DEEPWATER REDFISH (*Sebastes mentella*) IN NAFO SUBAREA 0: ADDENDUM TO THE RECOVERY POTENTIAL ASSESSMENT OF REDFISH IN THE NORTHWEST ATLANTIC

Context

In April 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Deepwater Redfish/Acadian Redfish complex (*Sebastes mentella* and *S. fasciatus*) in Canada. COSEWIC subdivided Deepwater Redfish into two Designatable Units (DUs): Northern population and Gulf of St. Lawrence - Laurentian Channel population. The Deepwater Redfish - Northern population is distributed from Baffin Bay south to the Grand Banks corresponding to Northwest Atlantic Fisheries Organization (NAFO) Subareas (SA) 0+2+ Divisions (Div.) 3KLNO. COSEWIC designated the Northern DU as Threatened (COSEWIC 2010).

A species Recovery Potential Assessment (RPA) process was developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the *Species at Risk Act* (SARA). The scientific information is used when analyzing the socio-economic impacts of adding a species to the SARA list as well as during subsequent consultations, where applicable. It serves as advice to the Minister of DFO regarding the listing of a species under the SARA and if listed it is used to support decision making with regard to SARA agreements and permits as well as to support development of recovery strategies.

An RPA for redfish was held in March 2011 (DFO 2011). The available data for assessing the Northern DU trends in abundance came from research surveys conducted in a subset of the Northern DU's distribution (Div. 2J + 3KLNO). These survey data and commercial catch data from SA 2 and Div. 3KLNO were used for stochastic projections. Data for redfish in SA 0[1] are limited to recent surveys and bycatch from the commercial Greenland Halibut and shrimp fisheries. There is no history of commercial redfish fishing in SA 0. As a result, data from SA 0 were not considered during the RPA and there is no advice in the RPA specific to SA 0.

Information from the RPA is the basis for developing management scenarios used in the socio-economic analyses to evaluate and consult on impacts of listing decisions. As it was not clear if the advice from the RPA applied to the Northern DU as a whole, the Species at Risk program in Central and Arctic Region requested Science advice on whether the RPA conclusions and advice (DFO 2011) and Limit Reference Points (DFO 2012) for Deepwater Redfish - Northern DU, can be applied to SA 0. If not, what level of harm could be allowed to Deepwater Redfish in SA 0 that would still allow population persistence or recovery?

Due to impending consultations, a Science Response Process was undertaken to address this request.

This Science Response Report results from the Science Response Process of November 6, 2013 on NAFO Subarea 0 Deepwater Redfish (*Sebastes mentella*): Addendum to the recovery potential assessment of redfish in the northwest Atlantic.

[1] Wherever this report refers to SA 0 it is intended to mean all those areas where Deepwater Redfish occur in DFO's Central and Arctic Region, including Baffin Bay, Davis Strait and Hudson Strait.

Background

In April 2010, COSEWIC assessed Deepwater Redfish. Information from several genetic studies (Roques et al. 2002, Valentin 2006) was considered in the assessment and provided support for two designatable units for Deepwater Redfish, the Northern population and the Gulf of St. Lawrence – Laurentian Channel population (Figure 1). COSEWIC assessed the Northern population as Threatened (COSEWIC 2010) for the following reasons:

> *As with other members of the family Sebastidae, this species is long-lived (maximum age about 75 yr), late-maturing (generation time 23 yr), and highly vulnerable to mortality from human activities. Recruitment is episodic, with strong year-classes only occurring every 5-12 years. Abundance of mature individuals has declined 98% since 1978, somewhat over one generation. However, declines have stopped since the mid-1990s and increases have been observed in some areas. Directed fishing and incidental harvest in fisheries for other species (bycatch) are the main known threats. Fisheries in parts of this designatable unit are currently closed, but remain open in other areas. Bycatch in shrimp fisheries has been substantially reduced since the 1990s by use of separator grates in trawls, but could still affect population recovery.*

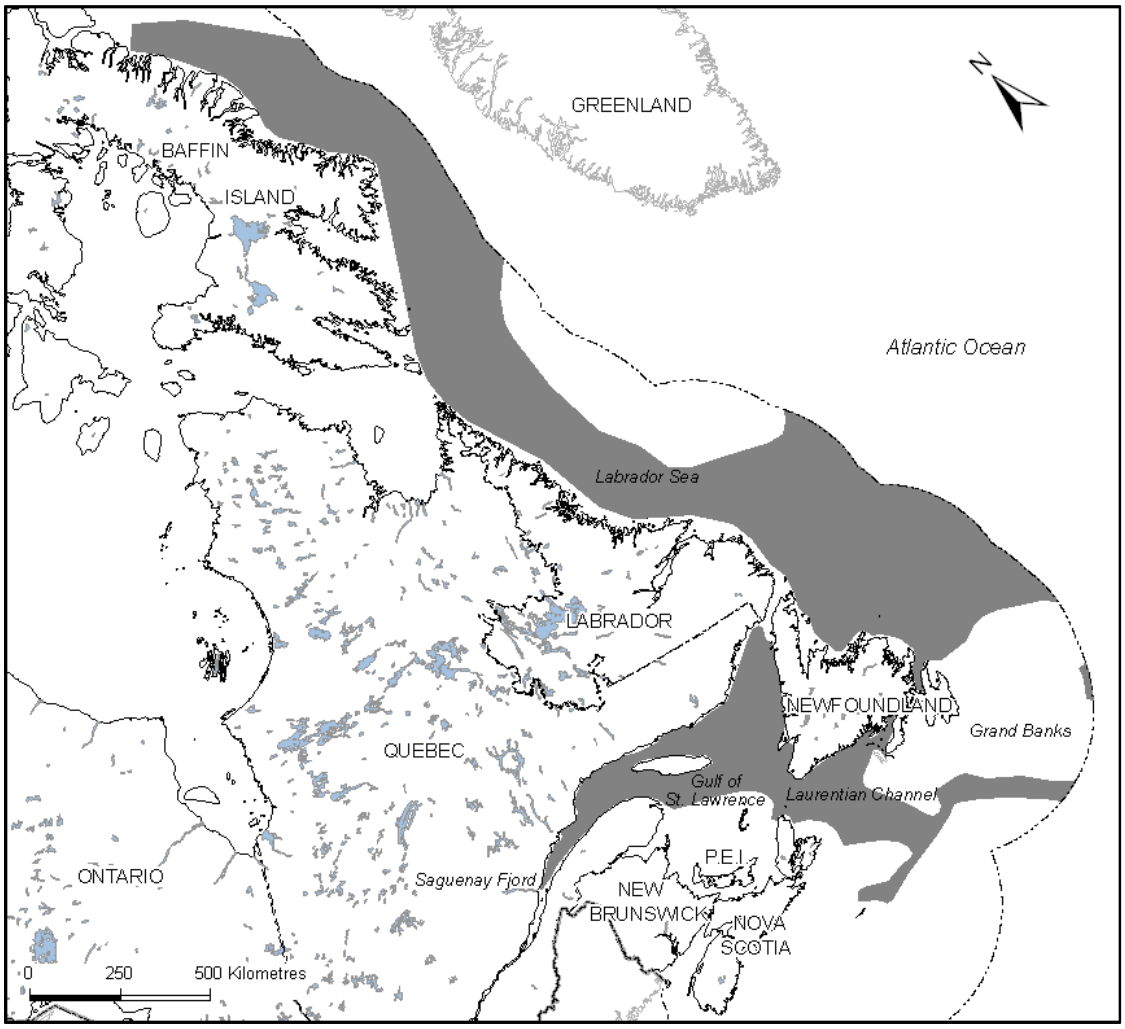

*Figure 1. Canadian distribution of Deepwater Redfish (*Sebastes mentella*) in both Designatable Units, Northern population and Gulf of St. Lawrence - Laurentian Channel population (COSEWIC 2010).*

COSEWIC (2010) described the northern boundary of the Northern DU as extending to the northern limits of the species distribution in Canada. This DU includes Deepwater Redfish in Baffin Bay, Davis Strait, the Labrador Shelf and Grand Banks. Since the COSEWIC assessment DFO has conducted surveys in Hudson Strait (including Shrimp Fishing Area (SFA) 3) where Deepwater Redfish were caught. The distinction between the Northern DU and the Gulf of St. Lawrence/Laurentian Channel DU was based on genetic studies (Roques et al. 2002, Valentin 2006) with three sample locations within the Northern DU: one from Greenland, one from the south Labrador coast and one from the northern Grand Bank. The genetics findings were supported by morphometric analyses.

In 2011, the RPA for Deepwater Redfish (DFO 2011) evaluated trends in the numbers of mature individuals from spring and autumn DFO research surveys that have been adjusted by conversion factors and had comparable coverage (Table 1). In Div. 3O and 3LN (Figure 2) there was a general variability without trend up to the early 1980s, followed by a decline up until the early 1990s and then an upward trend until the assessment. The Div. 3LN directed fishery was under moratorium from 1998 to 2009 then re-opened in 2010. In Div. 2J3K mature numbers declined between the late 1970s and mid-1990s after which the numbers increased to 2009. The SA 2 + Div. 3K management unit has been under a fishing moratorium since 1997. Div. 2GH surveys were sporadic and no trend in mature abundance was observed in years when they occurred.

Table 1. Range in abundance estimates for mature Deepwater Redfish - Northern DU from survey areas reported in the RPA (DFO 2011).

NAFO area	Lowest abundance of mature individuals	Highest abundance of mature individuals
Div. 3O	3 million (1992 spring survey)	20 million (2010 spring survey)
	1 million (1992 autumn survey)	36 million (2009 autumn survey)
Div. 3LN	4 million (1994 spring survey)	47 million (2010 spring survey)
	27 million (1991 autumn survey)	133 million (2009 autumn survey)
Div. 2J3K	14 million (1995)	413 million (2009)
Div. 2GH	no data available	no data available

Mature biomass for the Northern DU in 2010, as assessed from Div. 2J + 3KLNO, was about 54,000 t with 90% probability intervals ranging from 27,000 t to 118,000 t, which is 7–29% of B_{MSY} (DFO 2011). Long term projections were undertaken using Bayesian surplus production models. With catch levels of 3,000 t, the DU has a 90% chance of exceeding 40% of B_{MSY} by 2070. Although the current status of this DU is poor, current fishing levels appear to be sustainable and the population has potential for good growth, thus stock size increases should occur. The reconstruction target in the RPA was 40% of B_{MSY}. This is the default critical zone boundary in DFO's fishery decision-making framework which incorporates the Precautionary Approach.

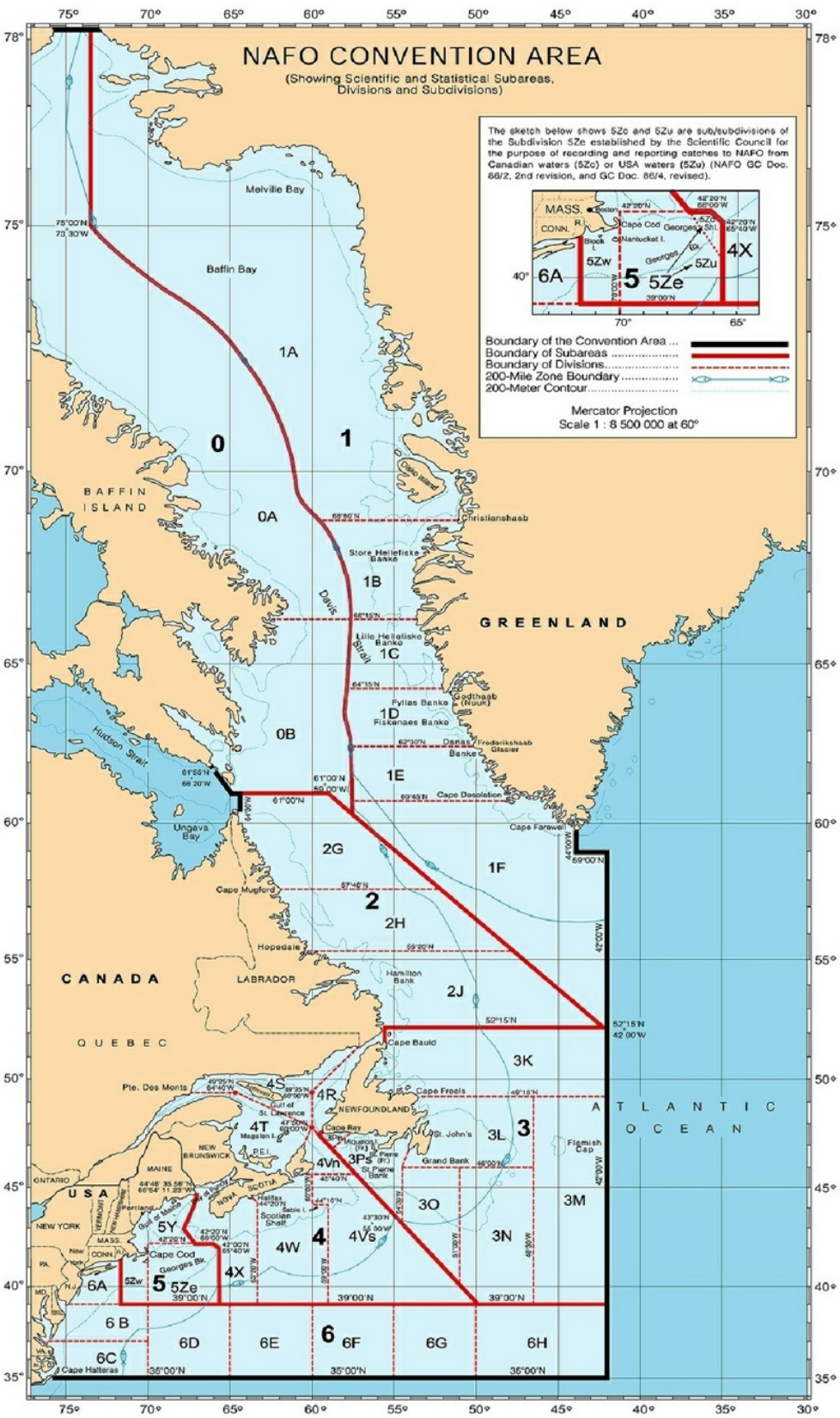

Figure 2. Northwest Atlantic Fisheries Organization (NAFO) convention boundaries illustrating management subareas and divisions.

In 2012, reference points were developed for redfish in the Northern DU (DFO 2012) using a Bayesian surplus production model. The limit reference point (LRP) was 40% B_{MSY} (or 20% of the maximum unfished biomass). The LRP for SA 2 + Div. 3K Deepwater Redfish in 2010 was 116 kt. Therefore the stock biomass at that time was 14% of the LRP. By comparing the most recent catch to the replacement yield from the model, the growth status for SA 2 + Div. 3K Deepwater Redfish was found to be increasing. Catches for Div. 3LNO + 2J3KL averaged 1.9 kt over the 10-year period (2001–2010) (McAllister and Duplisea 2011).

The RPA and the reference point development considered data from a portion of the Northern DU (autumn survey of Div. 2J3K and removals from SA 2 + Div. 3KLNO). These data were the most useful for modelling the population.

Threats in SA 0

Directed fisheries are considered the main threat to the survival and recovery of redfish (COSEWIC 2010, DFO 2011). There is no history of a directed fishery for Deepwater Redfish in SA 0. This species is encountered as bycatch in the Northern Shrimp, Striped Shrimp and Greenland Halibut fisheries (Table 2).

The majority of Deepwater Redfish bycatch comes from the shrimp fishery which uses bottom trawl gear. The high volume of catch of non-targeted species was a major management concern until the Nordmore grate, a bycatch excluder device, was introduced in 1993 to the Canadian shrimp industry. The Nordmore grate filters the catch entering the trawl, allowing animals larger than the grate size to escape through an opening in the top of the net. The grate proved effective at significantly reducing total bycatch (from a high of 32% to a low of 2% for SFA 2) while maintaining the catch rate of shrimp. In 1997, the Nordmore grate with a bar spacing of 28 mm was made mandatory in all SFAs in northern Canada. Siferd (2010) reports redfish bycatch in the shrimp fishery conducted in Baffin Bay, Davis Strait and Hudson Strait. Bycatch summary weight data, recorded by At-sea Observers and estimates of the total number caught for those years when measurement data were collected are presented (Table 2).

The Greenland Halibut fishery uses bottom trawl, gillnet and long-line gear with most of the redfish bycatch coming from bottom trawls in Div. 0B with little bycatch from 0A. The Greenland Halibut fisheries in Cumberland Sound use long-lines and there is no record of redfish bycatch.

The total bycatch of redfish for all commercial fisheries in SA 0 ranged from 55 to 236 t between 1997 and 2008 (Table 2).

Species Biomass and Abundance in SA 0

Deepwater Redfish from surveys in SA 0 up to 2006 were considered in the COSEWIC assessment of the DU. Redfish relative total biomass and abundance were estimated from surveys in Div. 0B in 2000 (Treble et al. 2001) and in Div. 0A and 0B in 2001 (Treble 2002). In 2000, Deepwater Redfish in Div. 0B had an estimated biomass of 3,448 t and abundance of about 4 million (Treble et al. 2001). In 2001, estimated biomass and abundance were 1,226 t and about 10.3 million, respectively for Div. 0A and 15,673 t and about 130 million for Div.0B (Treble 2002).

Analysis and Response

Science was asked whether the conclusions and advice of the RPA (DFO 2011) and Limit Reference Points (DFO 2012) for Deepwater Redfish, Northern DU can be applied to SA 0. If not, what level of harm could be allowed to Deepwater Redfish in SA 0 that would still allow population persistence or recovery?

Table 2. Deepwater Redfish catch (t) in DFO surveys and redfish bycatch in Greenland Halibut, Northern Shrimp and Striped Shrimp commercial fisheries in SA 0 by year. Species are not differentiated in commercial catch and "nf" indicates no fishing occurred. Years with no surveys are marked as "ns", incomplete surveys are marked "inc" and surveys with no redfish data are marked "nd". Since 2003, the management year has been 1 April to 31 March for fisheries in SFA2 and SFA3. Prior to that, and for all other fisheries, they are managed on a calendar year. Annual total includes both survey and bycatch removals combined.

Year	DFO Surveys							Commercial Bycatch				Annual Total
								Greenland Halibut	Shrimp			
	Div. 0A	Div. 0B	RISA	SFA0	SFA1	SFA2EX	SFA3	SA 0	SFA1	SFA2	SFA3	
2012	0.04	ns	4.75	ns	0.04	1.38	ns	4.46	0.09	11.77	0.55	23.08
2011	ns	4.49	3.21	ns	ns	2.52	0.03	18.33	4.95	42.37	0.13	76.03
2010	0.04[†]	ns	4.29	ns	0.09	4.48	ns	8.18	19.57	65.36	0.24	102.25
2009	ns	ns	1.26	ns	ns	2.08	0.01	4.07	nf	59.62	0.07	67.11
2008	0.07	ns	0.62	0.02	0.22	2.98	ns	1.94	nf	87.47	0.23	93.55
2007	ns	ns	0.80	ns	ns	4.31	0.003	11.43	24.14	58.77	0	99.45
2006	0.04	ns	0.12	0.02	inc	2.69		2.30	114.21	77.08	0.01	196.45
2005	ns	ns				4.52		6.05	80.80	148.80	0	240.17
2004	0.09	ns						2.36	97.37	47.28	0.03	147.13
2003	ns	ns						0.59	207.29	15.71	0.02	223.61
2002	ns	ns						0.82	135.19	35.65	0.00	171.66
2001	nd	0.39						0.32	44.15	12.71	0.04	57.61
2000	ns	0.40						1.31	13.61	39.62	0.03	54.97
1999	0.03							0.44	74.91	111.20	0.07	186.65
1998								0.46	106.99	63.32	0.23	171.00
1997								0.41	48.87	136.60	3.10	188.98

[†] Survey coverage expanded to include the northern portion of Div. 0A.

Findings of the RPA could apply to SA 0 if the Northern DU is one stock. Under this assumption the bycatch in SA 0 and unaccounted for fishing mortality in the rest of the Northern DU is accounted for in the fitted model parameters. Therefore, total allowable harm from the RPA corresponds to 3,000 t over and above the bycatch and survey-related mortality in SA 0 as of 2010.

If SA 0 is a separate stock then the impact of bycatch needs to be evaluated relative to resource indices for the area.

Deepwater Redfish catch data from scientific surveys and commercial harvesting were used as a proxy for local stock status to assess the impact of Deepwater Redfish bycatch up to 2012 on the stock in SA 0. Data were available from scientific surveys focused on Greenland Halibut, Northern Shrimp and Striped Shrimp and from the At-sea Observer Program. Greenland Halibut fisheries in Div. 0A are required to have 100% At-sea Observer coverage, as are bottom trawl fisheries in Div. 0B. All shrimp fisheries have 100% At-sea Observer coverage. Observer data and trends in survey data were used to examine the impact of bycatch over the last ten years (2003-2012) on the Deepwater Redfish stock in SA 0. Positive or non-significant trends in survey indices may indicate that fishery bycatch was not negatively affecting the redfish stock, while significant negative trends may indicate that an effect was occurring.

The Northern Shrimp Research Foundation (NSRF) survey [Resolution Island Survey Area (RISA) and SFA2EX survey areas = Eastern Assessment Zone (EAZ)] and DFO multi-species survey (SFA3, Div. 0A and Div. 0B) (Figure 3) are all of a stratified random survey design, with the number of sets apportioned by area with two set minimums in a stratum. The NSRF allocation is based on the Doubleday (1981) survey method while the DFO surveys are allocated by buffered random sampling (Kingsley et al. 2004). The NSRF surveys water depths from 100 to 750 m with a Campelen trawl. For 2005–2007 the standard 14” rock-hopper gear was used in all NSRF survey areas. The trawl was modified to reduce tear-ups in 2008 and used in RISA that year. The modified gear has been used in both RISA and SFA2EX starting in 2009. For SFA1, the Cosmos shrimp trawl samples waters between 200–800 m. For SFA3, the Cosmos shrimp trawl samples waters between 100–1000 m. In Div. 0A and 0B waters from 400–1500 m are sampled with an Alfredo trawl. The mean biomass of redfish in a survey area was calculated by areal expansion: the mean density of redfish in each stratum was multiplied by its corresponding area then all strata were summed to produce the total biomass. Most redfish caught in surveys in SA 0 were immature and ranged in size between 12 and 25 cm in length (DFO unpubl. data) which are below the L_{50} values (up to 33 cm in the Northern DU) reported by COSEWIC (2010).

Statistically significant declines in Deepwater Redfish catches were not observed in any of the DFO survey series (Figure 4). The main survey biomass index for SA 0 (EAZ) is stable suggesting that bycatch levels over the recent 10 year period (2003–2012) are not harming productivity of the stock.

Total annual redfish bycatch in the Greenland Halibut SA 0 fisheries reached a maximum of about 18 t in 2011 and is typically <10 t (Table 2). Total annual bycatch in the Northern Shrimp and Striped Shrimp fisheries ranged from 47 to 230 t since 1997, when use of a Nordmore grate became mandatory. Commercial redfish bycatch is not always differentiated to species and redfish catch in the shrimp and halibut fisheries is likely a combination of Deepwater Redfish, Golden Redfish (*S. marinus*[2]) and possibly some Acadian Redfish (*S. faciatus*). However, based on survey results most are likely Deepwater Redfish. Therefore, the current annual level of

[2] Recognized as *S. norvegicus* in the Integrated Taxonomic Information System (ITIS) and World Register of Marine Species (WoRMS).

commercial bycatch in SA 0 is relatively low for Deepwater Redfish. The DFO surveys typically catch <10 t of redfish annually.

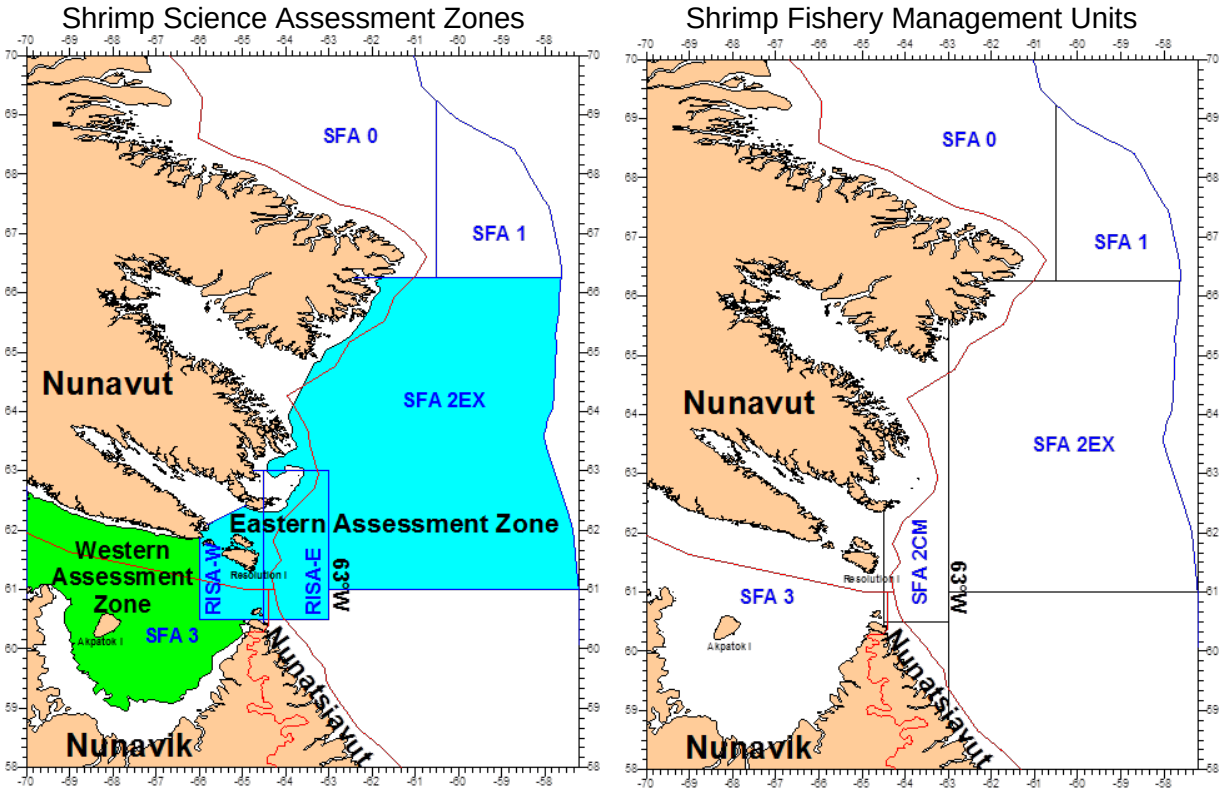

Figure 3. Locations of the shrimp survey areas (left panel) and shrimp management units (right panel) mentioned in this report. Boundaries of the Nunavut, Nunatsiavut and Nunavik Land Claim Areas are identified with red lines. Shrimp Fishing Area (SFA), Commercial (CM), Exploratory (EX), Resolution Island Study Area (RISA), East (E), West (W) (from DFO 2013).

Sources of Uncertainty

Canadian Deepwater Redfish are at the northern end of their range in SA 0. As there are no historic data for redfish in this area there is no information with which to evaluate long-term trends in abundance or biomass. There are no estimates of redfish abundance or biomass in SA 0 prior to 2000. An estimate of virgin biomass is not available so it is not possible to compare current level to historic levels.

Genetic stock structuring in the Northern DU is uncertain. Since the COSEWIC assessment and RPA were undertaken genetic sample coverage has expanded to include numerous sample locations throughout the Northern DU. Whether the results will change how redfish are assessed or managed is uncertain. The link between redfish in SA 0 and the subareas to the south is unknown. How much movement occurs between stock areas either during the larval/juvenile stages or as adults is also unknown.

Redfish bycatch in the commercial fisheries, not discriminated by species, are a source of uncertainty.

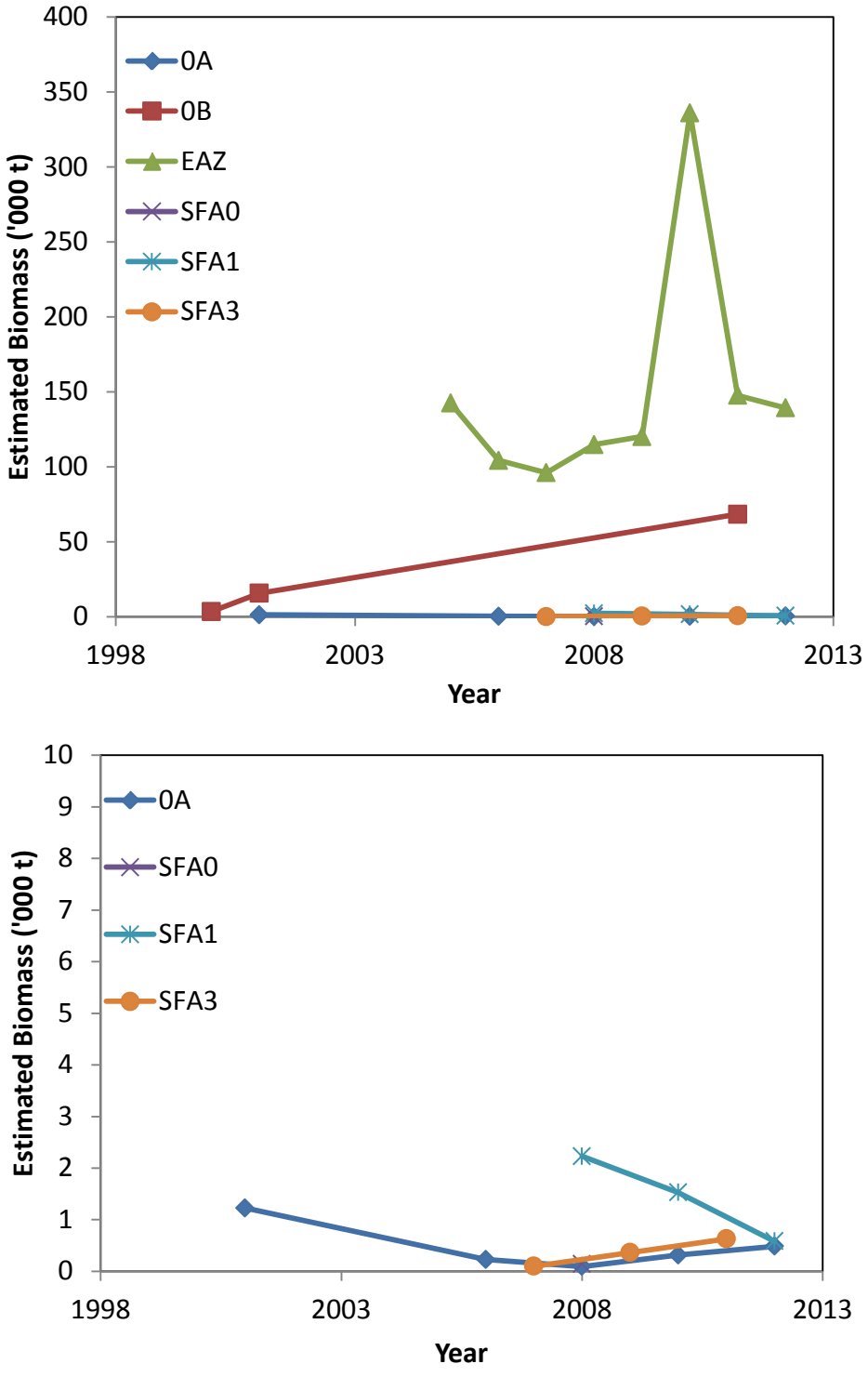

Figure 4. Deepwater Redfish total relative biomass estimates by year from different survey areas. Significant trends were not observed in the Eastern Assessment Zone (EAZ)(p=0.441) or in Div. 0B (p=0.212) (upper panel). A statistically significant increase in biomass was observed in SFA3 (p=0.005) but no significant trends were observed in Div. 0A (p=0.925) or SFA1 (p=0.209) (lower panel). There is only a single point for SFA0 (in 2008) obscured by 0A data.

Bottom trawl survey gear is not designed to target redfish. As a result, indices evaluated in SA 0 are based on immature fish as they are more susceptible to survey gear than mature (larger) redfish. Current biomass indices for SA 0 do not cover the entire area though they do cover the area where redfish are most abundant. The time series used in this assessment is short particularly relative to the lifespan of redfish.

Limited survey and catch history data are available in SA 0 with which to project future trends. Future modelling exercises for redfish should explicitly consider both catch and bycatch.

Conclusions

Two opposing assumptions were considered to address the requests for advice about what level of harm could be allowed in SA 0 and still permit population persistence or recovery. The first considered the whole Northern DU as a single stock. The survey index from Div. 2J + 3KLNO was the most informative and was used along with catch data from SA 2 + Div. 3KLNO as the basis for determining overall status and stochastic projections (DFO 2011). The RPA indicates that even catches of 3,000 t over the long term (60 years) can be sustained (DFO 2011). If it is a single stock then the bycatch in SA 0 and in the rest of the Northern DU is accounted for in the fitted model parameters because the 3,000 t catch limit does not include bycatch in SA 0. Additionally, if it is a single stock then the LRP developed for the SA 2 + Div. 3K stock would also apply.

The second assumption considered SA 0 separate from the remainder of the Northern DU so that the impact of bycatch would be evaluated relative to resource indices for SA 0. There is no history of a directed fishery for redfish in SA 0 and the current level of commercial bycatch is relatively low. No statistically significant declines in Deepwater Redfish catches were found in any of the DFO survey series. With bycatch levels over the past ten years (2003–2012) the main survey biomass index for SA 0 (EAZ) is stable suggesting these bycatch levels are not harming the productivity of the stock. The LRP for SA 0 would need to be developed in the future though this would be challenging given the limited data available for the area.

Regardless of which assumption is considered, the levels of bycatch in SA 0 over the past ten years (2003–2012) are low, averaging 127 t/year, with a maximum of 240 t/year. These bycatch levels would not affect the findings from the RPA under the single stock assumption and have not harmed productivity in SA 0 under the assumption of a separate stock. Therefore, continued bycatch at these levels is not expected to impair persistence or recovery of Deepwater Redfish in the Northern DU.

Contributors

Name	Affiliation
Jeff Adam	Fisheries and Oceans Canada Policy and Economics, C&A
Holly Cleator	Fisheries and Oceans Canada Science, C&A
David Coffin†	Fisheries and Oceans Canada Fisheries Management, NL
Daniel Duplisea	Fisheries and Oceans Canada Science, QC
Kevin Hedges	Fisheries and Oceans Canada Science, C&A
Beth Hiltz	Fisheries and Oceans Canada Resource Management, C&A
Martha Krohn	Fisheries and Oceans Canada Science, NCR
Kathleen Martin	Fisheries and Oceans Canada Science, C&A
Don Power †	Fisheries and Oceans Canada Science, NL
Jean-Marie Sévigny	Fisheries and Oceans Canada Science, QC
Tim Siferd	Fisheries and Oceans Canada Science, C&A
Sam Stephenson	Fisheries and Oceans Canada Species at Risk, C&A
Ross Tallman	Fisheries and Oceans Canada Science, C&A
Margaret Treble	Fisheries and Oceans Canada Science, C&A
Alexandra Valentin	Fisheries and Oceans Canada Science, QC
Rob Young	Fisheries and Oceans Canada Science, C&A

† Provided comments on the draft report in advance of the meeting.

Approved by

M. Wheatley, Director of Science, Central and Arctic Region

R. Young, Division Manager, Arctic Aquatic Research Division

Approved November 13, 2013.

Sources of information

This Science Response Report results from the Science Response Process of November 6, 2013 to evaluate the NAFO Subarea 0 Deepwater Redfish (*Sebastes mentella*): Addendum to the recovery potential assessment of redfish in the northwest Atlantic.

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Winnipeg, MB R3T 2N

Telephone: (204) 983-5131
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769

Correct Citation for this Publication:

DFO. 2014. Deepwater Redfish (*Sebastes mentella*) in NAFO subarea 0: addendum to the recovery potential assessment of Redfish in the northwest Atlantic. DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/026.

Aussi disponible en français :

MPO. 2014. Sébaste atlantique (Sebastes mentella) du sous-secteur 0 de l'OPANO : Addenda de l'évaluation du potentiel de rétablissement du sébaste dans l'antique nord-ouest. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2013/026.