 million in 1983 to 7 million in 1994. It has increased to reach a projected value of 20 million individuals in 2012. The exploitation rate of 7–9-year-old individuals, estimated using the model, was high (around 36%) from 1999 to 2002. The exploitation rate was very low in 2003 due to the moratorium. The 2011 exploitation rate associated with a fishery totaling 1,742 tons was 9%. The 2004 and 2006 year-classes were the strongest of the last 21 years. The 2004 cohort will be 8 and 9 years of age in 2012 and 2013, whereas the 2006 cohort will be 6 and 7 in 2012 and 2013. These year-classes were all exploitable in 2012 and 2013.

Prospects: Overall, the values of the various stock status indicators are comparable to the average values observed in recent years. With no major changes in these indices since the last assessment, the most recent scientific advice remains valid for the near future. This previous advice indicates that the spawning stock abundance for 2012 and projected to 2014 is well below the LRP. The stock has remained in the critical zone for the last 23 years. Maintaining catches in the near future at the same level as recently observed will result in zero growth for this stock. To promote stock rebuilding, catches in the near term should be maintained at the lowest possible level.

2.2 Shrimp in the Estuary and Gulf of St. Lawrence

The last Stock Status Report for this stock was published in 2014. The timing of the next assessment of this stock is not yet posted on the CSAS website.

The Fishery: The number of active licences in the Estuary and Gulf Northern Shrimp fishery in 2013 was 132. The harvesters come from five provinces and seven First Nations. The fishery management measures include the imposition of a minimum mesh size (40 mm) and, since 1993, the compulsory use of the Nordmore grate, which reduces groundfish by-catches. Shrimpers must also keep a log book, have their catches weighted by a dockside monitoring program and agree to have an observer on board at the DFO's request (5% coverage). The fishery opens on April 1 and closes on December 31. The fishery has been managed by TAC since 1982 and the traditional fishers have had individual quotas since the mid-1990's.

Landings of Northern Shrimp in the Estuary and Gulf of St. Lawrence have risen gradually since the fishery began. Landings rose from approximately 1,000 t in the early 1970's to more than 35,000 tons in the late 2010's. Landings decreased thereafter to reach 32,000 t in 2012. Preliminary statistics indicate that the Estuary and Gulf landings were 32,160 t in 2013, of which 1,117 t in Estuary, 14,217 t in Sept-Iles, 7,681 t in Anticosti and 9,145 t in Esquiman (Exhibit A9). In 2013, the TAC was increased by 15% in Estuary and Sept-Iles and reduced by 9% in Anticosti and 10% in Esquiman. The landings reached 96% of TAC in all areas except in Estuary where it represents 92% of the TAC, but the data are preliminary. The proportion of fishing effort between seasons spring, summer and autumn seems constant between years, with the exception of the Estuary area for the last three years where the fishing effort in the spring has significantly reduced for the benefit of both other seasons.

The Newfoundland and Labrador shrimp fleet based in 4R only participates in the fishery in the Esquiman Channel.

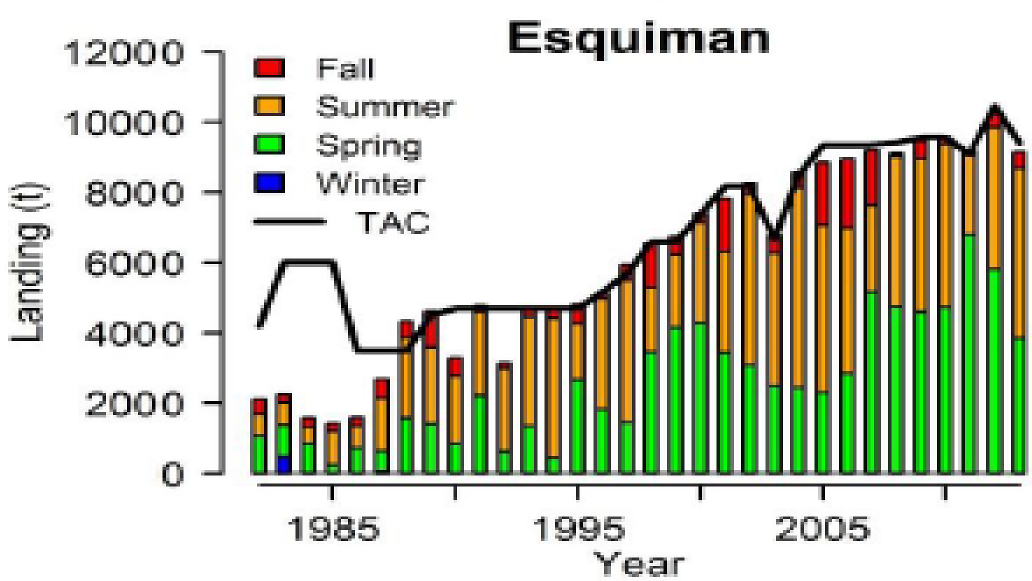


Exhibit A9. Trends in landings for Esquiman Channel shrimp (Source DFO).

Resource Status: Programs were implemented in the 1980's and 1990's to monitor the fishery and the status of Northern Shrimp populations in the Estuary and Gulf of St. Lawrence on an annual basis. Commercial fishery statistics (shrimper catch and effort) are used to estimate the fishing effort and calculate catch rates. The commercial catch samples allow the estimation of the number of shrimp harvested by size classes and by sexual maturity stage. A research survey is conducted every year in the Estuary and Gulf of St. Lawrence in August from a DFO vessel. Biomass indices are calculated using a geostatistical method. Survey catch samples provide abundance estimates of shrimp by size classes and by stage of sexual maturity.

The sectors that sustain fishing in the four areas have not changed in recent years and correspond to the spots where high concentrations of shrimp were observed during the survey. The distribution of the biomass from the research survey shows that high concentrations of Shrimp were found in all fishing areas in 2013. However, as before, the southern sector of Anticosti and Esquiman areas sustained very few Shrimp.

There was no significant change in the distribution of fishing effort in 2013. The same areas are fished by shrimp harvesters from one year to the next. Since 2003, the total annual fishing effort was around 100,000 hours, which is slightly below the historical average.

CPUE are standardized to take into account changes in fishery capacity and seasonal fishing patterns. The fishery's standardized catch rate decreased in Estuary from 2007 to 2010 and was average thereafter. In Sept-Iles, the catch rate has decreased since 2007 but remained above the historical average in 2013. It has been consistently stable and high since 2005 in Anticosti and Esquiman.

DFO's survey biomass index decreased in the Estuary, Sept-Iles and Anticosti between 2007 and 2011 and remained stable thereafter. In Esquiman, the biomass index has been stable since 2007.

An index of the exploitation rate is obtained by dividing the commercial catches in number by the abundance estimated from the research survey. This method cannot be used to estimate the absolute exploitation rate or to relate it to target exploitation rates. However, the method does make it possible to track relative changes in the exploitation rate over the years. The exploitation rate index increased in Estuary and Sept-Iles but decreased in Anticosti and Esquiman.

The main indicator of stock status is calculated from the male and female indices obtained from the summer fishery (number per unit effort for June, July and August) and research survey (abundance). In order to combine the indices, each is standardized with respect to the reference period. The main stock status indicator represents the mean of the four indices. The main indicator shows that the stocks were in the healthy zone in 2013. However, relative to 2012, the stock status indicator in 2013 decreased by 45%, 25% and 12% in Estuary, Sept-Iles and Esquiman, respectively, and increased by 19% in Anticosti. The Sept-Iles stock status indicator has shown a decreasing trend for some years.

Prospects: The purpose of the precautionary approach adopted in 2012 is to maintain a constant exploitation rate when the stock is in the healthy zone. TAC variations in the past two years were reflected through exploitation rate variations in the same directions, which maintained or came close to exploitation rates near historical averages. Harvest guidelines were established according to the main indicator and its position in relation to the stock status classification zones (healthy, cautious and critical) in compliance with the precautionary approach. According to the guidelines, the projected harvest for 2014 is 802 t for Estuary, 10,570 t for Sept-Iles, 9,100 t for Anticosti and 8,248 t for Esquiman. The main stock indicator is well above the LRP and even above the Upper Stock Reference Point in all four areas. For the Esquiman the stock indicator is 4-5 times higher than the LRP and about double the upper stock reference point.

2.3 Greenland Halibut in Divisions 4RST

The last Stock Status Report for this stock was published in 2013. There have been updates completed in 2014 with the next full assessment scheduled for February, 2015.

The Fishery: In 2012, the number of active licences was 170 from Quebec and 90 from NL. The fishery management measures include the imposition of a minimum mesh size of 152 mm (6.0 inches) and a implementation of a small-fish tolerance protocol for commercial catches of 44 cm. Fish harvesters must also keep a log book, have their catches weighted by a dockside monitoring program and agree to have an observer on board at the Department's request (5% coverage). The fishery opens on May 15 and closes on May 14 of the following year. The fishery has been managed by TAC since 1982. Some fish harvesters have individual quotas while others are under competitive fishery regime.

Until the mid-1970s, Greenland halibut landings in 4RST consisted mainly of by-catches from other fisheries. Subsequently, a directed gillnet fishery developed and landings fluctuated substantially, exceeding 8,000 t in 1979 and 1987 (Exhibit A10). These peaks were both followed by sharp declines. Catches remained between 2,000 t and 4,000 t from 1989 to 1998. Landings decreased between 1999 and 2001, dropping from 3,600 tons to less than 1,300 t. Landings increased to 3,900 t between 2001 and 2004 and have been relatively stable since. TAC was set at 4,500 t since 2004 and the allocation for the fixed gear directed fishery for Greenland halibut was set at 3,751 t.

In 2011, landings for NAFO Divisions 4RST amounted to 3,811 t for fixed gear and 44 t for mobile gear, for a total of 3,855 t. In 2012, preliminary landings by December 31 were 3,515 t for fixed gear and 35 t for mobile gear, for a total of 3,550 t.

On January 10, 2014, directed fishery landings of Greenland Halibut were 2,272 t out of a potential allocation of 3,607 t, or 63% of this allocation. The total fishing effort for 2013 was comparable to that of 2012; however, the spatial distribution of the effort changed. In 2013, the effort was spread over a larger area. An expansion of the fishing effort eastward in the Laurentian Channel, as well as to the south and north of Anticosti Island was observed. However, the fishing effort in the area southwest of Esquiman was lower in 2013 than in 2012.

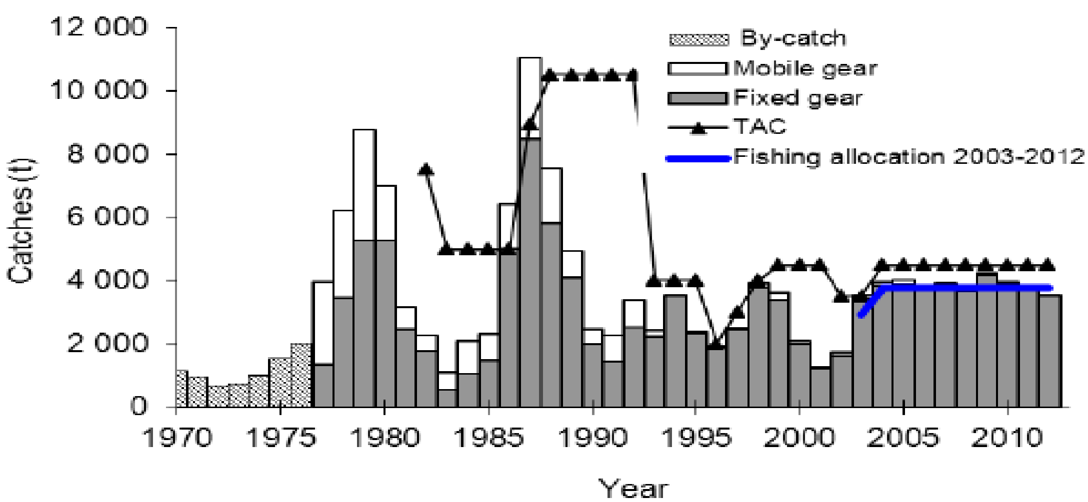


Exhibit A10. Trends in landings for Div. 4RST Greenland Halibut (Source DFO).

Resource Status: The mean catch rate in 4RST in 2013 declined by 43% from 2012. This decline can be observed in the three geographic fishing areas in the Gulf: the western Gulf (-35%), northern Anticosti (-51%) and Esquiman (-56%). The biomass index from the DFO survey decreased in 2013. It is close to the mean for the series (1990–2012), but is the lowest value since 2000. The biomass index from the mobile sentinel fisheries program survey has been in constant decline since 2007 and in 2013 dropped to one of the lowest values observed since this survey began.

The abundance of pre-recruits (40–43 cm) and recruits (> 44 cm) in the DFO survey decreased by 28% and 41%, respectively, compared to 2012. The abundance of fish that will be available to the fishery in 2014 (40 cm and above) has therefore decreased and is now close to the mean. Data from the research surveys and the commercial fishery therefore show a significant reduction, to a similar extent, in the abundance of commercial-size 4RST Greenland Halibut in 2013.

Landings in 2013 declined by 35% from 2012. This decline is comparable to that recorded by stock status indicators, which suggests similar exploitation rates in 2012 and 2013. The capture and abundance rate values for pre-recruits and recruits estimated in the 2013 DFO survey are comparable to the values observed in the early 2000s. For the same stock status, landings were 2,105 t, 1,280 t and 1,730 t in 2000, 2001 and 2002, respectively, i.e., at least 44% lower than the potential annual allocation for 2013–2014.

Prospects: The short and medium-term outlooks for Greenland Halibut abundance depend on, among other things, the abundance of the various cohorts. Juvenile abundance varies considerably from one year to the next and these fluctuations have an impact on the success of the fishery. The year classes expected to contribute to the 2014 fishery are of low or medium abundance. According to the DFO survey, the 2010 cohort, whose abundance was high at one and two years, no longer stands out as much from the mean at three years of age. That cohort will probably not start being recruited to the fishery until 2015 and will be fully recruited by 2016. It is therefore unlikely that the stock status will improve in 2014.

2.4 Atlantic Halibut in Divisions 4RST

The last Stock Status Report for this stock was published in 2013 with an update on main indicators of stock status published in 2014. The next full assessment of this stock will occur in February, 2015.

The Fishery: Significant landings, average ~1,500 t, of Atlantic halibut harvested in the Gulf of St. Lawrence during the first half of the 20th century indicate that this stock was once very abundant and associated with a very high CPUE. Halibut landings, which were around 650 t in the early 1960s, hit a record low in 1982 at 91 t. Until 1995, they seldom exceeded 300 t, the TAC established in 1988. Ranging between 260 and 420 t between 1996 and 2006, landings exceeded 500 t in 2008 and were 737 t and 722.5 in 2011 and 2012 respectively (Exhibit A11). For the 2013-14 fishing season, landings in early December 2013 totaled 763.7 t. Landings of the last three years are the highest recorded in the past 60 years.

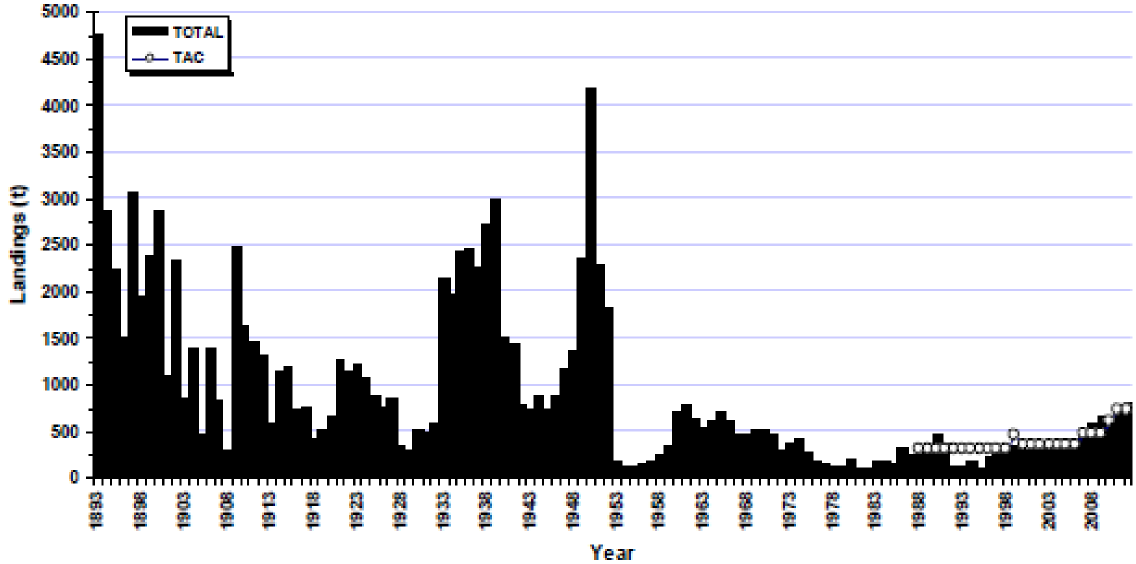


Exhibit A11. Trends in landings for Div. 4RST Atlantic Halibut (Source DFO).

Several management measures have been introduced over the years to protect the resource, in addition to the TAC. In 1997, a minimum legal catch size of 81 cm, based on a yield and value per recruit model, was added to the Canadian commercial fishing license conditions for Atlantic halibut. In 2010 the minimum legal catch size was increased to 85 cm for all the Gulf Atlantic halibut stock and any halibut below that size must be returned to the water.

Mandatory discarding of commercial size halibut by-catches by cod directed longline fleets in the Gulf, the Maritimes and Newfoundland and Labrador was implemented in 2008 and 2009. This measure was also made effective in the Magdalen Islands after that geographical fleet reached its Atlantic halibut allocation. However, all other fleets in Quebec had to keep their catches on board and land them. In 2010, the release of commercial-size halibut by-catches caught by longline in the cod directed fishery was only mandatory in Newfoundland. This measure was also implemented among Quebec longliners in 2011-2013. These halibut releases are not recorded.

Resource Status: Results of trawl surveys indicate the distribution of Atlantic Halibut in the northern and the southern Gulf in August and September 2013 respectively was similar to that observed in 2012 with catches concentrating along and in Esquiman, Anticosti and Laurentian channels, and on the periphery of the Magdalen basin. The values of distribution index in the northern Gulf are still among the highest in the 1990-2013 survey series. They have risen sharply in the southern Gulf in 2013, reaching the second highest in the 1985-2013 survey series. Indices of abundance and biomass of trawl surveys in the northern and southern Gulf in 2013 remained relatively stable compared to the values observed in 2012. The indices for the two surveys were maintained well above the average of each survey series.

The range of sizes of halibut caught during surveys in 2013 remained extensive, ranging between 20 and 130 cm in the northern Gulf and up to 170 cm in the southern Gulf. As for previous years, catches were mostly (~80 %) composed of pre-recruits (< 85 cm). The median size for the survey in the northern Gulf has declined below the 1990-2012 average median whereas for the southern Gulf survey, it remained stable at a higher level than the long-term period average median.

The distribution of Atlantic Halibut in the mobile trawl survey by Sentinel program in 2013 was similar to that observed in the DFO survey in the northern Gulf, excluding the Estuary that is not covered by the Sentinel survey. The distribution indices decreased in 2013 but still remain high relative to all the values observed for the 1995-2013 series. In 2013, the indices of abundance and biomass were slightly higher than in 2012. The value of the abundance index remained in the average for the 1995-2012 period while the value of the biomass index remained at a higher level than the average for the same period. The survey catches in 2013 were still represented by a wide range of sizes (27-124 cm) with a majority (83%) of non-commercial fish size (<85 cm). The median size observed was maintained close to the average for the 1995-2012 period.

Prospects: Indicators from DFO research trawl surveys in the northern and the southern Gulf, as well as those from the Sentinel mobile survey in the northern Gulf for 2013, suggest the abundance and biomass indices are still well above the average of their respective series, with the exception of sentinel survey for which the value of the abundance index is comparable to the average of the series. In addition, the demographic structure is as extensive as previous years, and composition still has a strong majority (over 80 %) of pre-recruits (halibut <85 cm). The update of the main indicators of the stock status of Atlantic Halibut in the Gulf shows no major changes compared to the assessment in February 2013. Insofar as the great majority of stock status indicators in recent years have been positive and stable at levels exceeding series mean values, scientists find that the stock could tolerate a TAC increase by a maximum of 20% in total for the next two fishing seasons (2013-14 and 2014-15). However, industry stakeholders disagree with this recommendation. In their opinion, the stock is still growing and the TAC increase should consequently be greater.

2.5 Capelin in Divisions 4RST

The last Stock Status Report for this stock was published in 2013. The timing for the next full assessment of this stock is not yet posted on the CSAS website.

The Fishery: In the Estuary and Gulf of St. Lawrence, capelin has traditionally been used as fertilizer, bait or for its oil. Towards the end of the 1970's, the emergence of a Japanese market for roe-bearing females sparked a rapid growth of the fishery with catches that increased from approximately 700 t per year to more than 10,000 t. In NAFO Divisions 4RST, most capelin catches are made on the west coast of Newfoundland by a fleet of small and large purse seiners and by "Tuck ring" seines and rap fish harvesters. Capelin are also caught using traps on Quebec's Lower North Shore and weirs in the St. Lawrence Estuary. In addition to recreational catches made on beaches during the spawning season, capelin are also a by-catch of the shrimpers and the multidisciplinary groundfish and shrimp surveys conducted annually by DFO in the Estuary and northern and southern Gulf of St. Lawrence.

Capelin fishing seasons are generally short and correspond to the pre-spawning period for the seine fishery and to the spawning period for the trap and weir fisheries. In the case of the purse seine and trap, the fishery mostly targets mature females for the Japanese roe market. The emergence of this market in the late 1970's is responsible for the sharp increase in landings, up from an average of 700 t/year between 1960 and 1976 to approximately 10,000 t in 1978 and 1979, and in 1992, 1993, 1998, and 2005. Landings exceeding 10,000 t were even made in 2006 and between 2008 and 2011.

Since 2005, a 13,000 t TAC was established and associated with the Estuary and Gulf of St. Lawrence. The distribution of the TAC is 11,195 t for Division 4R and 1,805 t for Divisions 4ST. Most capelin catches in the Estuary and Gulf of St. Lawrence are from the west coast of Newfoundland, i.e. in NAFO Division 4R. In Divisions 4R and 4S, the most intensive fishing is usually made in June and July.

Since 2008, annual landings in Division 4R totaled between 7,846 t and 10,147 t, which represent 70-91% of the portion of the TAC allocated, 11,195 t, to this division (Exhibit A12). For the same period, landings in Division 4S have varied from 478 t to 2,126 t and from 99 t to 1,449 t in Division 4T. In 2012, landings associated with the prominent fishing gears were 6,374 t, 2,287 t, and 684 t, respectively.

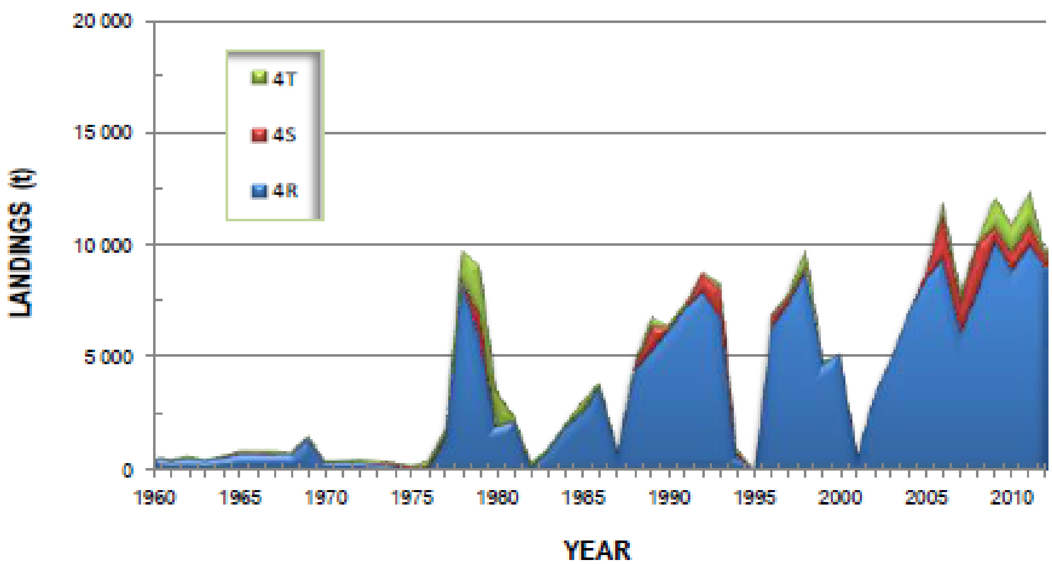


Exhibit A12. Trends in capelin landings in Division 4RST (Source DFO).

Resource Status: The performance of the purse seine fishery in Division 4R is measured using a standardized index of the catch-per-unit-effort (t/day). This index is on the rise since 2005 and the values since the recent years are the highest of the series. The average index of the 1986-2011 period is 46 t per fishing day. The upper limit has been exceeded since 2008. The index presents a non-significant decline between 2011 and 2012.

Capelin are a regular catch in the DFO groundfish and shrimp multidisciplinary surveys conducted in the Estuary and Gulf of St. Lawrence. A dispersion index (and not of abundance) was calculated by indicator based on the catches (presence and absence) made during these surveys. This index indicates a clear upward trend since 1990 for the Estuary and Gulf of St. Lawrence. Since 2010, the index values are the highest of the series. The review of the indices for each division reveals the presence of fluctuations on the west coast of Newfoundland (Division 4R) and upward trends in the northern Gulf (Division 4S), and more significantly, in the southern Gulf (Division 4T). During these surveys, the highest probabilities, 80-100%, of catching capelin were found in the Estuary, in the Anticosti area, and in the southern Gulf, between the Magdalen Islands and Prince Edward Island.

Capelin catches from the groundfish multidisciplinary survey in the southern Gulf of St. Lawrence have increased significantly since 1990, being almost nil prior. The first significant catches were made offshore Gaspé in 1991, and gradually extended southward in following years. Since 2010, capelin are found in almost all bottom trawl tows.

Prospects: It is currently impossible to estimate the impact of a significant increase in landings on the capelin population(s) and the rest of the ecosystem because variations in capelin abundance are first and foremost the result of natural factors. As capelin has a short lifespan, its abundance can be subject to large changes as a population consists of only a few age groups. To satisfy market demand, fishing effort is strongly correlated to the size of female capelin. Although the commercial fishery may harvest a very small proportion of the total biomass, any TAC increase should be made cautiously due to capelin's prominent role as a forage species in the marine ecosystem. Any increase in the 4RST TAC should be made cautiously, less than 10% as a total over the next two years.

2.6 Atlantic Mackerel in Subareas 3 and 4

The last Stock Status Report for this stock was published in 2014. The timing for the next assessment of this stock is not yet posted on the CSAS website.

The Fishery: Atlantic mackerel is found in the waters of the North Atlantic, from the Mediterranean to Norway, Iceland and the Faroe Islands in the east and from North Carolina to Newfoundland in the west. During spring and summer, Atlantic mackerel is found in inshore waters. From late fall and in winter, it is found deeper in warmer waters at the edge of the continental shelf. In the Northwest Atlantic, two main spawning areas characterize its distribution range. In Canadian waters, spawning occurs mainly in the southern Gulf of St. Lawrence during June and July. In American waters, spawning occurs during March and April between the coasts of Rhode Island and Virginia.

Following the arrival of a foreign fishery, Atlantic mackerel landings in the Northwest Atlantic, NAFO subareas 2 to 6, increased significantly from the end of the 1960's, reaching historical highs of over 250,000 t per year between 1970 and 1976 (Exhibit A13). Atlantic mackerel landings dropped considerably in 1977 with the introduction of the 200-nautical-mile exclusive economic zone (EEZ). However, as a result of agreements between the United States and the USSR in the early 1980s, they increased again to reach nearly 90,000 t in 1990. Landings then dropped considerably as the US gradually reduced the quotas allocated to the USSR and closed the foreign fleet fishery completely in 1992. Landings of mackerel have experienced an increase of almost 400% between 2000 and 2006 due to the presence of a dominant year-class (1999) and a significant increase of the fishing effort. Landings of more than 100,000 t were reached in 2004 and 2006. Landings are decreasing since 2006, and in 2013 they were the lowest of the Canadian–US historical series.

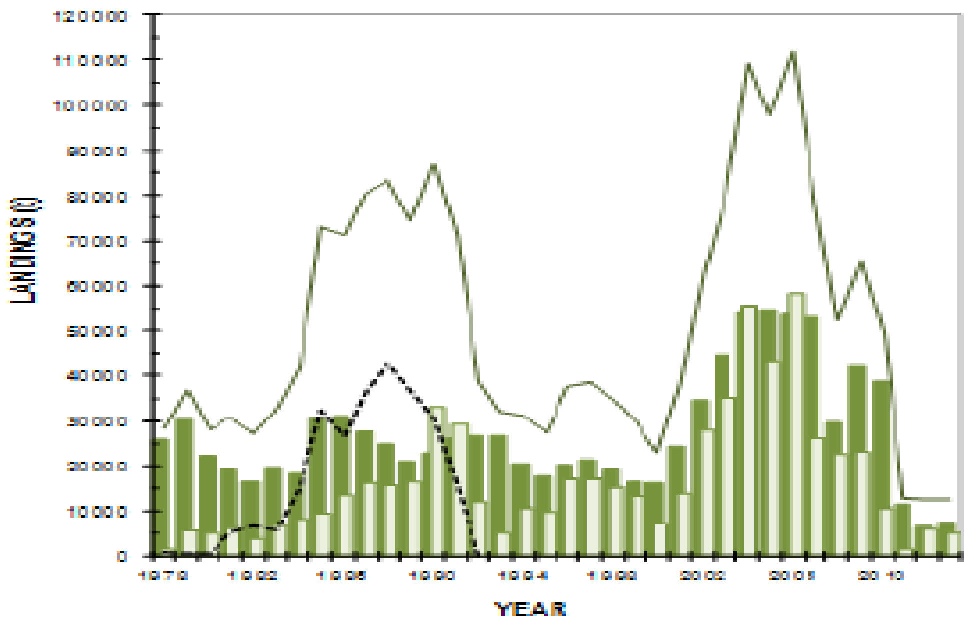


Exhibit A13. Trends in Mackerel landings for Subareas 3 & 4 (Source DFO).

For the Northwest Atlantic, NAFO subareas 2 to 6, Atlantic mackerel preliminary landings in 2013 totaled 12,681 t. These landings are of the same order of magnitude than those of 2011 and 2012 and represent a significant drop from the years prior to 2011.

Landings by Canadian fish harvesters were stable, average of 22,520 t per year, in the 1980's and 1990's. However, landings increased significantly in the early 2000's, reaching a historical high of 54,621 t in 2005. Landings averaged approximately 40,510 t per year between 2000 and 2010, before falling to 11,400 t, 6,468 t, and 7,431 t in 2011, 2012, and 2013, respectively. Canadian Atlantic mackerel landings are underestimated because commercial catches and catches for bait are not all recorded. Summer recreational catches are not recorded either.

Resource Status: The Atlantic mackerel age structure is mainly influenced by the periodic arrival of dominant year-classes. Such year-classes, as those of 1967, 1974, 1982, 1988 and 1999, completely dominated commercial catches for several years. For example, fish from the 1999 year-class contributed to 77% of all catches, in numbers, that were made between 2000 and 2004. The abundance of this year-class started declining in 2005 and since then, the age structure of Atlantic mackerel is instead characterized by the quick capture of the new year-classes. This was the case for the 2003, 2005, 2007, 2008, and 2010 year-classes, the relative importance of which was higher than the average.

The spawning biomass of the Canadian mackerel contingent is evaluated using an analytical assessment calibrated by the abundance index from an egg survey conducted annually in the southern Gulf of St. Lawrence. During the 2012 and 2013 surveys, the highest egg densities (n/m2) were measured in the northwest part of the sampled area and in St. Georges Bay located between Nova Scotia and Cape Breton. The densities measured in 2013 were generally higher than those in 2012. The abundance index from the egg survey has increased three times over the years due to the arrival of the dominant year-classes of 1982, 1988, and 1999. The index fell sharply between 1993 and 1998. The lowest values of the series have been calculated since 2005. The index shows a very slight increase in 2013.

An analytical assessment based on a sequential population analysis (SPA) model was undertaken for the stock in Subareas 3 + 4. The model results indicate the arrival of very strong year-classes in 1967, 1969, 1972, 1974, 1981, 1982, 1999, and 2003. The abundance of all these year-classes was greater than the high recruitment level. More recently, the 2004, 2005, and 2008 year-classes presented an abundance greater than the medium recruitment level compared to 2013 which is just above the lower level.

Annual fishing mortalities were stable, sustainable, between 1968 and 1992. They then increased since 1993 to reach values above 0.50 at the end of the 1990's. Following a decrease in mortality in young age groups, a new increase was measured in the 2000's with maximum values reached in 2011. A decrease was observed in all year-classes in 2012 and 2013. However, mortalities calculated by age group remain high with values more than 0.46. The significant increases in fishing mortality were accompanied by declines in the spawning and total biomasses. The lowest biomasses of the whole historical series were estimated in 2012 and 2013.

Prospects: According to projections made at the level of the average fishing mortality of the 1968–1992 stability period (F=0.087) the spawning biomass (SSB) at the beginning of 2015 and 2016 would be respectively 7,532 t and 9,045 t for catches in 2014 and 2015 of 662 t and 821 t respectively. The abundance index from the egg survey in the southern Gulf of St. Lawrence is at its lowest level in 2012 with a slight increase in 2013. The situation is similar for the spawning biomass estimated from the assessment model. Given the critical situation of the stock, the priority is for its rebuilding. According to the projections based on the average sustainable fishing mortality from the assessment model, annual catches in 2014 and 2015 should not exceed 800 t. Additionally, with the current situation of this stock, it is even more important to know and control the bait and recreational fisheries.

2.7 Herring in Division 4R

The last Stock Status Report for this stock was published in 2014. The timing for the next full assessment of this stock is not yet posted on the CSAS website.

The Fishery: Herring are a pelagic species that perform significant annual migrations associated with spawning, feeding and wintering. Herring are part of a commercial fishery and in Canadian waters, the main fishing areas are south-western Nova Scotia and the Bay of Fundy (complex of stock 4VWX), the southern Gulf of St. Lawrence (4TVn stocks), the northern Gulf of St. Lawrence (4S stocks), and the west (4R stocks), east and south-east coasts (3KLPs stocks) of Newfoundland. On the west coast of Newfoundland (NAFO Division 4R), the average annual landings of herring have been about 16,000 t since 1975. The main fishing gear is the purse seine with average annual landings of near 11,000 t. In order of important gears, the purse seine is followed by the “tuck” seine, the gillnet, and the trap.

Herring landings on the west coast of Newfoundland increased between 1999 and 2008 and have since remained close to 20,000 t (Exhibit A14). In 2013, they totaled 19,364 t compared to 19,351 t in 2012, and with an annual average (2000–2011) of 16,857 t.

On the west coast of Newfoundland, most herring landings are associated with the purse seine. In 2013, landings by large seiners (>65') totalled 9,996 t compared to 4,888 t by small seiners (<65'), 2,306 t by the "tuck" seine, 1,228 t by trap and 946 t by gillnet. The "tuck" seine, which is a modified bar seine, has been used in the herring fishery since 2005. It is considered a fixed gear.

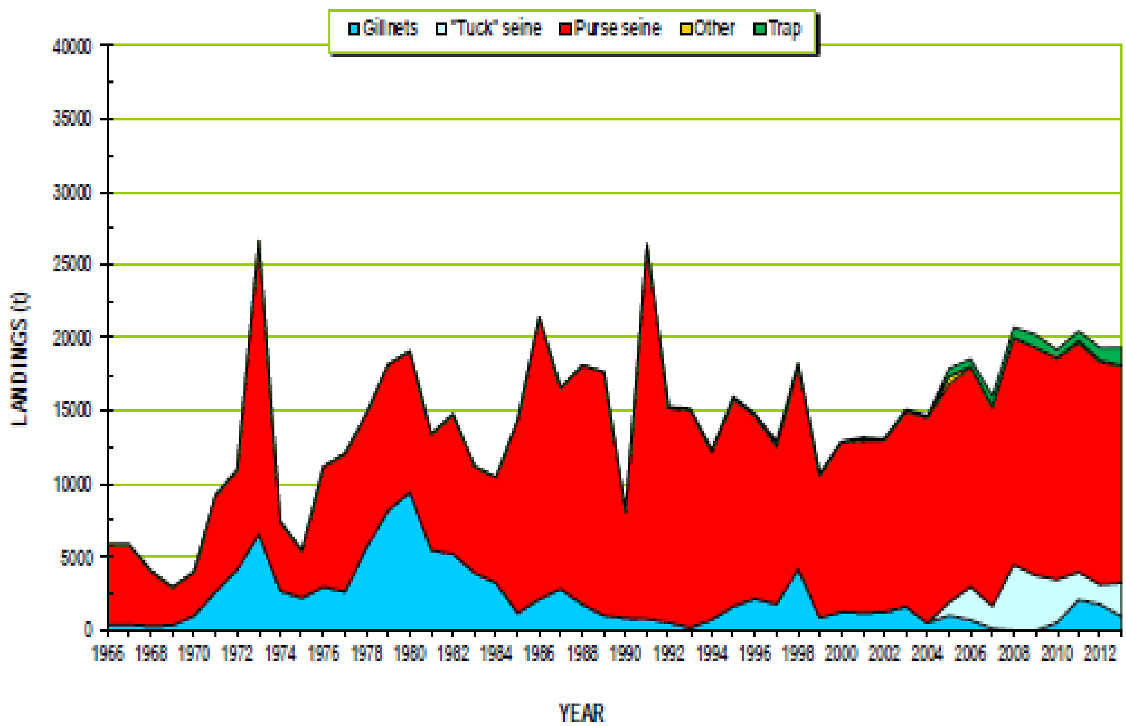


Figure 14A. Trends in landings for Herring in Division 4R.

In 2013, the quotas allotted for the large seiners' and fixed gear fleets were almost reached whereas the quota for the small seiners' fleet was exceeded (Figure 4A). Between 1990 and 2004, fixed gear took on average only 30% of their quota. The arrival of the "tuck" seine in this fishing fleet increased the average for the 2005–2011 period to 86%.

Resource Status:

Length frequency analysis indicates that herring stocks on the west coast of Newfoundland are characterized by the periodic occurrence of dominant year-classes. These dominant year- classes are identified by the occurrence of a main mode that shifts toward longer lengths over the years. For spring spawners, the most recent of these year-classes was 2002 compared to the 2000 year-class of fall spawners. From 2005 to 2009, this year-class alone accounted for 43% to 53% of catches (in number). However, this proportion decreased to 18% in 2010. In 2011, herring in the 11+ age group, which are included in this year-class, accounted for 15% of catches. In 2013, the 2004 year-classes (age 9) and 2003 year classes (age 10) dominated the spring and fall spawners catches respectively.

A first series of acoustic surveys was conducted between 1991 and 2002. A second series of surveys began in the fall of 2009 following FRCC recommendations. The first surveys from this new series should be conducted on an annual basis to enable the fastest possible return of an analytical assessment as well as the updating of reference points.

The total biomass index of spring-spawning herring fell considerably between 1991 and 1993. After some stability, this index fell again, decreasing from 34,550 t in 2002 to 7,448 t in 2009, 11,363 t in 2010, 14,624 in 2011 and finally 335 t in 2013. In 2002, spring herring accounted for 29.6% of the abundance (in number) of the two spawning stocks compared to 6.9% in 2009, 8.0% in 2010, 7,7% in 2011 and only 0.4% in 2013.

The total biomass index of fall-spawning herring also fell between 1991 and 1993. In 2009, this index was estimated at 85,014 t compared to 72,916 t in 2002. From 2010 to 2013, the index decreased from 121,888 t to 106,521 t. Note the presence of large standard deviations in 2009 and 2013.

Prospects: Acoustic survey results from the fall of 2013 suggest the almost complete disappearance of spring-spawning herring. Predictions made using the environmental model indicate that recruitment and weight-at-age for this stock have declined dramatically since the mid-2000s owing to changing environmental conditions. Therefore, in the absence of signs of rebuilding, it is recommended that the management measures implemented several years ago to protect the reproduction of this stock remain in place. However, despite these measures, stock status levels remain very low. Survey results from 2013 also indicate a slight decrease in the abundance of fall-spawning herring. This stock consists mainly of older fish. In recent years, catches of about 20,000 t have been supported by the dominant 2000 year-class of fall spawners. This year-class alone has ensured stability in the herring fishery on the west coast of Newfoundland over the past few years. With the decline of this year-class, and without strong recruitment, it is unlikely that catches of about 20,000 t can be sustained in coming years. Without abundant recruitment, the current catch level (20,000 t) should not be increased for 2014 and 2015.

2.8 Atlantic Halibut in Div. 3NOPs4VWX5Zc

The last assessment update for this stock was is published in 2014. The timing for the next assessment in not yet published on the CSAS website.

The Fishery: Until 1988, the fishery was unregulated. A TAC of 3,200 t was first established in 1988 and was reduced to a low of 850 t in 1995, in response to an eight year decline in landings. Beginning in 1999, the TAC has been increased several times and was set at 2,447 t in 2013. Average landings from 1960 to 2012 for this region have been approximately 1,800 t annually (Exhibit A15). NAFO statistics are used to describe removals, because landings occur in two DFO regions (Maritimes and Newfoundland) and outside Canada's Exclusive Economic Zone (EEZ) as well as other from countries including Portugal, Spain, and France. The 2011 and 2012 NAFO landings may be underestimated, as there is often a delay in reporting. Also, at the time of the most recent report, the 2013 fishing season was ongoing, thus, the 2013 landings data are incomplete. Within the management unit, halibut is fished mostly along the edges of the continental shelf mainly by longline. Since 1994, management plans and licence conditions require the release of halibut less than 81 cm.

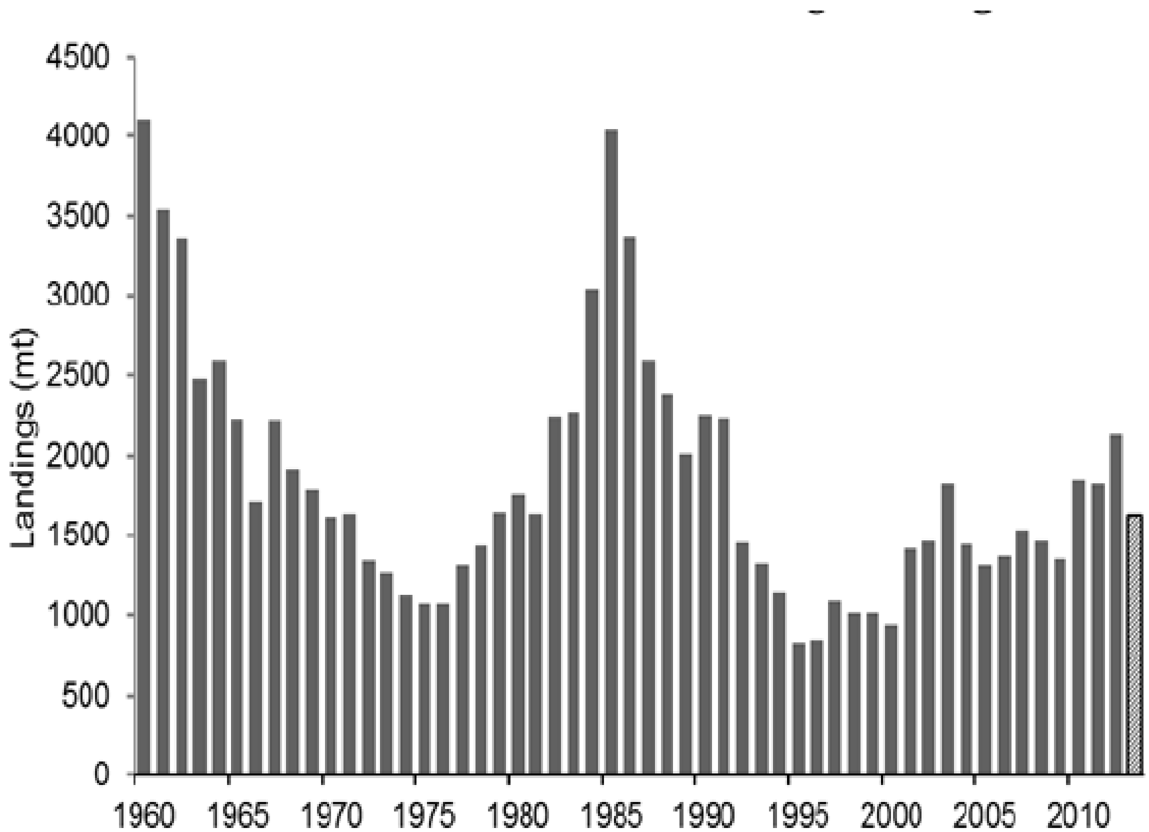


Exhibit A15. Trends in Atlantic Halibut Landings in Divisions 3NOPs4WX5Zc (Source DFO)

Resource Status: The industry-DFO longline halibut survey provides an important index of abundance of halibut ranging in size between 50 and 230 cm. The survey is completed by commercial fish harvesters with onboard observers. Based on this catch rate analyses, there is a small increase in the biomass of 3NOPs4VWX Atlantic Halibut in the past five years, with the 2013 standardized catch rate values being the highest in the time series. The commercial index catch rate has been elevated since 2009. Although the 2013 standardized catch rate is the lowest in the last five years, it is still above the long term mean. The commercial index catch rate does not show a linear trend over the survey time series. This index is more difficult to interpret than the halibut survey biomass indices because the fishing practices vary, and these important sources of variability have not been included in standardization.

The Scotia-Fundy groundfish RV survey has been conducted every July since 1970. The catch of Atlantic Halibut in the 4VWX RV survey increased between 2000 and 2011.

Since 2011 catch rates appear to be declining, but the 2012 and 2013 catch rates remain among the four highest in the time series and above the long term mean. Further the RV catch in 2012 and 2013 was above the long-term mean for almost all 3cm groups including the smallest size groups.

In 2006, DFO and the Atlantic Halibut Council (AHC) began the Halibut All Sizes Tagging (HAST) program to estimate population size, exploitation rate and evaluate the distribution of halibut within the Scotian Shelf southern Grand Banks management unit. While estimates of fishing mortality from tagging are not directly comparable to the assessment model estimates and the established reference points, they indicate that despite the increase in quota, F has been stable or slightly reduced between 2007 and 2012. This is consistent with a recruitment pulse seen both in the catch composition of the landings and the high RV survey catch rates.

Prospects: In 2012, based on model projections, 3NOPs4VWX5Zc Atlantic halibut was concluded to be in a productive period due to high recruitment. The SSB was expected to increase, and it was concluded that there was little risk in harming the productivity of the stock at harvest levels <4,000 t. The updated 2012 and 2013 abundance indices, including the 4VWX RV survey, the halibut survey and the commercial index standardized catch rates, indicate that abundance of both pre-recruits and recruits continue to be high. Over the past few years the TAC has increased, with the 2013 TAC at 2,447 t, which is still well below 4,000 t. Fishing mortality estimated from the multiyear tagging study indicates that F has been stable or slightly reduced between 2007 and 2012. Despite moderate increases in TAC, the Atlantic halibut stock appears to be increasing. The 4VWX RV survey standardized catch rates remain well above the long term mean and suggest that the fishery will continue to benefit from high recruitment in the next couple of years. However, if the declining trends in the 4VWX RV survey catch rates continue and the stock returns to a state of lower productivity, the TAC will have to be reconsidered.

The LRP for this stock is 1,960 t with an upper stock reference of 3,920 t. The SSB projected for 2012-2014 are all in excess of 8,000 t, well above the LRP and USR for this stock.

3.0 Stocks Assessed by the Scientific Council of NAFO

3.1 Cod in Divisions 3NO

The last assessment for this stock was conducted in 2013 with an interim monitoring report compiled in 2014. The next full assessment of Cod in Divisions 3NO will occur in 2016.

Fishery: The Divisions 3NO cod stock occupies the southern part of the Grand Bank of Newfoundland. Fish are distributed over the shallower parts of the bank in summer, particularly in the Southeast Shoal area (Div. 3N), and on the slopes of the bank in winter when cooling occurs. Some seasonal mixing between fish in Division 3O and Subdivision 3Ps may occur. This stock has been under moratorium to all directed fishing both inside and outside the Regulatory Area since February 1994. In 1998 the Scientific Council Report recommended that there should be no directed fishing for cod in Div. 3N and 3O in 1999 and that by-catches in fisheries targeting other species should be kept at the lowest possible level. All subsequent assessments have re-iterated this advice.

Catches from this stock peaked at 227,000 t in 1967, mainly by the former USSR and Spain, but declined steadily thereafter to 15,000 t in 1978. From 1979 to 1991 catches ranged from 20,000 to 50,000 t. A consecutive decline in TAC's in the early 1990's reduced catches to a level of about 10,000 t in 1993 the last full year of a directed fishery. Total catches since the moratorium, increased from 170 t in 1995, peaked at about 4,800 t in 2003 and have been between 600 t and 1,100 t since that time (Exhibit A16). The catches in 2012 and 2013 were 734 t and 1,052 t respectively.

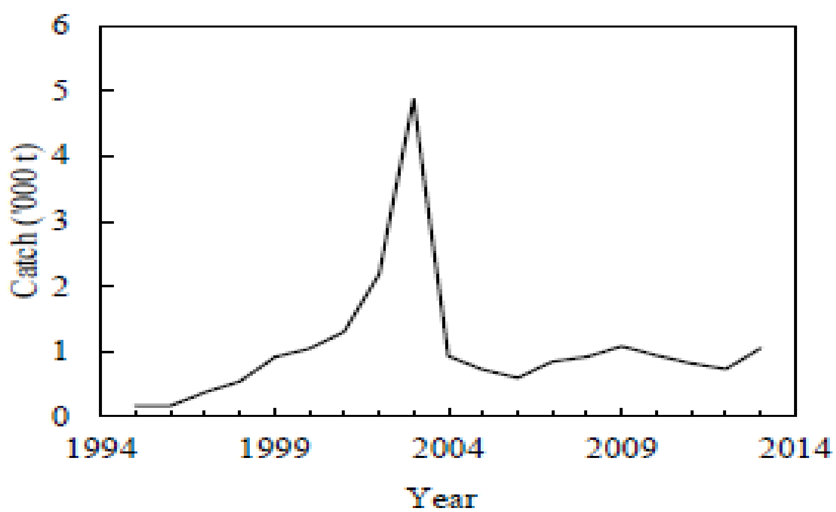


Exhibit A16. Trends in Divisions 3NO cod landings since 1994 (Source NAFO).

Resource Status: The Canadian spring survey biomass index declined from 1984 to the lowest level in 1995. Except for a brief increase from 1998 to 2000, the spring index remained low to 2008. There was a substantial increase in 2009, the highest index since 1993, resulting from improved recruitment from the 2005-2007 year classes. The index declined for 2010 and 2011 before increasing again in 2012 and 2013. The trend in the autumn survey biomass index was similar to the spring series.

The biomass index from the EU-Spain stratified-random survey in the NRA portion of Div. 3NO was relatively low and stable from 1997-2008. There was a considerable increase in the index from 2009 to the highest estimate in the series in 2011. However, the index has declined substantially in each of the last two years. Indices from this survey may not be suitable as indicators of overall stock trend since the survey covers only a small portion of the stock area and trends can be confounded by fish movement in and out of the area.

During the last full assessment of this stock an assessment model was applied to catch-at-age and the Canadian spring, autumn and juvenile survey data, ages 2-10, to estimate population numbers at ages 3-12 in 2013. The model results based on the three Canadian survey indices indicate that the spawning stock was at an extremely low level in 1994 and remained stable at a low level to 2010. SSB has subsequently increased and the 2013 estimate of 25,160 t is the highest level observed since 1991. The 2005-2006 year classes were estimated to have the highest levels of recruitment in the past two decades, with levels comparable to those from the mid - late 1980s but well below historic values. Estimated recruitment has not been as strong for subsequent year classes.

Prospects: The 2013 spawning biomass has doubled since 2010 but remains well below the LRP. This increase in biomass has been driven by the relatively strong 2005 and 2006 year classes and by fishing mortality values that are amongst the lowest in the time series (F<0.10). More recent year classes do not appear strong. The current estimate of the LRP is 60,000 t. SSB in 2013 is estimated to be 25,160 t which is 42% of the LRP. The SSB is approaching the point at which LRP will be re-evaluated.

The 2014 interim monitoring report indicated that the most recent analytical assessment, 2013, concluded that SSB was well below the LRP of 60,000 t in 2012. Canadian survey indices for 2013 suggest little change in the overall stock biomass since that time, and the EU-Spain survey indices have declined for the portion of the stock outside the Canadian EEZ. Overall, the 2013 indices are not considered to indicate a significant change in the status of the stock.

An Interim 3NO Cod Conservation Plan and Rebuilding Strategy was developed in 2011 which will guide management decisions during the moratorium and also if/when this stocks recovers and a fishery reopens.

3.2 American Plaice in Divisions 3LNO

The last assessment for this stock was conducted in 2014. The next assessment will occur in 2015.

Fishery: In most years the majority of the catch has been taken by offshore otter trawlers. Catches from this stock were generally in the range of 40,000 to 50,000 t per year throughout the 1970's and 1980's, before declining to low levels in the early 1990's (Exhibit A17). There has been no directed fishing on this stock since 1993 and the TAC has been set at 0 since 1995. Catches increased after the moratorium until 2003 after which they began to decline. The estimated catches during the period 2009-2013 were in the range 2,900-3,100 t. The total catch based on ratios of fishing effort in 2013 to effort in 2010 was 3,064 t, mainly taken in the NAFO Regulatory Area. In 2011-13, American plaice were taken as by-catch in the Canadian yellowtail fishery, EU-Spain and EU-Portugal skate, redfish and Greenland halibut fisheries. To estimate catch for 2011-2013 for Div. 3N, information on effort from NAFO observers and logbook data was used where possible with the assumption that CPUE has not changed substantially from 2010.

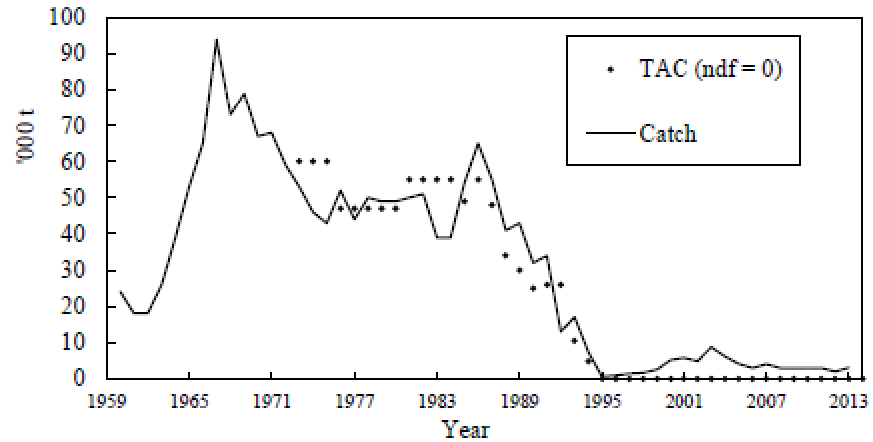


Exhibit A17. Trends in Divisions 3LNO American Plaice Landings (source NAFO).

Resource Status: Biomass and abundance estimates for Div. 3LNO from the Canadian spring survey declined during the late 1980's-early 1990's. Generally there has been an increasing trend in both biomass and abundance indices since 1995. Biomass estimates increased from 1996 to 2008 but declined in 2009 to levels of the late 1990's, however since then have continued to increase. Abundance has fluctuated since 1996 with a slight increase over the period until 2008, followed by a drop in 2009. In the past five years there has been a steady increase in biomass and abundance, in particular, the abundance of fish ages 0-5 has been increasing and is amongst the highest in the time series.

Biomass and abundance indices from the Canadian autumn survey declined from 1990 to the early-mid 1990's. Both indices have shown an increasing trend since 1995 but remain well below the level of the early-1990's. There was an 80% increase in biomass and a 60% increase abundance from 2012 to 2013. Over the past five years the average proportion of fish aged 0-5 has been 70% of the total.

From 1998-2013, surveys have been also been conducted annually in May-June by EU-Spain in the Area in Div. 3NO outside 200 miles. Estimates of both biomass and abundance indices from this survey followed a trend similar to the Canadian survey estimates with a drop in both biomass and abundance in 2009; since then have increased.

Based on Canadian survey data, historically the largest portion of this stock was located in Div. 3L but the highest declines in survey indices were also experienced in this region. The stock in recent years was more heavily concentrated in Div. 3N in the area outside 200 miles and the largest catches in the surveys are still found there. From 2011-2013 there has been some evidence that there has been an expansion in survey biomass into Div. 3L

A Virtual Population Analysis (VPA) assessment model based on Canadian and EU-Spain survey data was used for the assessment of this stock. This analyses showed that population abundance and biomass declined fairly steadily from the mid- 1970s to 1995. However, biomass and abundance have been increasing over the last number of years. Spawning stock biomass has shown 2 peaks, one in the mid-1960s and another in the early to mid-1980s. It declined to a very low level of less than 10 000 t in 1994 and 1995. Since then the SSB has been increasing, reaching about 38 000 t in the current year, which is about 75% of the LRB of 50,000 t. Estimated recruitment at age 5 indicates there have been no year classes above the long term average since the mid-1980s.

As the SSB for this stock remained below the limit reference point (LRP), the Scientific Council recommended that, in accordance with the current rebuilding plan, there should be no directed fishing on American plaice in Div. 3LNO in 2015 and 2016. In addition, by-catches of American plaice should be kept to the lowest possible level and restricted to unavoidable bycatch in fisheries directing for other species.

Prospects: Simulations were carried out to examine the trajectory of the stock under two scenarios of fishing mortality, F=0 and F=F2013 (0.10). Under no removals (F=0), SSB is projected to increase in 2017 with a 0.95 probability that the SSB will be above the LRP. SSB was projected to have a probability of 0.30 of being greater than LRP by the start of 2017 with F=F2013. This indicates that the current level of fishing mortality is delaying the recovery of this stock.

An Interim 3LNO American Plaice Conservation Plan and Rebuilding Strategy was developed in 2011 which will guide management decisions during the moratorium and also if/when this stock recovers and a fishery reopens.

3.3 Yellowtail Flounder in Divisions 3LNO

The last assessment for this stock was conducted in 2013 with an interim monitoring report completed in 2014. The next full assessment will occur in 2015

Fishery: Yellowtail flounder is caught in a directed trawl fishery and as by-catch in other trawl fisheries. The fishery is regulated by quota and minimum size restrictions. American plaice and cod, are taken as by-catch in the yellowtail flounder fishery.

The annual catch increased from negligible amounts in the early 1960’s to a peak of 39,000 t in 1972. With the exception of 1985 and 1986, when the catch was around 30,000 t, catches were in the range of 10,000 to 18,000 t from 1976 to 1993, the year before the moratorium. During the moratorium (1994-97), catches decreased from approximately 2,000 tons in 1994 to around 300-800 tons per year, as by-catch in other fisheries. Since the fishery re-opened in 1998, catches have increased from 4,400 tons to a high of 14,100 tons in 200 (Exhibit 18).

Overall, catches exceeded the TAC’s during 1985 to 1993 and again from 1998-2001, by about 10% in the latter period. Since 2002 the catches have been below the TAC. Corporate restructuring and labour disputes, in 2006, prevented the Canadian fleet from prosecuting the Yellowtail flounder fishery, and Canadian catch was only 177 t. The total catch in that year was only 930 t, well below the TAC of 15,500 t. In 2007, the participation in the fishery increased by Canadian fleet, but was still low at 3,673 tons, and the total catch was 4,617 tons. Catch increased in 2008 to 11,400 t Catches since 2009 were low ranging from 3,000 to 6,200 t taken of the 17,000 t TAC’s. Reduction in the effort by the Canadian fleet 2011 and 2012 years was the result of industry-related factors. However, in 2013, catch was higher at 9,800 t.

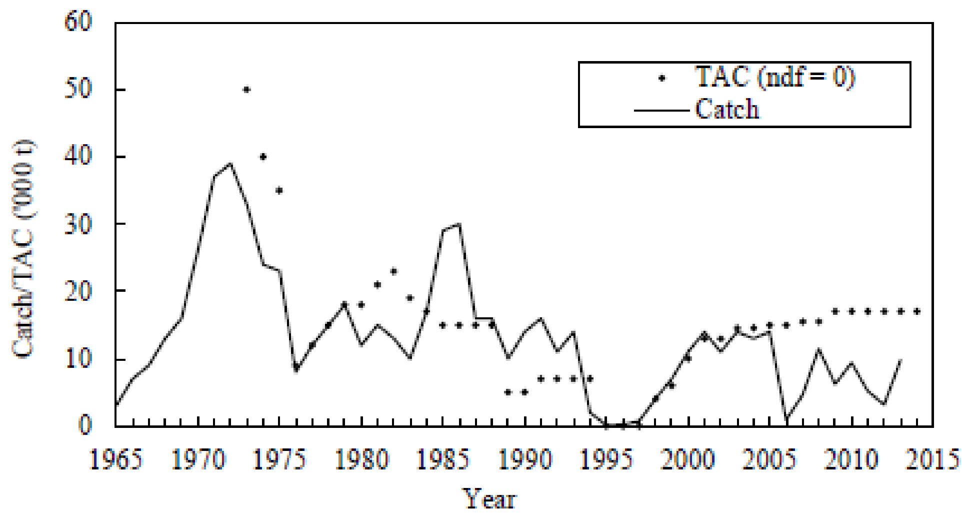


Exhibit. A18. Trends in 3LNO Yellowtail landings (Source NAFO).

Resource Status: Although variable, the Canadian spring survey index of biomass shows an increasing trend since 1995 and remains well above the level of the late 1980s and early 1990's. The Canadian autumn survey index of biomass for Div. 3LNO increased steadily from the early-1990's to 2001, and although variable, it has remained relatively high since then. EU-Spain spring surveys occur in the area outside 200 miles in Div. 3NO. The biomass index from this survey increased sharply up to 1999 and has thereafter remained relatively stable. This is in general agreement with the Canadian surveys which covers the entire stock area.

In all surveys, yellowtail flounder were most abundant in Div. 3N, in the area of the Southeast Shoal well as the area immediately to the west, which straddles the Canadian 200 mile limit. Yellowtail flounder appeared to be more abundant in the area outside 200 miles of Div. 3N in the 1999-2013 surveys than from those of 1984-1995 The stock has continued to occupy the northern portion of its range in Div. 3L, similar to the mid-1980s when overall stock size was also relatively large. The vast majority of the stock is found in waters shallower than 93 m in both spring and autumn.

Total numbers of juveniles (<22 cm) from spring and autumn surveys by Canada and spring surveys by EU-Spain were examined. High catches of juveniles seen in the autumn of 2004 and 2005 were not evident in either the Canadian or EU-Spain spring series. Although no clear trend in recruitment is evident, the number of small fish was above the 1996-2013 average in the Canadian surveys of 2010, and above average in several recent Canadian spring surveys. The spring survey by EU-Spain has shown lower than average numbers of small fish in the last seven surveys. Based on a comparison of small fish (<22 cm) in research surveys, recent recruitment appears to be about average.

The surplus production model results are very similar to the 2011 assessment results, and indicate that stock size increased rapidly after the moratorium in the mid-1990's and has now begun to level off. Estimates from the model suggest that a maximum sustainable yield (MSY) of 18,970 t can be produced by total stock biomass of 74,760 t (Bmsy) at a fishing mortality rate (Fmsy) of 0.25. Biomass estimates in all surveys have been relatively high since 2000. Relative biomass from the production model has been increasing since 1994, is estimated to be above the level of Bmsy after 1999, and is 1.8 times Bmsy in 2013.

Prospects: The stock size has increased since 1994 and is now above Bmsy. There is very low risk (<5%) of the stock being below Bmsy or F being above Fmsy. Recent recruitment appears about average. Stock projections were carried out by the Scientific Council to 2018 assuming two levels of catch. The first level was the TAC of 17,000 t and the second level was the average catch from the 2001-2012 period of 6,656 t. At the end of the projection period, the risk of the biomass being below the Bmsy is less than 5% in all cases. Clearly this stock is at a very high level and is expected to remain there for the next 4-5 years.

3.4 Greenland Halibut in Subarea 2 and Divisions 3KLMNO

The last assessment for this stock was conducted in 2014. The next full assessment of Greenland Halibut will occur in 2015

Fishery: Greenland halibut are widely distributed throughout the waters adjacent to Labrador and eastern Newfoundland. During the late 1970's and most of the 1980's they were found in relatively high abundance along the deep slopes of the continental shelf, particularly in Division 2G. They were likewise plentiful in the deep channels running between the fishing banks especially in Divisions 2H, 2J and 3K. By 1991 distribution in the northern areas was greatly reduced and most of the resource was located in Division 3K.

TAC's prior to 1995 were set autonomously by Canada; subsequent TAC's have been established by NAFO FC. Catches increased sharply in 1990 due to a developing fishery in the NAFO Regulatory Area in Div. 3LMNO and continued at high levels during 1991-94. The catch was only 15,000 to 20,000 t per year in 1995 to 1998. The catch increased since 1998 and by 2001 was estimated to be 38,000 t, the highest since 1994. The estimated catch for 2002 was 34,000 t. The 2003 catch could not be precisely estimated, but was believed to be within the range of 32,000 t to 38,500 t.

In 2003, a fifteen year rebuilding plan was implemented by Fisheries Commission for this stock. Though much lower than values of the early 2000's, estimated catch over 2004-2010 has exceeded the TAC by considerable margins. TAC over-runs have ranged from 22%-64%, despite considerable reductions in effort. The STACFIS estimate of catch for 2010 was 26,170 t (64% over-run). STACFIS could not estimate total catches for 2011-2013 (Exhibit A19).

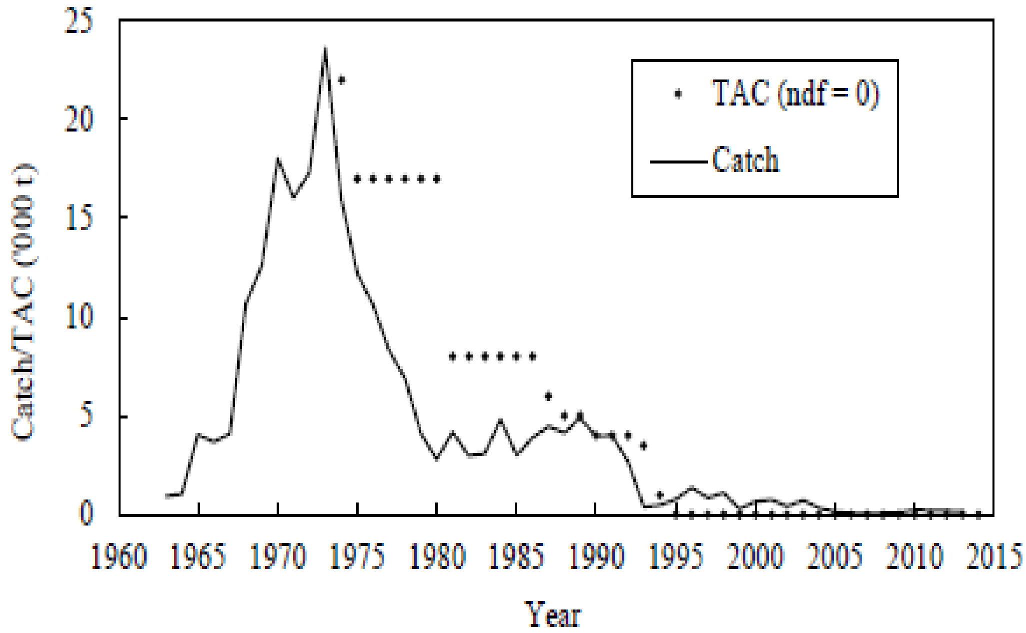


Exhibit A19. Trends in Greenland halibut catches in SA2+3KLMNO (Source NAFO).

Resource Status: Analysis of otter trawl catch rates from Canadian vessels operating inside of the Canadian 200 mile limit indicated a general decline from the mid-1980's to the mid-1990's. The 2010–2012 estimates of standardized CPUE for Canadian otter-trawlers decreased substantially from the 2007-2009 levels. The Canadian CPUE series was not updated with 2013 data. Catch-rates of Portuguese otter trawlers fishing in the NRA of Div. 3LMNO over 1988-2013 declined sharply in 1991 from initial levels. Between 1991 and 1994 catch rates remained stable at a low level. Since then, catch rates gradually increased, reaching an upper level in 1999-2000. Catch rates declined in 2001 and remained stable at that lower level in 2002 and 2003. In 2004 the catch rates declined again, reaching the lowest value since 1994. However, after 2004 the Greenland halibut catch rates increased and, despite the high variability from 2006 to 2013, the catch rates reached, in this period, the highest values observed of the time series. Analyses of data from the Spanish fishery show that in 2013 the CPUE has increased reaching maximum levels similar to the 2007-2008 level. In general, for the Russian fishery, the catch rate per fishing vessel day in the area ranged from 0.6 t to 10.2 t and averaged 7.2 t per fishing vessel day and 0.44 t per hour of hauling.

A comparison of the available standardized CPUE estimates from the Canadian, Spanish and Portuguese fleets indicates consistency in the timing and relative magnitude of change over the 2004-2007 period, but less consistency thereafter. However, CPUE for all three countries is higher from 2007-2012 than in the period of the 1990's to the mid-2000s.

Most research vessel survey series providing information on the abundance of Greenland halibut are deficient in various ways and to varying degrees. Variation in divisional and depth coverage creates problems in comparing results of different years. A single survey series which covers the entire stock area is not available. A subset of standardized (depth and area) stratified random survey indices have been used to monitor trends in resource status, and are described below.

The Canadian autumn Div. 2J3K survey index provides the longest time-series of abundance and biomass indices for this resource. Biomass declined from relatively high estimates of the early 1980s to reach an all-time low in 1992. The index increased substantially due to the abundant 1993-1995 year-classes, but this increase was not sustained, with declines over 1999-2002. The index continually increased over the next five years. The increasing trend has not continued, though in 2012 the index is near the time-series average. Mean numbers per tow were stable through the 1980s, but increased substantially in the mid-1990's, again due to the presence of the 1993-1995 year-classes. After this, abundance declined to the late 1990's and had been relatively stable except for the decline in 2005. Following improved estimates of abundance in 2010 and 2011, the 2012 index is considerably lower as much fewer age 1 and 2 fish were observed. The 2013 biomass and abundance indices both increased compared to 2012, with more age 1 than in 2012. However, the number of age 1-4 in 2013 is still below the series average.

Abundance and biomass indices from the Canadian spring surveys in Div. 3LNO declined from relatively high values in the late 1990's and have been relatively low in most years thereafter. In 2013, both abundance and biomass were below the time-series average. The abundance of recruits (ages 1-4) in 2013 is much lower than that observed in 2011 and 2012.

Surveys conducted by the EU in Div. 3M during summer indicate that the Greenland halibut biomass index in depths to 730 m, increased in the 1988 to 1998 period to a maximum value in 1998. This biomass index declined continually over 1998-2002. The 2002 - 2008 results were relatively stable, with the exception of an anomalously low value in 2003. In 2009 to 2013, the index has decreased and is presently at its lowest observed value. The Flemish Cap survey was extended to cover depths down to 1460 m beginning in 2004. Biomass estimates over the full depth range doubled over 2005-2008 but declined thereafter. The 2012 and 2013 estimates are below the time-series average. Over 2009-2013, recruitment indices (ages 1-4) from this survey are below average. The biomass index for 3NO portion of this survey of the area outside 200 miles generally declined over 1999 to 2006 but increased four-fold over 2006- 2009. The survey index declined to 2013 and from 2011-2013 is below average.

Overall, the above noted surveys provide coverage of the majority of the spatial distribution of the stock and the area from which the majority of catches are taken. Over 1995-2003, indices from the majority of the surveys generally provided a consistent signal in stock biomass. Results since 2004 show greater divergence which complicates interpretation of overall status. Three of the 4 indices have declined since 2010, while the Canadian Div. 2J3K survey increased.

Prospects: Survey data from 2009-2013 are variable. The Canadian Div. 2J3K autumn survey has increased, the Canadian spring Div. 3LNO survey has varied with no trend, while the EU survey of Flemish Cap and the EU-Spain survey of the NRA of Div. 3NO have both declined. Results of Canadian surveys and the EU Flemish Cap survey indicate that recruitment was well below average in 2013. Fishing Mortality is unknown, as estimates of total catch were unavailable. Precautionary approach reference points have not been determined for this stock at this time. Yield per recruit reference points were estimated in previous assessments. Fmax was computed to be 0.41 and F0.1 was 0.22.

In 2010, the Fisheries Commission implemented a survey-based harvest control rule (HCR) using a Management Strategy Evaluation to generate annual TAC's over at least 2011-2014. In 2013 Fisheries Commission extended this management approach to set the TAC's for 2015–2017. The current TAC for 2015 for this stock is 15,578 t based on the HCR using the most recent five years of survey data (2009-2013). Based on the HCR the TAC's in the next two years will change by a maximum of ± 5% of the 2015 and 2016 TAC's respectively.

3.5 Shrimp in Divisions 3LNO

The last assessment for this stock was conducted in 2014. The next full assessment of Shrimp in Divisions 3LNO will occur in 2015

Fishery: The northern shrimp (*Pandalus borealis*) stock, in Div. 3LNO, extends beyond Canada's 200 mile limit and therefore is a NAFO regulated stock. Northern shrimp, within NAFO divisions 3LNO, have been under TAC regulation since 1999. TAC's have increased in a stepwise fashion from 6 000 t in 2000 to 30 000 t in 2009 and 2010 but then decreased to 4 300 t by 2014 due to continued declines in survey and commercial fishery indices.

Catches increased dramatically since 1999, with the beginning of a regulated fishery. Over the period 2004-2009, catches increased from 13,200 to 26,000 t. Due to declines in resource indices, the TACs have been steadily decreasing with the 2014 TAC being set at 4,300 t during the 2013 NAFO meeting. Preliminary catch records indicate that the 8 600 t TAC was taken in 2013 (Exhibit A20). By August 25, 2014, 1,700 t of shrimp had been taken, down from the 6 000 t taken by the same time in the previous year. As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 10,300 t in 2004 to 18,900 t in 2008 but have since decreased to 6,100 t in 2013.

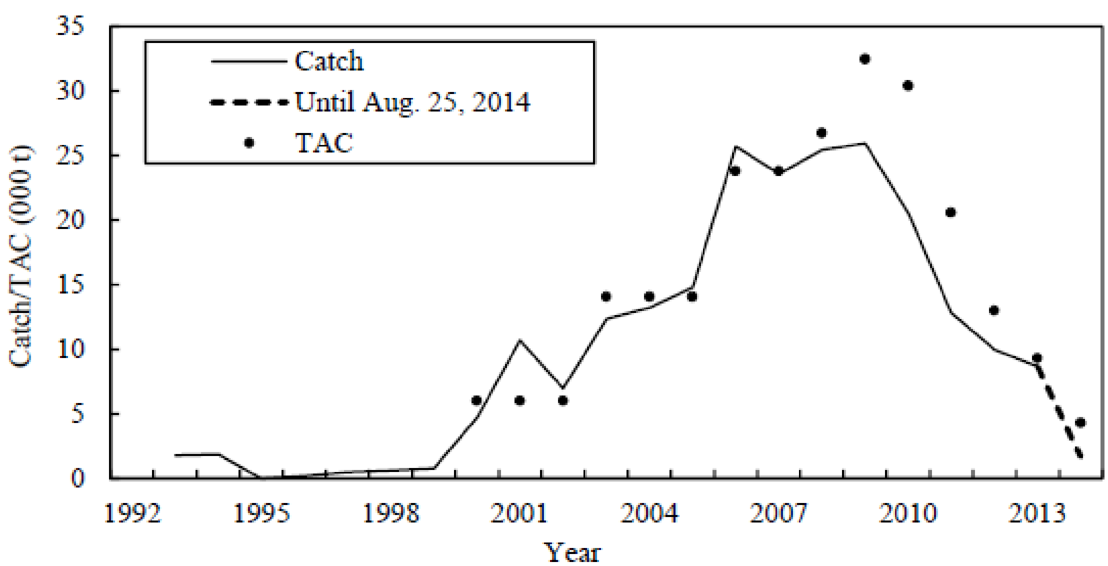


Exhibit A20. Trends in landing for Division 3LNO shrimp.

Catches by other contracting parties increased from 2,900 t in 2004 to 7,700 t in 2006, however, preliminary data show that catches decreased to 2,552 t by 2013. These contracting parties fish in 3L outside the 200 mile limit known as the NAFO Regulatory Area (NRA). Preliminary data indicate that non Canadian vessels took 7 t of Northern Shrimp by September 2014 while they took 170 t by the same period in the previous year.

Since 2000, small inshore and large offshore shrimp fishing vessel catches have been taken from a broad area near the northern border with 3K south east along the 200 – 500 m contours to the 200 mile limit. However, discussions with fishing Captains indicate that fishing patterns have been changing over the past few years. Since 2012 the small vessel Captains indicated that they usually fished at the 3L-3K border as it was closer to their ports than going as far away as the 200 mile line. They felt that shrimp was available throughout much of the 3L area in depths of 200 – 500 m.

The small vessel fleet takes most of their quota during the spring and summer of each year while the large vessel fleet fishes mainly in the late fall and early winter although this has varied over time. In 2014, the small vessel fleet took its quota during the summer while the large vessel fleet had taken only 12% of its quota by August 25, 2014.

Resource Status: Catch and effort data have been available from vessel logbooks and observer records since 2000. Data for the time series has been updated for these analyses. CPUE models were standardized to 2001. The 2010-14 indices for small vessel CPUE's were significantly lower than the long term mean and were similar to the 2001 values while the large vessel CPUE's were the lowest in the time series. CPUE, while reflecting fishery performance, is not effectively indicating the status of the resource. The trends of these CPUE indices show conflicting patterns with the survey biomass indices and were therefore not used as indicators of stock biomass.

Canada has conducted stratified-random surveys in Div. 3LNO, from which shrimp data is available for spring (1999–2014) and autumn (1996–2013). The autumn survey in 2004 was incomplete and therefore of limited use for the assessment. EU-Spain has been conducting a stratified-random survey in the in the area outside 200 miles in Div. 3L since 2003. There was no Spanish survey in 2005.

In Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185 to 550 m. There was an overall increase in both the spring and autumn indices to 2007 after which they decreased by over 90% to 2013. However, there was a slight increase during spring 2014. Biomass estimates from the spring surveys are usually more variable than those from the autumn surveys. Spanish survey biomass indices for Div. 3LNO, based on areas outside 200 miles only, increased from 2003 to 2008 followed by a 93% decrease by 2012 remaining near that level in 2014.

The autumn Div. 3LNO female SSB index showed an increasing trend to 2007 but decreased 91% by 2013. The spring SSB index decreased by 91% between 2007 and 2014. Both males and females showed a broad distribution of lengths in recent surveys indicating the presence of more than one year class. Recruitment indices were based upon abundances of all shrimp with carapace lengths of 11.5–17 mm from Canadian survey data. These animals are thought to be one year away from the fishery. The 2006 – 2008 recruitment indices were among the highest in both spring and autumn time series. Both indices decreased through to autumn 2013. The index increased slightly in spring 2014, with a high degree of uncertainty.

Prospects: Recruitment indices have decreased since 2008 and are now among the lowest observed values. Spring and autumn biomass indices have decreased considerably since 2007. The index of exploitation generally increased over the 1997–2014 period. The stock has declined since 2007, and in 2013 the risk of being below the LRP is greater than 95%. The autumn 2013 SSB index is 11,780 t which is below the LRP set at 19,330 t. Given expectations of poor recruitment and relatively high fishing mortality, the stock is not predicted to increase in the near future.

This stock was closed to directed fishing by NAFO in 2014 for at least 2015 fishing season. Given current stock status related to recruitment and spawning stock biomass and prospects outlined above it is likely stay that way for some time.

3.6 Witch Flounder in Divisions 3NO

The last assessment for this stock was conducted in 2014. The next assessment will occur in 2015

Fishery: The first TAC for witch flounder was introduced by the International Commission for Northwest Atlantic Fisheries (ICNAF) in 1974 at a level of 10,000 t, largely based on average historical catches. This level remained in effect until 1979 when it was reduced to 7,000 t in consideration of declining commercial catch rates. It was further reduced to 5,000 t in 1981 and remained at that level to 1993. The Scientific Council advised that for 1994, catches from this stock should not exceed 3,000 t. A TAC of 3,000 t was agreed by the NAFO FC, however, it was also agreed that no directed fishery would be conducted for witch flounder in 1994 to permit rebuilding due to the poor state of the stock. The FC introduced a complete moratorium for directed fishing in 1995, which has continued through 2014.

Reported catches in the period 1972-84 ranged from a low of about 2,400 t in 1980 and 1981 to a high of about 9,200 t in 1972. Catches increased to around 9,000 t in the mid-1980's but then declined steadily to less than 1,200 t in 1994, when a moratorium was imposed on the stock (Exhibit A21). Since then, catches have averaged about 500 t, as by-catch in other fisheries. In 2013 the catch was estimated to be 323 t, taken mainly in the NRA (the area outside 200 miles).

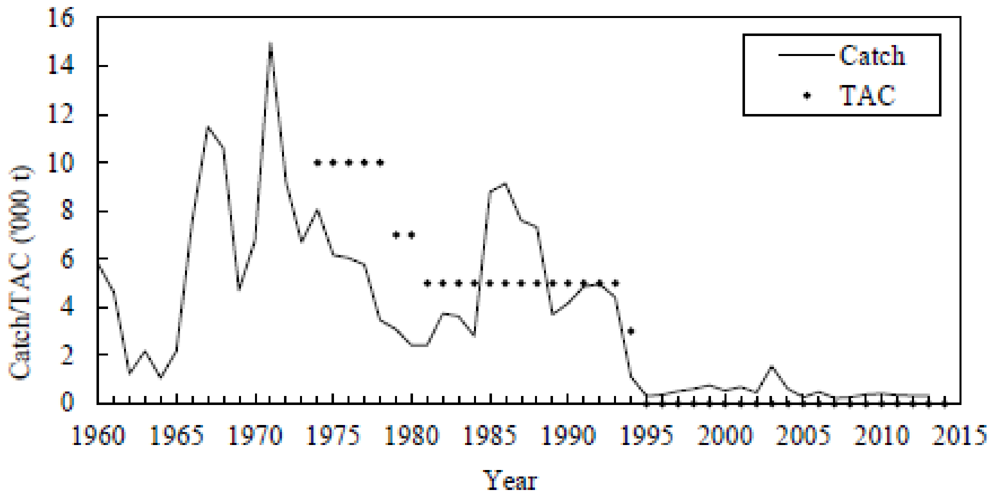


Exhibit A21. Trends in landings for Division 3NO Cod (Source NAFO).

Historically, the fishery was conducted primarily by Canada and the former Soviet Union. Canadian catches fluctuated from between 1,200 and 3,000 tons from 1985-91 but increased to about 4,300 tons in 1992 and 1993. Canadian catches since the moratorium have averaged 31 t per year. Catches by the USSR/Russian vessels declined from between 1,000 and 2,000 tons in the period 1982-88 and have averaged 29 t per year since the 1994 moratorium.

Resource Status: The Canadian spring survey biomass indices increased substantially from 2011 to 2013 to levels near the time-series high. However, the 2013 point estimate was imprecise. A proxy for the biomass LRP was calculated to be 9,200. The biomass index has been above LRP since 2011. The Canadian autumn survey biomass index was at the highest levels of the series from 2008 to 2013 The EU-Spanish spring survey biomass indices showed no clear trend from 2001 to 2013.

Recruitment, defined as fish less than 21cm, in both the spring and autumn Canadian surveys and the EU-Spanish spring surveys although somewhat variable has generally been low since 2002.

The ratio of catch over biomass index, a proxy for F, suggests fishing mortality has been low since a moratorium on directed fishing was imposed in 1994.

The biomass has increased since 2010, and the 2013 point estimate is above LRP. The probability that the 2013 biomass is below the LRP is 0.14. Considering this uncertainty and the variable nature of this index, there is no scope for large increases in catch at this time. Future removals, if allowed to increase, should only increase in an adaptive, gradual manner from current catch levels.

Prospects: The TAC determined at the last NAFO meeting for the 2015 fishing season is 1,000 t. This is the first year a fishery will occur on this stock since 1994. It is difficult to determine the mid to long term prospects for this stock given the uncertainty in some of the survey data used in the assessment. The next assessment for this stock was originally scheduled to occur in 2017, but due to the uncertainty described above another assessment will be completed in 2015. NAFO tasked its Working Group on Risk-based Management Strategies to develop a strategy for 3NO Witch flounder in 2015 for application in the determination of TAC's for future years.

3.7 Redfish in Divisions 3LN

The last assessment for this stock was conducted in 2014. The next assessment will occur in 2016

Fishery: There are two species of redfish that have been commercially fished in Div. 3LN; the deep-sea redfish (*Sebastes mentella*) and the Acadian redfish (*Sebastes fasciatus*). The external characteristics are very similar, making them difficult to distinguish, and as a consequence they are reported collectively as "redfish" in the commercial fishery statistics.

Between 1959 and 1964 reported catches declined from 45,000 t to 10,000 t, oscillating over the next 21 years (1965-1985) around an average level of 21,000 t (Exhibit A22). Catches increased afterwards to a 79,000 t high in 1987 and fall steadily to a 450 t minimum reached in 1996. Catches were kept at a low level since then (450-3,000 t), until 2009.The NAFO FC implemented a moratorium on directed fishing for this stock between 1998 and 2009. The fishery reopened in 2010 with a TAC of 3,500 t. The NAFO FC implemented a moratorium on directed fishing for this stock between 1998 and 2009. The fishery reopen in 2010 with a TAC of 3,500 t. Catches increased with the reopening of the fishery in 2010 and have reached just over 6,000 t in 2013, the highest level recorded on 20 years. Catches from EU-Portugal, Russian and Canadian fleets comprised most of the increase on the redfish catch observed on both Divisions 3L and 3N. The TAC for 2014 and 2015 are 7,000 t and 10,200 t respectively.

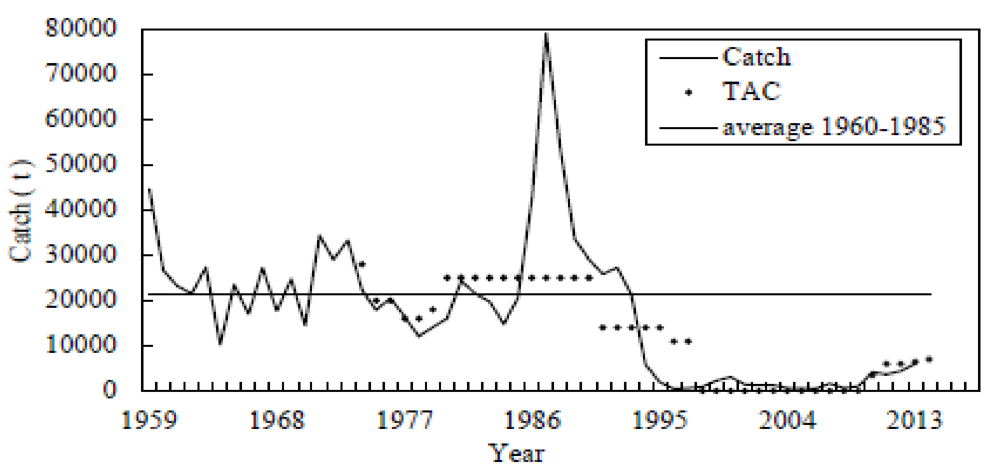


Exhibit A22. Trends in landings for Divisions 3LN Redfish (Source NAFO).

Resource Status: From 1978 onwards several stratified-random bottom trawl surveys have been conducted by Canada in various years and seasons in Div. 3L and in Div. 3N.

Since 1991 two Canadian series of annual stratified-random surveys covered both Div. 3L and Div. 3N on a regular annual basis: a spring survey (May-Jun.) and an autumn survey (Sep.-Oct. 3N/Nov.-Dec. 3L for most years). No survey was carried out in spring 2006 on Div. 3N. There were also surveys conducted by Russia and EU-Spain intermittently during the period of the Canadian surveys.

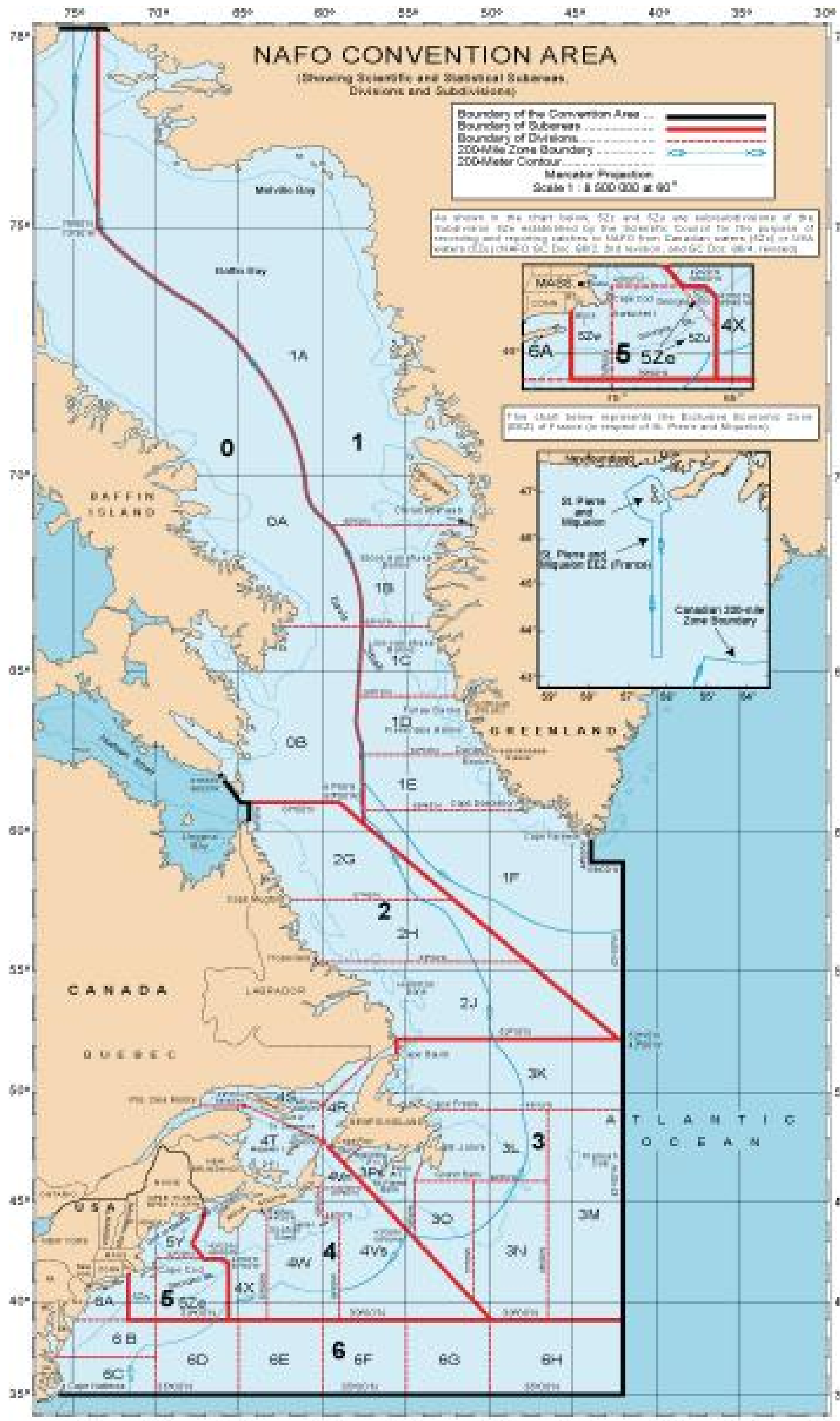
During the first half of the 1990's surveys indicated the mean lengths were negative or slightly above average. Mean lengths on most of the years between 1996 and 2007 (spring survey) and 2006 (autumn survey) were above the mean, reflecting a shift on the stock length structure to larger individuals. Since 2008 mean lengths generally fall to below-well below average, just as observed on the commercial catch at length. This most recent pattern on the length structure of both surveys and by catch seems to confirm the occurrence of recent pulses on recruitment after a low productivity regime that prevailed for more than 15 years.

There was a relatively good pulse of recruitment picked up in the 1991-1992 Canadian autumn survey in Div. 3LN in the range of 12-14 cm for 1991 and 15-18cm for 1992. From 2005 onwards commercial catch and Canadian survey length data indicate that the proportion of redfish smaller than 20cm has increased significantly.

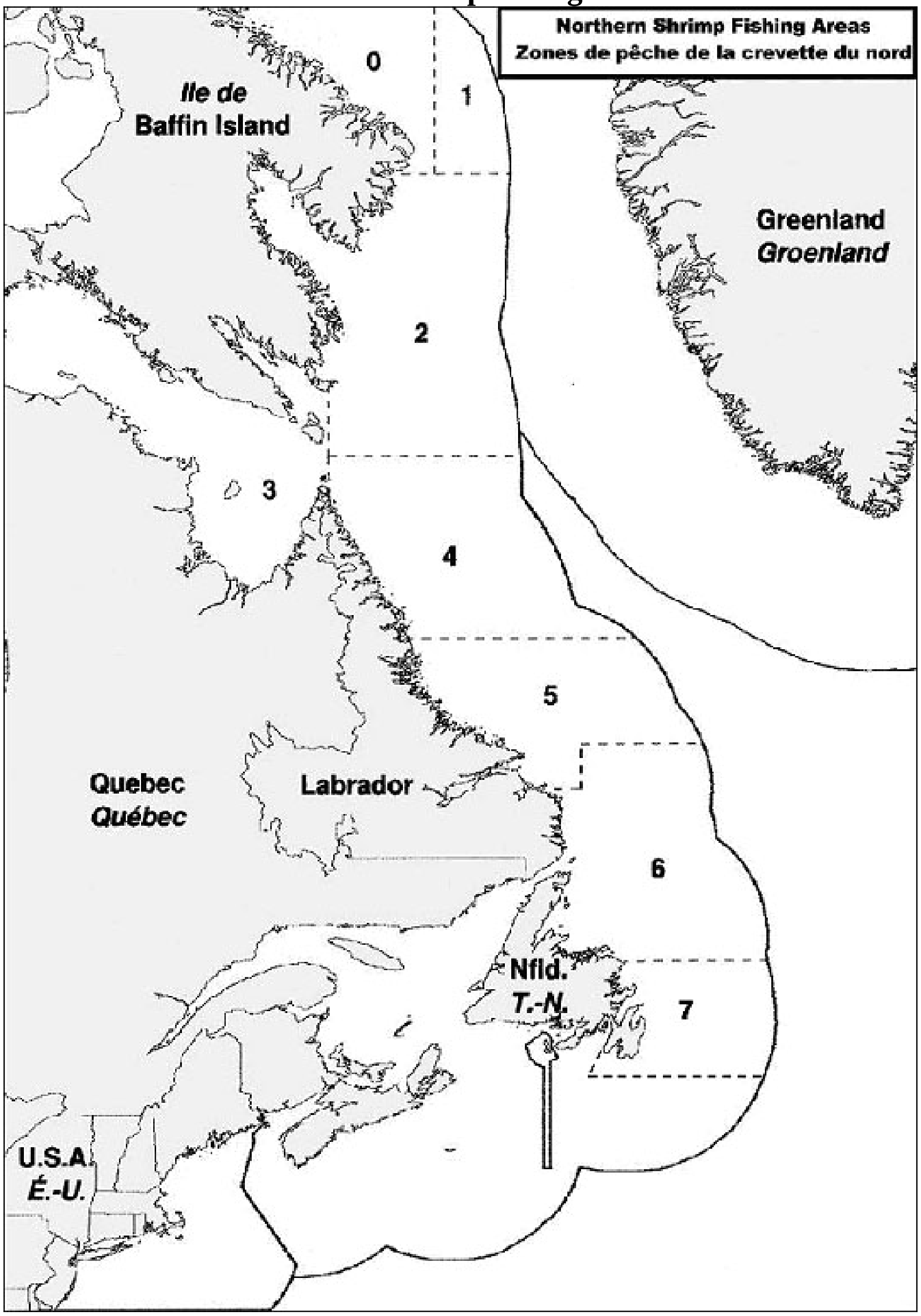
Results of an assessment model suggest that the maximum observed sustainable yield (MSY) of 21,000 t can be a long term sustainable yield if fishing mortality stands at a long term level of 0.11 for this stock. The correspondent stock biomass is considered this stock Bmsy (136,800 t). Relative biomass was slightly above Bmsy for most of the former years up to 1985, under a fishing mortality in the vicinity of Fmsy. Between 1986 and 1992 catches were higher than 21,000 t (26,000 t-79,000 t), increasing fishing mortality to well above Fmsy from 1986 till 1993. Those eight years of heavy over-fishing led to a reduction in biomass, from Bmsy in 1986 to 12% Bmsy in 1994-1995, when the minimum stock size was observed. Since 1995 catches were kept at low to very low levels. Over the moratorium years, biomass recovered at the beginning of 2014 it is predicted to be 1.4 x Bmsy or 191,500. The probability of being at or above Bmsy to very high.

Prospects: Commercial catch and Canadian survey length data indicate that recent recruitment (2005-2013) is above average. The stock is estimated to be at 1.4 x Bmsy (191,500 t) and approximately five times the limit reference point (41,000 t). There is a low risk of the stock being below Bmsy. Fishing mortality is currently only 22% Fmsy, and the probability of being above Fmsy is very low. Recent recruitment (2005-2013) appears to be above average. Scientists suggest that the TAC's for this stock be increased in a step-wise manner to ensure that the biomass remains above Bmsy with a high probability.

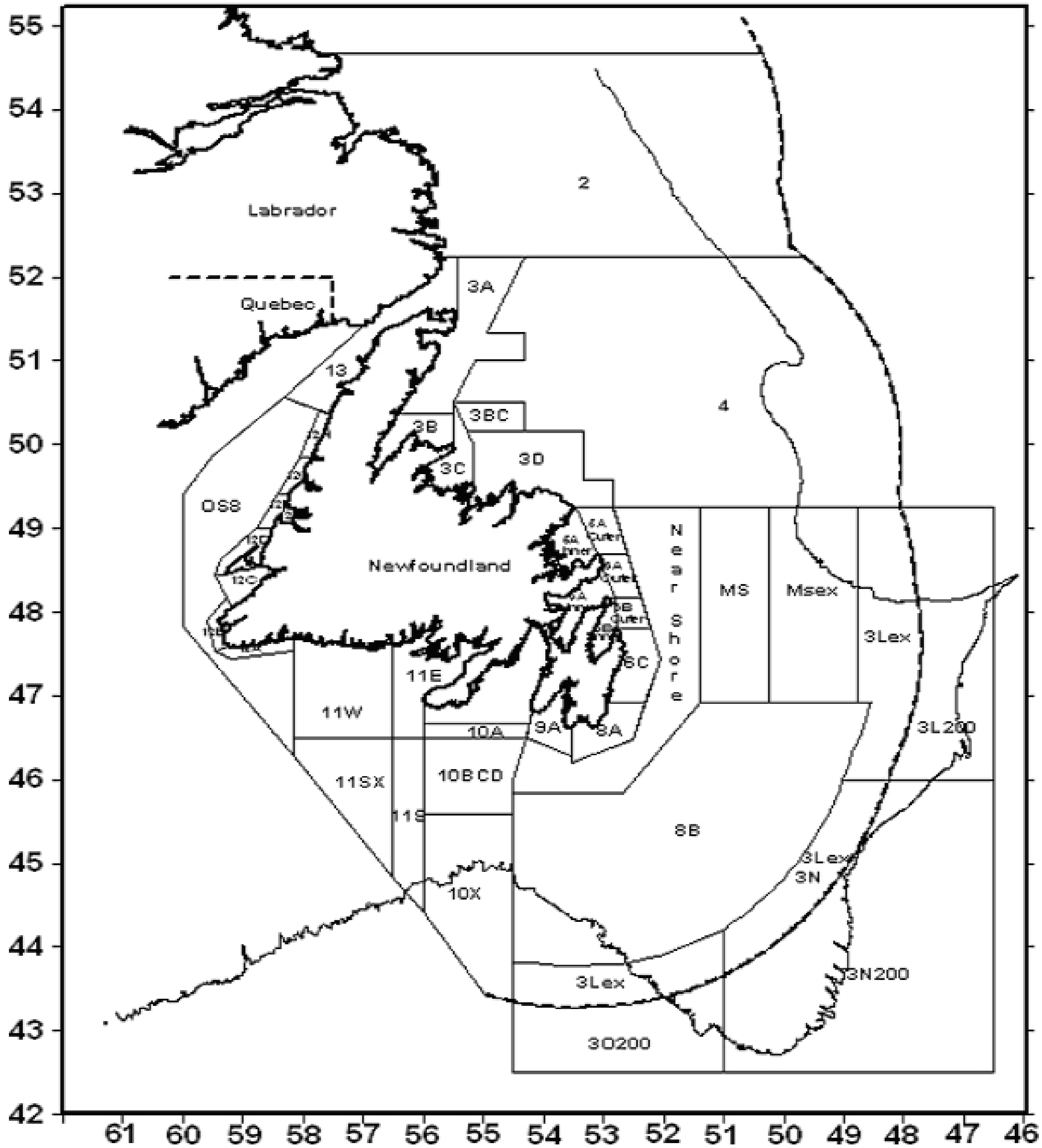
NAFO Convention Area.



Northern Shrimp fishing areas.



Newfoundland and Labrador Snow Crab Areas



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