SUBMISSION TO THE

NUNAVUT WILDLIFE MANAGEMENT BOARD AND NUNAVIK MARINE REGION WILDLIFE BOARD

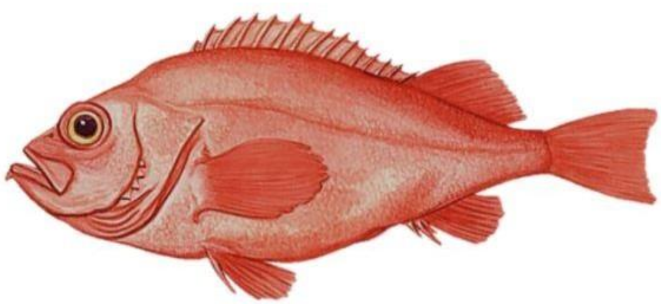
FOR

Information: X **Decision:** **Recommendation:**

Issue: Juvenile redfish (*Sebastes mentella* and *Sebastes fasciatus*) bycatch in the Northern Shrimp Fishery in the Eastern Assessment Zone

Northern shrimp (*Pandalus borealis*)

Striped shrimp (*Pandalus montagui*)



Redfish (*Sebastes mentella and S. fasciatus*)

Background

Two shrimp species (*P. borealis* and *P. montagui*) occur in the Northern shrimp fishery that takes place in the Davis Strait and eastern Hudson Strait. This fishery is managed according to two distinct stock assessment zones, the Western Assessment Zone (WAZ) and the Eastern Assessment Zone (EAZ) (Appendix 1).

In October 2020, representatives of the offshore Northern shrimp sector reported high juvenile redfish bycatches in portions of the EAZ (Davis Strait West) and Shrimp Fishing Area (SFA) 4 to the extent that it triggered move-away provisions within Conditions of Licence (COL).

These provisions require vessels to change fishing locations by a minimum of 10 nautical miles in the event that groundfish bycatch (including redfish) in any tow exceeds a pre-defined threshold (the greater of 2.5% by weight of the catch of shrimp, or 100kg) (Appendix 2).

In fall 2020, industry reported that these move-away provisions were repeatedly triggered in the EAZ and SFA 4 to the extent that they inhibited successful prosecution of the shrimp fishery, posing a serious economic viability concern for the offshore shrimp sector. The occurrence of high juvenile redfish bycatch was considered an urgent and unusual circumstance. The need for a management response to address the interruption of shrimp fishing was urgent since fishing opportunity remaining was limited and subject to ice conditions. The high prevalence of redfish bycatch has persisted into this season based on industry reports.

There is currently no open directed redfish fishery in this area. The redfish fishery in Northwest Atlantic Fisheries Organization (NAFO) Subarea 2 + Division 3K has been under moratorium since 1997.

Science Advice

Redfish stocks exhibit periodic pulse recruitment, exhibited by very small year classes in most years and occasionally extremely large year classes that can be a decade apart. These periodic large pulses of population recruitment are important to sustain the population over time.

Where redfish and Northern shrimp are found in similar environments, the first sign of a strong cohort is typically evidenced via increased bycatch rates in other fisheries with non-selective gear types like Northern shrimp. Redfish bycatch may consist of two or three species (depending on the area) that are not separated in fishery reporting or for stock assessment purposes. The relative abundance of each redfish species in bycatches changes with latitude.

The last assessment of the redfish stock in NAFO Subarea 2 + Division 3K occurred in 2016. Survey results showed that redfish biomass increased considerably from 2003 to 2010 and that biomass during 2010-2015 was approximately half of the pre-collapse (1978-1990) levels. The 2016 survey showed that redfish recruitment since 2000 was above the long term average, with a time-series high in 2014 (Appendix 3).

More recent preliminary results from the multi-species survey (not dedicated to surveying redfish) in NAFO Subarea 2 + Division 3K show an increase in juvenile redfish recruitment in 2019 (likely 2018 year-class), as well as variability in the indices since the 2016 assessment.

Given there are no recent biomass estimates for redfish populations in SFA 4 or the EAZ, it is not possible to estimate the impact of juvenile redfish bycatches in these areas on population recovery. Further, it is not yet known if these recent large recruitments will persist over time in the population.

Fisheries and Oceans Canada (DFO) Resource Management has submitted requests for peer-reviewed stock assessments for redfish in NAFO Subarea 2 + Division 3K and Subarea 0 (overlapping with the EAZ).

More recently, research was conducted regarding whether trawl modifications could potentially help address the prevalence of redfish bycatch was conducted. The purpose of the project was to evaluate the effectiveness of various Nordmøre grid bar spacings in mitigating bycatch of juvenile redfish. Two experimental grids of 17mm and 15mm were used, in comparison to the tradition 22mm grid often used by industry. This project was conducted in SFAs 4 and 5. Preliminary results indicated that a reduction in grid size reduced redfish bycatch by 28.37% for 17mm grids and 18.69% for 15mm grids. The final report is expected this fall.

In addition, a retroactive analysis of redfish bycatch in the Northern Shrimp fishery was conducted prepared for the Canadian Association of Prawn Procurers by Pisces Consulting (see Appendix 5). This report was shared with the Department in the summer of 2021 to support decision-making. It indicates that while redfish bycatch is still a concern, it has mostly remained under the adjusted limit and does not represent a worst-case scenario.

<u>Management Response</u>

In November 2020, the Department sought views from industry and Board staff on an interim management response to high redfish bycatch that allowed harvesters to successfully prosecute the remainder of the 2020-21 shrimp fishery, while taking into consideration the potential impact on redfish stocks. The use of an interim measure was intended to facilitate innovative fishing techniques by harvesters in the affected areas to reduce future redfish bycatch.

The Department carefully considered industry-proposed measures in consultation with Board staff and DFO Science. In late November, offshore shrimp COLs were amended to require vessels to move 5 nautical miles if the total bycatches of redfish over the previous six tows exceeded 10% by weight of the total catch of shrimp (Appendix 2). This measure would allow for increased redfish bycatches and reduce the frequency of move-aways. This interim measure was approved for a period of 8 weeks (November 26, 2020, to January 21, 2020). Given the persistence of the issue into 2021, the interim measure was then approved for two additional 8 week periods (May 28, 2021 to July 23, 2021 and July 30, 2021 to September 24, 2021) to allow for the successful prosecution of the fishery. Finally, an extended interim measure was approved on September 25, 2021 to account for the remainder of the year (September 25, 2021 to December 31, 2021).

This targeted, responsive approach was limited to SFA 4 and Davis Strait West management units in November. In late May, the scope was expanded to include SFA 5. Where Nunavut and Nunavik allocation holders may cross the between Davis Strait West and Nunavut / Nunavik East management units in the same tow, extension of this interim measure to Nunavut / Nunavik East was required from an operational standpoint.

Next Steps

To follow the availability of an updated stock assessment for redfish, DFO – Fisheries Resource Management has requested science advice on management measures to address the issue of redfish bycatch in the Northern shrimp fisheries that occur in SFAs 4- 6 the EAZ and WAZ. Science advice is requested in order to understand the potential impact of redfish removals on the health of the population in these areas. Scoping discussions regarding science advice are ongoing. Timelines regarding the provision of science advice are currently being discussed.

DFO - Fisheries Resource Management will continue to monitor bycatch in the Northern shrimp fishery in the EAZ and neighboring shrimp management units to better understand the potential impact to harvesters and to the conservation of redfish stocks. In addition, DFO will support further industry initiatives to test innovative fishing techniques that may reduce future redfish bycatches, and consider the possible use of these techniques in future management decisions, where appropriate.

It is not yet clear whether future circumstances may suggest a need for further interim response. At the time of this submission, no further flexibilities have been proposed or approved.

Prepared by: Erika Parrill, Fisheries Resource Management, Fisheries and Oceans Canada

Date: October 19, 2021

Appendices

Appendix 1 – Map of groundfish and shrimp administrative areas in Atlantic Canada

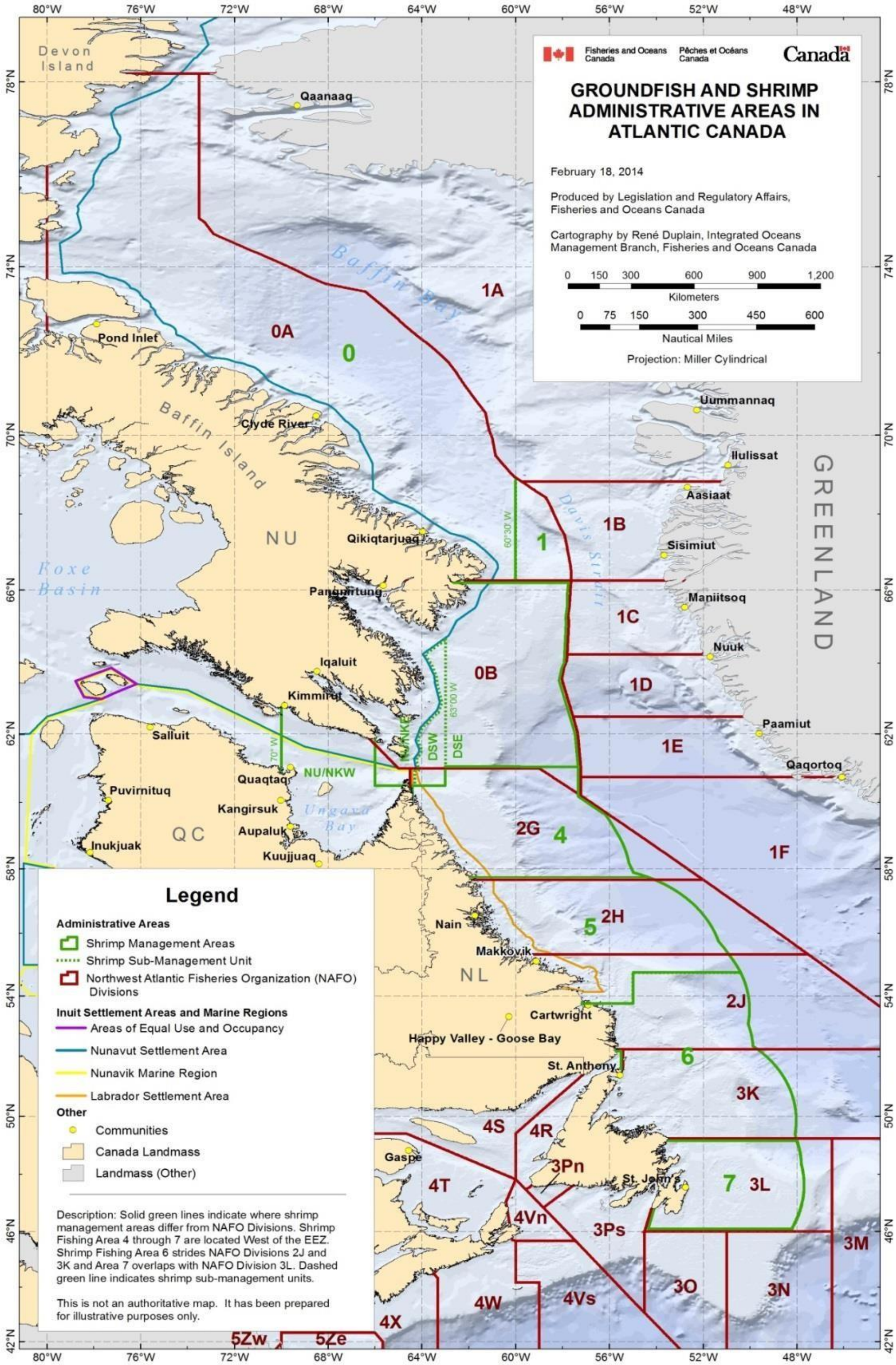
Appendix 2 – Condition of Licence amendments

Appendix 3 – Summary: Stock status of redfish in NAFO SA 2 + Divs. 3K (Science Advisory Report 2020/021)

Appendix 4 – Full publication: Stock status of redfish in NAFO SA 2 + Divs. 3K (Science Advisory Report 2020/021)

Appendix 5 – Full publication: Retroactive Analysis Redfish Bycatch in the Northern Shrimp Fishery

APPENDIX 1


Fisheries and Oceans Canada
Pêches et Océans Canada
Canada
GROUNDFISH AND SHRIMP ADMINISTRATIVE AREAS IN ATLANTIC CANADA
February 18, 2014
Produced by Legislation and Regulatory Affairs, Fisheries and Oceans Canada
Cartography by René Duplain, Integrated Oceans Management Branch, Fisheries and Oceans Canada
0 150 300 600 900 1,200
Kilometers
0 75 150 300 450 600
Nautical Miles
Projection: Miller Cylindrical
Legend
Administrative Areas
Shrimp Management Areas
Shrimp Sub-Management Unit
Northwest Atlantic Fisheries Organization (NAFO) Divisions
Inuit Settlement Areas and Marine Regions
Areas of Equal Use and Occupancy
Nunavut Settlement Area
Nunavik Marine Region
Labrador Settlement Area
Other
Communities
Canada Landmass
Landmass (Other)
Description: Solid green lines indicate where shrimp management areas differ from NAFO Divisions. Shrimp Fishing Area 4 through 7 are located West of the EEZ. Shrimp Fishing Area 6 strides NAFO Divisions 2J and 3K and Area 7 overlaps with NAFO Division 3L. Dashed green line indicates shrimp sub-management units.
This is not an authoritative map. It has been prepared for illustrative purposes only.
Devon Island
Qaanaaq
Baffin Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Pangnirtung
Iqaluit
Kimmirut
Salluit
Quaqtaq
Puvirnituq
Kangirsuk
Aupaluk
Inukjuak
Kuujjuaq
Ungava Bay
Foxe Basin
Davis Strait
GREENLAND
Uummannaq
Ilulissat
Aasiaat
Sisimiut
Maniitsoq
Nuuk
Paamiut
Qaqortoq
Nain
Makkovik
Cartwright
Happy Valley - Goose Bay
St. Anthony
Gaspe
St. John's
NU
QC
NL
NU/NKW
NU/NKE
DSW
DSE
60°30' W
63°00' W
70° W
0A 0B 1A 1B 1C 1D 1E 1F
2G 2H 2J 3K 3L 3M 3N 3O 3Pn 3Ps
4R 4S 4T 4Vn 4Vs 4W 4X 5Zw 5Ze
0 1 4 5 6 7
80°W 76°W 72°W 68°W 64°W 60°W 56°W 52°W 48°W
78°N 74°N 70°N 66°N 62°N 58°N 54°N 50°N 46°N 42°N

Offshore Shrimp Condition of Licence

5.2. If total by-catches of all groundfish species in any haul exceed the greater of 2.5% by weight of the catch of shrimp or 100 kg, the licence holder or vessel operator must immediately change fishing area by a minimum of ten (10) nautical miles from any position of the previous tow in an effort to avoid further by-catches of all groundfish. If after moving and for all subsequent moves, the next haul exceeds the greater of 2.5% by weight of the catch of shrimp or 100kg, the vessel must continue to move 10 nautical miles from any position of the previous tow to avoid by-catch. The licence holder or vessel operator must record in the logbook (in the Remarks field)the active avoidance measures taken in response to any tows that contained excessive groundfish by-catch, the position (latitude and longitude) at the time of groundfish by-catch, as well as the quantity caught by weight in kilogram.

Condition of Licence amendment effective November 26, 2020, to January 21, 2021:

5.2.3 Notwithstanding section 5.2 above, while fishing within and/or across the waters of the following Management Units on a single fishing trip: Nunavut East, Nunavik East, Davis Strait West, and/or Shrimp Management Unit 4, if total by-catches of Redfish exceed 10% by weight of the total catch of shrimp over the previous six tows, the licence holder or vessel operator must immediately change fishing area by a minimum of five (5) nautical miles from any position of the previous tow. Whenever the vessel moves five (5) nautical miles or more from any position of the previous tow, the following tow is to be considered to be the first of the next six tows to be considered. The licence holder or vessel operator must record in the logbook (in the Remarks field) the active avoidance measures taken in response to any tows that contained excessive Redfish by-catch, the position (latitude and longitude) at the time of Redfish by-catch, as well as the quantity caught by weight in kilogram. The above provisions of 5.2.3 are effective between 0001 UTC on November 26, 2020, to 2400 UTC on January 21, 2021.

Condition of Licence amendment effective May 28, 2021, to July 23, 2021:

5.2.3 Notwithstanding section 5.2 above, while fishing within and/or across the waters of the following Management Units on a single fishing trip: Shrimp Management Unit 1, Nunavut East, Nunavik East, Davis Strait West, Davis Strait East, Shrimp Management Unit 4,and/or Shrimp Management Unit 5, if total by-catches of Redfish exceed 10% by weight of the total catch of shrimp over the previous six tows, the licence holder or vessel operator must immediately change fishing area by a minimum of five (5) nautical miles from any position of the previous tow. Whenever the vessel moves five (5) nautical miles or more from any position of the previous tow, the following tow is to be considered to be the first of the next six tows to be considered. The licence holder or vessel operator must record in the logbook (in the Remarks field) the active avoidance measures taken in response to any tows that contained excessive Redfish by-catch, the position (latitude and longitude) at the time of Redfish by-catch, as well as the quantity caught by weight in kilogram. The above provisions of 5.2.3 are effective between 0001 UTC on May 28, 2021, to 2400 UTC on July 23, 2021.

Condition of Licence amendment effective July 30, 2021, to September 24, 2021:

5.2.3 Notwithstanding section 5.2 above, while fishing within and/or across the waters of the following Management Units on a single fishing trip: Shrimp Management Unit 1, Nunavut East, Nunavik East, Davis Strait West, Davis Strait East, Shrimp Management Unit 4,and/or Shrimp Management Unit 5, if total by-catches of Redfish exceed 10% by weight of the total catch of shrimp over the previous six tows, the licence holder or vessel operator must immediately change fishing area by a minimum of five (5) nautical miles from any position of the previous tow. Whenever the vessel moves five (5) nautical miles or more from any position of the previous tow, the following tow is to be considered to be the first of the next six tows to be considered. The licence holder or vessel operator must record in the logbook (in the Remarks field) the active avoidance measures taken in response to any tows that contained excessive Redfish by-catch, the position (latitude and longitude) at the time of Redfish by-catch, as well as the quantity caught by weight in kilogram. The above provisions of 5.2.3 are effective between 0001 UTC on July 30, 2021, to 2400 UTC on September 24, 2021.

Condition of License amendment effective September 25, 2021, to December 31, 2021:

5.2.3 Notwithstanding section 5.2 above, while fishing within and/or across the waters of the following Management Units on a single fishing trip: Shrimp Management Unit 1, Nunavut East, Nunavik East, Davis Strait West, Davis Strait East, Shrimp Management Unit 4,and/or Shrimp Management Unit 5, if total by-catches of Redfish exceed 10% by weight of the total catch of shrimp over the previous six tows, the licence holder or vessel operator must immediately change fishing area by a minimum of five (5) nautical miles from any position of the previous tow. Whenever the vessel moves five (5) nautical miles or more from any position of the previous tow, the following tow is to be considered to be the first of the next six tows to be considered. The licence holder or vessel operator must record in the logbook (in the Remarks field) the active avoidance measures taken in response to any tows that contained excessive Redfish by-catch, the position (latitude and longitude) at the time of Redfish by-catch, as well as the quantity caught by weight in kilogram. The above provisions of 5.2.3 are effective between 0001 UTC on September 25, 2021, to 2400 UTC on December 31, 2021.

SUMMARY: Stock status of redfish in NAFO SA 2 + Divs. 3K (Science Advisory Report 2020/02)

- Biomass increased considerably from 2003 to 2010. Biomass during 2010-2015 was approximately half of the pre-collapse (1978-1990) levels.
- Recruitment (abundance of Redfish <15 cm) since 2000 was above the long term average with a time-series high in 2014.
- A fishing mortality proxy has been very low (<1%) since 2006. The fishery remains under moratorium, and average bycatch (including discards) since 2006 has been approximately 500 t.
- The meeting was neither able to validate nor invalidate existing reference points (DFO 2012) derived from production models due to substantive concerns about input data and an incomplete documentation of the rationale for model formulation.
- Other options for Limit Reference Points (LRPs) were considered. However, considering difficulties with respect to application of the LRP concepts for Redfish including its episodic recruitment, species separation, and other data limitations, these other LRP options were not accepted.
- No LRP examined (including DFO 2012) was considered applicable at this time.
- In the absence of a LRP, it is not possible to identify what zone of the Precautionary Approach (PA) framework this stock is currently within. It is recommended that adaptive and cautious management be applied to any reopened fishery.

Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Newfoundland and Labrador Region

Canadian Science Advisory Secretariat
Science Advisory Report 2020/021

STOCK STATUS OF REDFISH IN NAFO SA 2 + DIVS. 3K

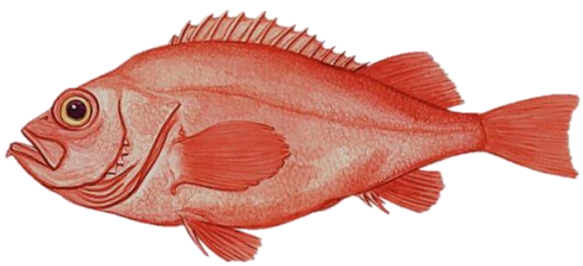


Image: Redfish

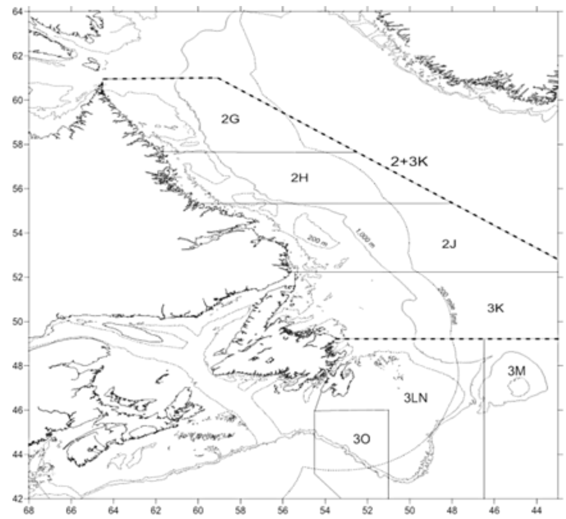


Figure 1. Map of the Northwest Atlantic indicating the SA 2 + Divs. 3K management area for Redfish.

Context:

In the Northwest Atlantic, Redfish range from Baffin Island in the north, to waters off New Jersey in the south and are managed in several discrete units. Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 2 (2G, 2H, and 2J) + Division 3K comprise stock complexes of two species (Sebastes mentella and S. fasciatus) recorded together in the landings because they cannot easily be distinguished visually, plus an additional less dominant species S. marinus that is visually distinct from the other species. The fishery on this stock was under Total Allowable Catch (TAC) regulation from 1974 (30,000 t) to 1996 (200 t). From 1997 to the present, the stock has been under moratorium to directed fishing. A previous assessment in 2001, of Redfish in stock status in Subarea (SA) 2 + Divs. 3K concluded that the population declined rapidly over a 10 year period from 1980-1990 and that surveys up to 2000 continue to indicate that the resource was at a low level reflecting over 25 years of recruitment failure. A Recovery Potential Assessment was conducted in a 2011 Zonal Advisory Process in which limit reference points (LRPs) were determined. During this process, stock status was updated and it was concluded that the biomass had remained stable at a low level from the mid-1990s until the mid-2000s when a period of marginal increase was evident.

This Science Advisory Report is from the October 19-21, 2016 Assessments of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, and Subarea 2 and Division 3K. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule] as they become available.

SUMMARY

- Biomass increased considerably from 2003 to 2010. Biomass during 2010-2015 was approximately half of the pre-collapse (1978-1990) levels.
- Recruitment (abundance of Redfish <15 cm) since 2000 was above the long term average with a time-series high in 2014.
- A fishing mortality proxy has been very low (<1%) since 2006. The fishery remains under moratorium, and average bycatch (including discards) since 2006 has been approximately 500 t.
- The meeting was neither able to validate nor invalidate existing reference points (DFO 2012) derived from production models due to substantive concerns about input data and an incomplete documentation of the rationale for model formulation.
- Other options for LRPs were considered. However, considering difficulties with respect to application of the LRP concepts for Redfish including its episodic recruitment, species separation, and other data limitations, these other LRP options were not accepted.
- No LRP examined (including DFO 2012) was considered applicable at this time.
- In the absence of a LRP, it is not possible to identify what zone of the Precautionary Approach (PA) framework this stock is currently within. It is recommended that adaptive and cautious management be applied to any reopened fishery.

INTRODUCTION

Redfish have been fished commercially in both the Atlantic and Pacific Oceans. They occur on both sides of the north Atlantic Ocean in cool waters (3 to 8°C) along the slopes of banks and deep channels generally in depths of 100-1,000 m. In the Northwest Atlantic, Redfish range from Baffin Island in the north, to waters off New Jersey in the south (Gascon 2003, Fig. 1).

Redfish found on the Northeast Newfoundland and Labrador Shelves (NAFO SA 2 + Divs. 3K) comprise a stock complex formed by three distinct species, *Sebastes mentella* (Deepwater Redfish) and *Sebastes fasciatus* (Acadian Redfish), which dominate commercial fisheries, and *Sebastes marinus* (Golden Redfish) which is much less abundant. Currently, *S. marinus* is recognized as being synonymous with *S. norvegicus* with most authorities reverting to *S. norvegicus* as the accepted binomial name. However, for consistency with previous Canadian Science Advisory Secretariat (CSAS) and Department of Fisheries and Oceans (DFO) publications, and this stock assessment, we will refer to this species as *S. marinus*. *S. mentella* and *S. fasciatus* are visually and anatomically very similar, and historically they have not been separated in commercial catches or in research vessel (RV) surveys. *S. marinus* can be distinguished by colour, eye size and the relative size of a bony protrusion on its lower jaw. These species are not separated in the fishery and are managed together. The current assessment is based upon *S. fasciatus, S. mentella,* and *S. marinus* combined.

Along the continental shelves and slopes *S. mentella* range predominantly from the Gulf of St. Lawrence northward whereas *S. fasciatus* range predominantly from the southern Grand Banks to the Gulf of Maine. Generally, *S. mentella* is distributed deeper than *S. fasciatus* (Gascon 2003).

Redfish are longlived (up to 75 years) with a slow growth rate (Campana et. al. 1990). Estimates of size at maturity vary between and within populations with lower estimates in the range of 22-24 cm (Sévigny et al. 2007) and upper estimates of 38-39 cm for deep-sea *S. mentella* (Magnússon and Magnússon 1995). Redfish produce live young that can disperse over large distances (Valentin et. al. 2015). Recruitment is episodic and there may be decades between strong cohorts. They form aggregations throughout life and survey results for Redfish are typically dominated by one or two very large samples which has an unknown influence on survey results.

Fishery Removals

A Canadian and non-Canadian Redfish fishery has been prosecuted in SA 2 + Divs. 3K since the late 1940s. Total Allowable Catch (TAC) was established in 1974 when a 30,000 t quota was implemented (Fig. 2). The TAC was increased to 35,000 t in 1980 and remained at that amount until it was lowered to 20,000 t in 1991 (Fig. 2). The TAC decreased to 1,000 t in 1994 and was reduced to 200 t in 1995. The stock has been under moratorium since 1997 (Fig. 2).

The highest recorded removal of SA2 + 3K Redfish was 187,000 t in 1959 (Fig. 2). Removals from 1980 onwards also include discard estimates from Canadian shrimp (1980-2015) and Canadian Greenland Halibut fisheries (1995-2015) derived from fishery observer data scaled to total shrimp and Greenland Halibut landings. Reported removals fell to 56,000 t in 1961 and varied between 14,500 t and 56,000 t during the period 1962 to 1987 (Fig. 2). Removals declined after 1987 ranging from 30 t to 7,500 t up to the declaration of the moratorium in 1997 (Figs. 2 and 3). Removals from bycatch and discards have ranged between 50 t and 1,500 t since the 1997 moratorium (average of 500 t annually). From 1980 to 1996, discards ranged between 15 t to 700 t annually, averaging 200 t per year. Since the moratorium in 1997, estimates of discards ranged between 50 t and 600 t annually, averaging <300 t per year (Fig. 3). Note that Russian (2001-2008) and Lithuanian (2001-2011) catches are considered to be from the Irminger Sea and are not included in SA2 + 3K removal totals for those years.

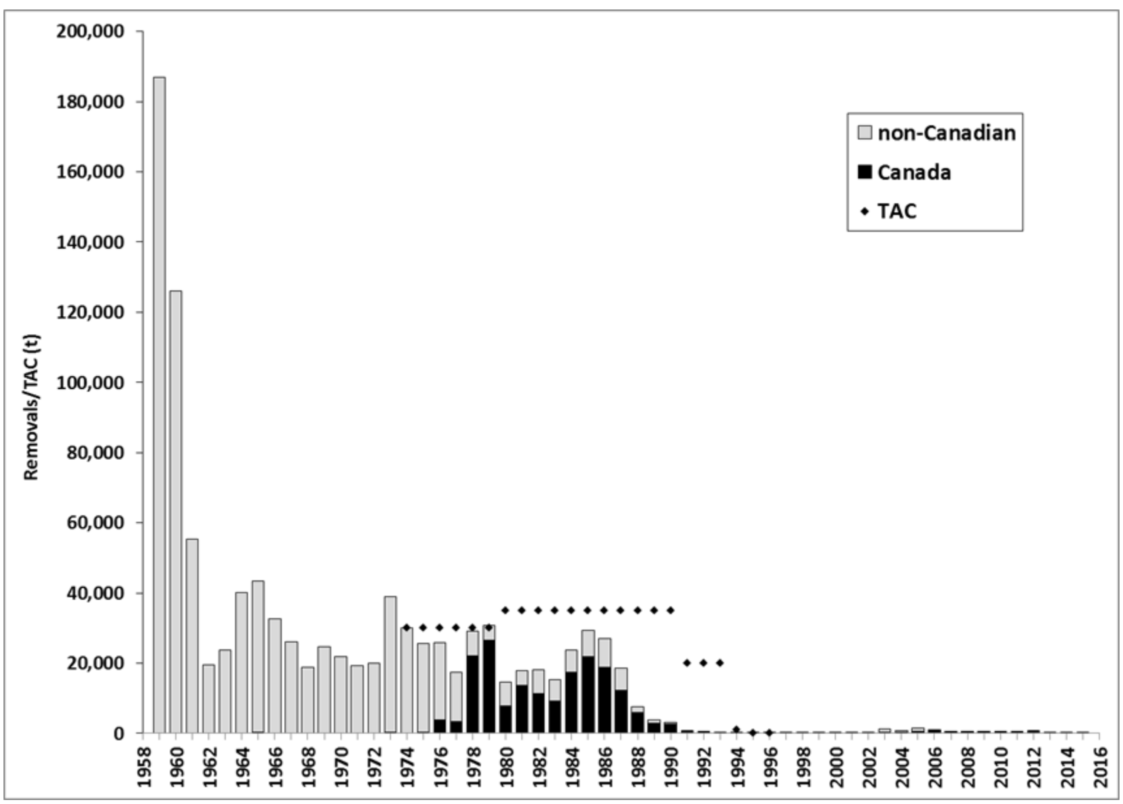


Figure 2. Redfish reported removals (t) by Canadian and non-Canadian fleets (including Canadian discard estimates from 1980-2015) and TAC in SA 2 + Divs. 3K from 1959 to 2015.

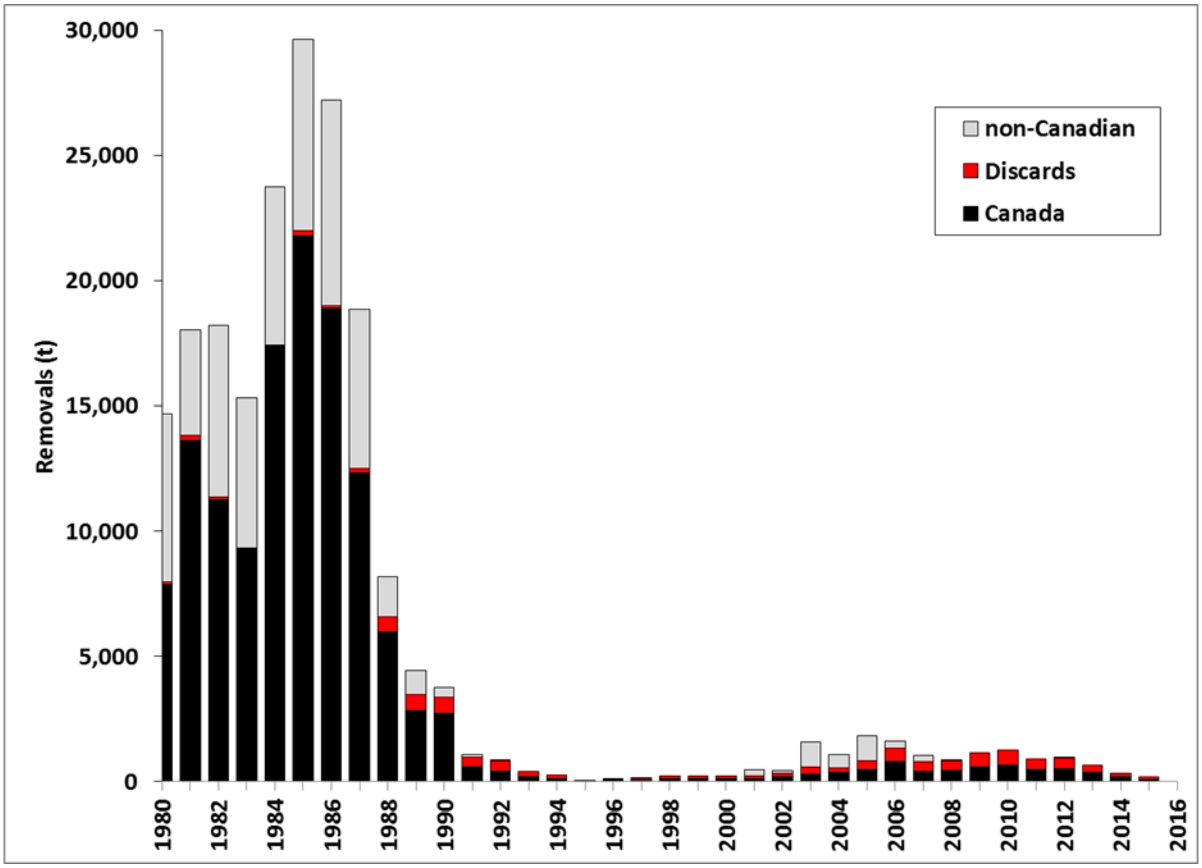


Figure 3. Redfish reported removals (t) by Canadian and non-Canadian fleets in SA 2 + Divs. 3K from 1980-2015 with Canadian discard estimates shown in red.

ASSESSMENT

This assessment considered information from landings from all countries (1959-2015) in conjunction with analyses of data from research vessel (RV) surveys conducted during autumn from 1978 to 2015.

Survey Methodology

Stratified random bottom trawl surveys were conducted in the autumn in Divs. 2J and 3K from 1977 to 1995 covering depths from 100 to 1,000 m and from 1996 to 2015 covering depths from 100 to 1,500 m. Surveys in Divs. 2G were conducted sporadically with varying spatial coverage and timing between 1978 and 1999 (the last year this Division was surveyed). Surveys were conducted sporadically in Divs. 2H between 1978 and 2010. Between 1978 and 1995 Divs. 2H surveys sampled depths from 100 to 1,000 m; in 1996 the depth range was extended to 1,500 m. Surveys have been conducted annually in Divs. 2H since 2010, although deep strata (>700 m) were not sampled in 2014 and 2015. Due to the inconsistent coverage of Divs. 2G and 2H, the primary indices for this stock are from Divs. 2J and 3K combined.

Survey Indices

Abundance and Biomass

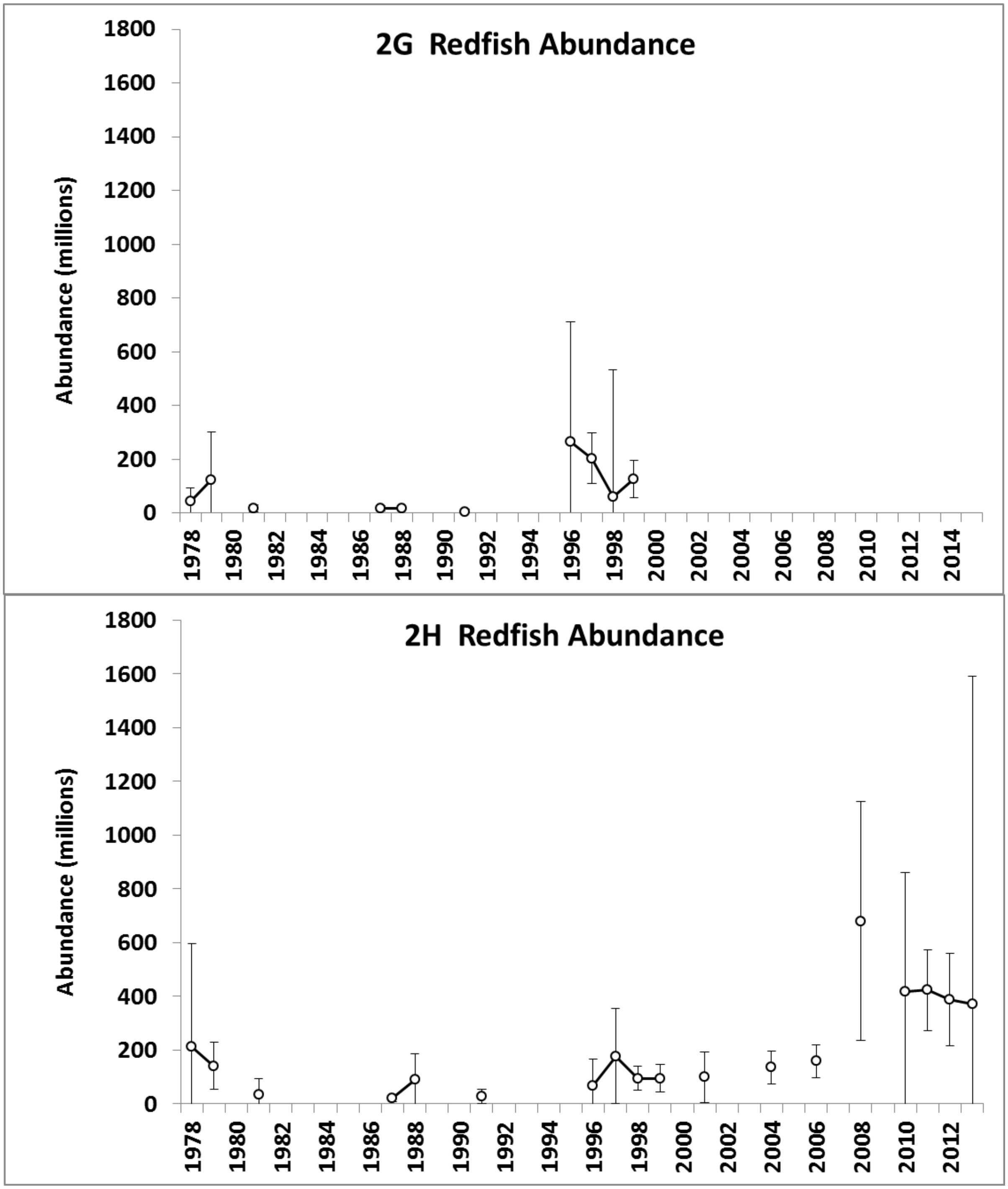


Figure 4. Abundance indices (millions) for Redfish in NAFO Divisions 2G and 2H from 1978 to 2013 (vertical lines represent 95% confidence intervals). Note that deep strata (>700 m) were not sampled in 2H in 2014 and 2015 (gaps represent years when the Division was not sampled).

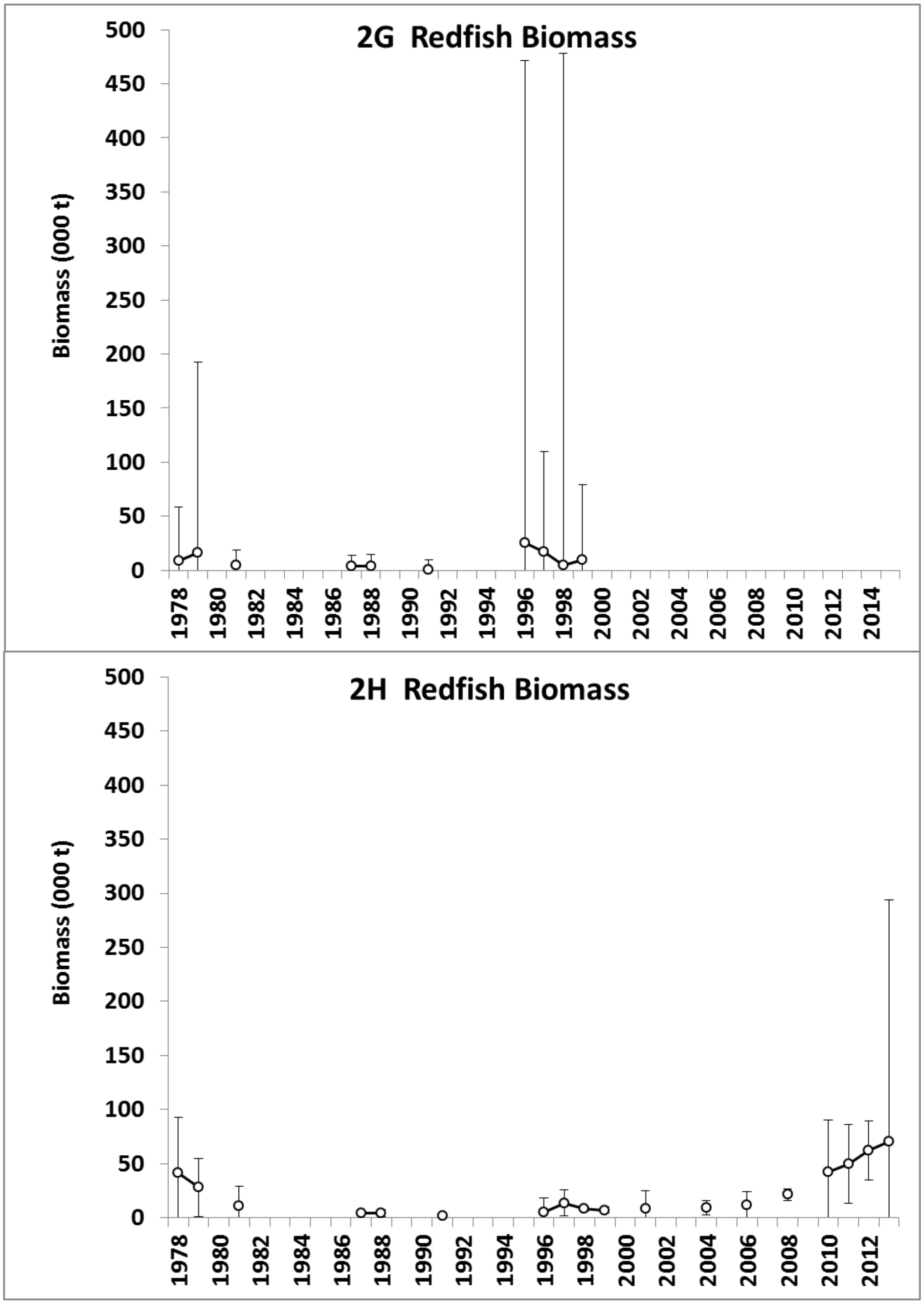


Figure 5. Biomass indices (000 t) for Redfish in NAFO Divisions 2G and 2H from 1978 to 2013 (vertical lines represent 95% confidence intervals). Note that deep strata (>700 m) were not sampled in 2H in 2014 and 2015 (gaps represent years when the Division was not sampled).

Abundance indices were relatively stable in Divs. 2H from 2010 to 2013 (Fig. 4). During this period, biomass values increased (Fig. 5) due to fish growth. In 2014 and 2015 the survey was incomplete as important areas for Redfish (depths >700 m) were not covered. Overall, both 2G and 2H represent a relatively small portion of the Redfish abundance and biomass within Divs. SA 2 + Divs. 3K.

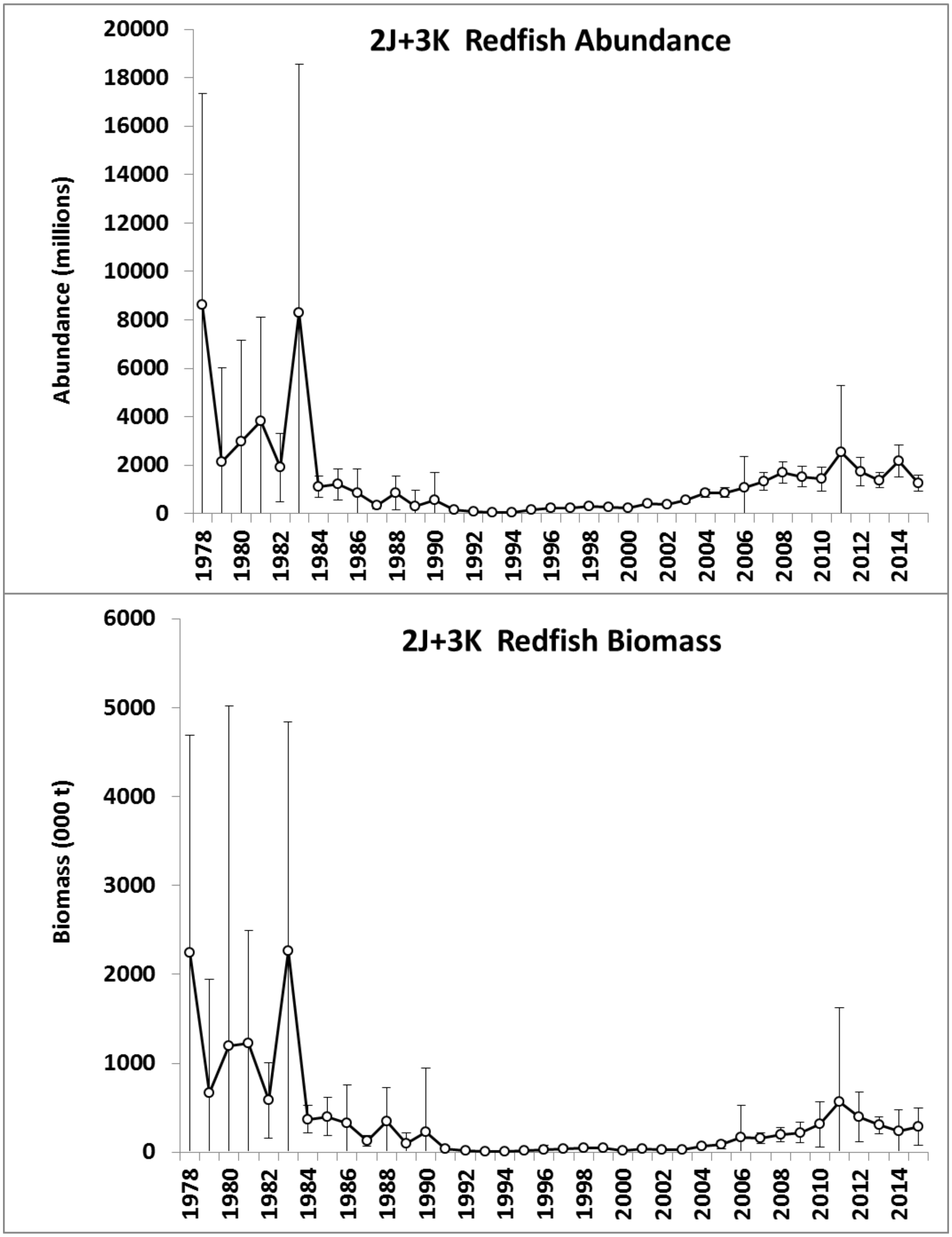


Figure 6. Abundance (millions) and biomass (000 t) indices for Divs2J3K Redfish from 1978 to 2015 (vertical lines represent 95% confidence intervals).

Abundance and biomass (Fig. 6) indices for Divs. 2J3K) were relatively high from 1978 to 1983, compared to the 1991 to 2003 collapse period. The biomass index increased by approximately a factor of 10 from 2003 to 2011. Biomass from 2011 to 2015 declined marginally but was relatively stable at approximately half of the pre-collapse (1978-1990) levels. Abundance values from 2011 to 2015 were also relatively stable at approximately 70% of pre-collapse levels. Generally, patterns were consistent between the abundance and biomass indices.

Mortality

A proxy for fishing mortality was calculated as the ratio of total landings (including discard estimates) in a given year to the RV survey biomass index from the previous year. This proxy was variable from the 1980s to the mid-2000s but since 2006, has been low (<1%) (Fig. 7).

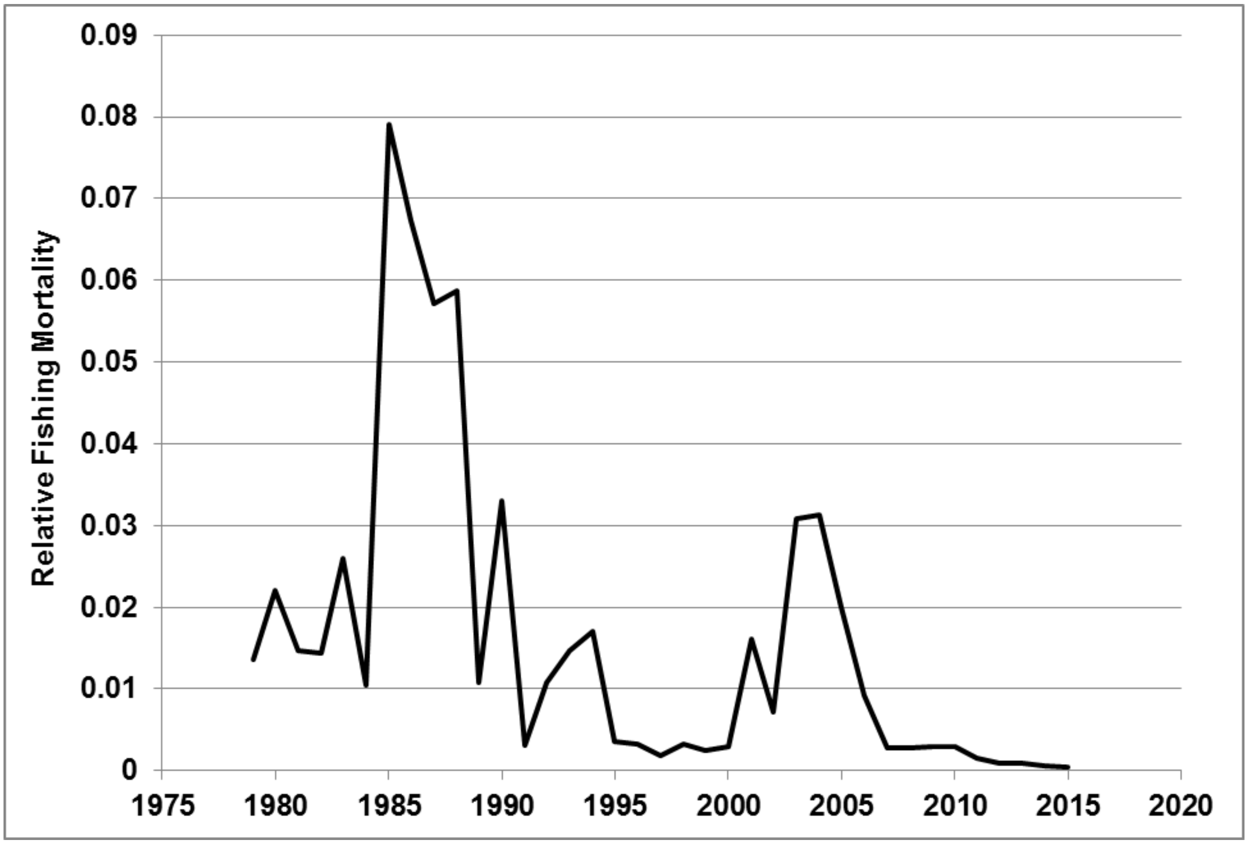


Figure 7. Proxy for Redfish fishing mortality from 1978 to 2015 in SA 2 + Divs. 3K calculated as the ratio of total landings in a given year to the survey biomass index in the previous year.

Recruitment

Length Composition

Although the Campelen trawl (1995 onward) samples small (<20 cm) Redfish more effectively than the Engel trawl, relatively few small Redfish were collected in annual sampling before 2001. From 2002 onward, one or multiple length modes were apparent in the length frequency distributions within Divs. 2H, 2J, and 3K. These modes persisted over time and some can be tracked over several years. However, few fish larger than 30 cm were sampled recently relative to the 1978 to 1983 period.

A strong length mode that first appeared in Divs. 3K during 2014 at 6 cm was apparent in both Divs. 2J and 3K at approximately 10 cm during 2015. Presently, it is unclear how these young fish will contribute to future fisheries. Previously, similar events have been observed in survey results, but modes were not tracked consistently over time.

Recruitment Index

A recruitment index, calculated as the abundance of Redfish less than 15 cm, was relatively low from 1979 to 2000 (Fig. 8). Since then, the recruitment index has generally been near or above the long term average with a time series high in 2014 (Fig. 8). As Redfish grow quite slowly, sequential index values are not independent and annual index values are comprised of multiple cohorts.

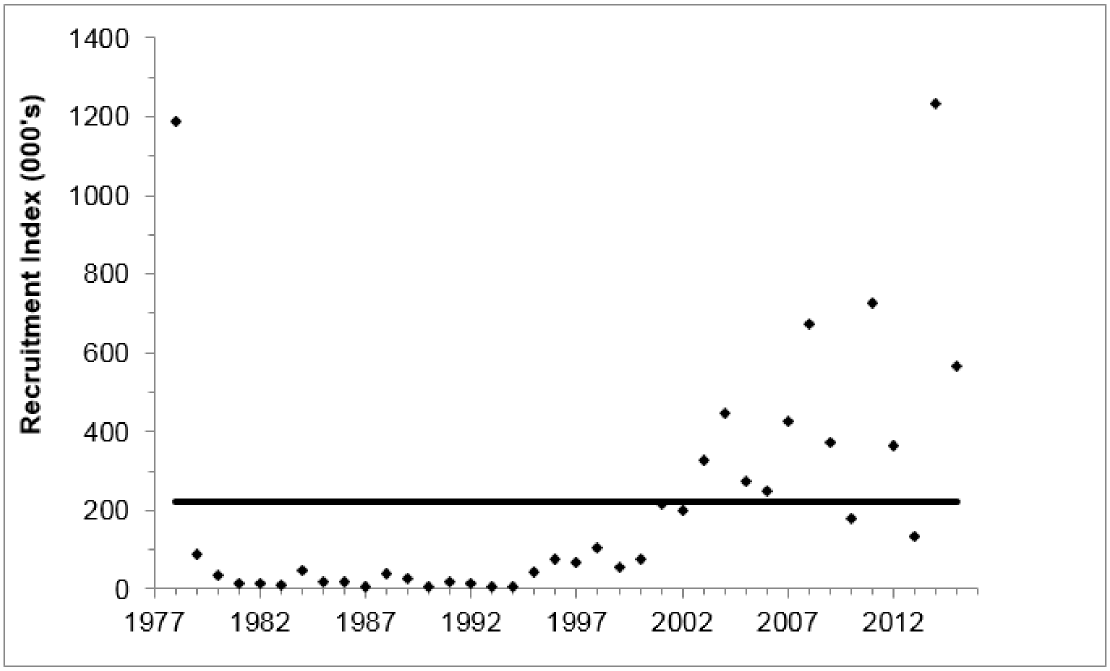


Figure 8. Recruitment index for Redfish in SA 2 + Divs. 3K based on total abundance estimates of Redfish less than 15 cm. The solid line indicates the time series average.

Reference Points

Models were developed through an external contract to explore LRPs for Redfish based on survey mature biomass (MacAllister and Duplisea 2011). Reference points for several Redfish stocks in the Northwest Atlantic were adopted by DFO based upon Bayesian production model results and various empirical methodologies (DFO 2012). This model was designed to investigate reference points but has not been applied directly to SA 2 + Divs. 3K stock assessments, nor has it been formally accepted for this purpose. Participants noted that assessments for Unit 1 and Unit 2 Redfish have discarded the production model. Prior to the current assessment of SA 2 + Divs. 3K Redfish, DFO received a critique of the existing production model and limit reference points for the stock from a former DFO Redfish biologist (GEAC [Atkinson, D.B. 2016] in Lee et al. in prep, Appendix 1[1]).

During the assessment plenary session it was agreed that there were substantive concerns about the input data and incomplete documentation of the rationale for model formulation.

[1] Lee, E., Ings, D. Mello, L., and R. Rideout. In prep. Stock status of Redfish (*Sebastes sp.*) in NAFO SA 2 + Div. 3K. Appendix 1 – GEAC (Atkinson D. B. 2016) An investigation of inputs to the analytical model used to determine stock status and limit reference points (LRP's) for Redfish (*Sebastes sp.*) in NAFO Subarea 2 + Division 3K. CSAS Res. Doc.

Specifically, the meeting recognized issues with separating the species in the survey and commercial catch data based on preliminary results from studies in the 1980s.

The assessment model for *S. mentella* was developed for the designatable unit spanning SA 2 + Divs. 3KLNO rather than just the SA 2 + Divs. 3K stock complex. This required apportioning biomass between Divs. 2J3K and Divs. 3LNO based on area of occupancy for the determination of LRPs. The meeting identified concerns with the validity of using this approach to delineate the critical/cautious and healthy zones for the SA 2 + Divs. 3K Redfish complex. The model built for *S. fasciatus* was specific to 2J3K. In both models, survey Q was allowed to vary across time blocks informed by Bayesian posteriors. Q shifts were incorporated to improve model fit, and were not based on gear changes. The need to sub-divide the survey series into multiple time periods to produce acceptable model fit caused concern as there is no *a priori* justification to support these groupings.

Length at maturity was based on empirical results from Unit 2 (Gulf of St. Lawrence/Southeastern NL). However, it is known that L_{max} increases in more northern populations; this may lead to overestimation of the spawning stock biomass if the L_{50} applied is less than the real L_{50}. Further, index-based LRPs using both $B_{Recovery}$ and B_{MSY} concepts were also presented to the meeting but were not accepted due to difficulties with respect to applying LRP concepts to Redfish, including its episodic recruitment, species separation and other data limitations.

Due to the incomplete documentation of model formulations, resource and data limitations, the existing model was not updated during the meeting nor were the previously calculated reference points accepted. Therefore, no LRP, including the previously established values (DFO 2012), was considered applicable at this time. In the absence of a LRP, it was not possible to identify which zone of the Precautionary Approach framework the stock is currently within.

Ecosystem

Physical Oceanographic Environment

The SA 2 + Divs. 3K region extends off northern Labrador to the eastern Newfoundland Shelf with bottom topography consisting of relatively shallow banks, deep cross-shelf channels and steep continental slopes. The ocean circulation is dominated by the southward-flowing Labrador Current which transports colder relatively fresh water from the north, as well as warmer saltier Labrador Sea water along the continental slope regions. Hydrographic conditions are determined in part by these and other factors, such as local winds and air temperatures. The main features of an analysis of historical climate data show mostly above average temperature conditions during the 1960s, a brief cold period during the early 1970s and again in the mid-1980s. Temperature conditions then declined to the coldest on record in the early 1990s and remained below normal until the mid-1990s. Since then there has been a significant warming trend with temperature values reaching record highs in the late 2000s. The most recent years, notably 2014 and 2015, experienced a short term decline but data available to date in 2016 indicates a return to a warming trend.

Invertebrate and fish community

The structure of the ecosystem within NAFO Divs. 2J and 3K has undergone significant changes since the mid-1990s. The entire fish community collapsed in the late 1980s and early 1990s, with average fish size also declining during this period. After the collapse, the system became highly dominated by shellfish, with peak dominance in 2003 when more than 60% of the estimated Fall RV biomass was shellfish. Consistent signals of rebuilding of the fish community appeared in the mid-to-late 2000s; this signal was also associated with an increase in average fish size. In the 2010s the overall biomass has remained relatively stable, but the dominance of groundfish has increased, while shellfish has decreased. Redfish is the dominant fish among plank-piscivores, having a three-fold increase in biomass between the mid-1990s and the 2010s.

Studies of diet composition of key groundfish species in Divs. 2J and 3K since 2008 indicate that Redfish is a frequent food item for Atlantic Cod and Greenland Halibut, and an occasional one for American Plaice. Despite its regular occurrence, Redfish does not appear as a dominant prey for these predators. However, long term diet data for Greenland Halibut indicate that Redfish represented up to 20% of its diet in the late 1980s, while available data from Divs. 2H shows up to a maximum of 30% of Redfish in the Greenland Halibut diet in 2010. Major diet changes in recent years involve the shift from shrimp to capelin as key prey item among fish top predators. As a predator, Redfish shows a variable diet composition between years, but amphipods, shrimp, myctophids, and euphausiids appear as consistently important prey items.

Sources of Uncertainty

Russian (2001-2015) and Lithuanian (2001-2015) catches assigned to Divs. 2J in the NAFO Statlant 21 database are fished outside the 200 mile limit and likely originate from the Irminger Sea pelagic stock (Power 2001). Subsequently, these values are omitted from the catch totals for SA 2 + Divs. 3K (2J + 3K) for the years 2001 to 2015. Prior to 2001, Russian and Lithuanian (and non-Canadian) catch are assumed to be primarily within the 200 mile limit and are included in the catch total. It is possible that a larger portion of non-Canadian catch currently assigned to SA 2 + Divs. 3K also originates within the Irminger Sea.

Redfish in SA 2 + Divs. 3K are composed of a mixture consisting primarily of *S. mentella*, lesser amounts of *S. fasciatus*, and sporadic occurrences of *S. marinus. S. mentella* and *S. fasciatus* are similar in appearance and are not separated in either the commercial or research survey catch. Despite their physical similarities the species have different depth and temperature preferences; changes in environmental conditions will not affect the three species equally, increasing the difficulty in interpreting survey indices changes in the stock complex.

Atlantic *Sebastes spp.* are known as episodically recruiting species where large year-classes may occur only once a decade or less frequently even in healthy populations.

Redfish survey catchability can vary significantly due to biological (formation of dense aggregations) or environmental (water temperature effects or depth range) reasons. This can result in inconsistent catch results within surveys, leading to high inter-annual variation at times. This is exacerbated by the combination of three species into a stock complex since the catchability of individual species can change independently in response to environmental changes.

Incomplete observer coverage of certain gear types, such as <50% coverage of trawl effort or <10% of gillnet effort, can introduce bias and/or uncertainty into analyses to determine Redfish bycatch and/or discards within commercial fisheries.

Lack of age information precludes certain types of analyses such as weight at age and cohort-based population modelling.

CONCLUSIONS AND ADVICE

Redfish biomass increased considerably from 2003-2010 with biomass during 2010-2015 reaching approximately half of the pre-collapse (1978-1990) levels. Recruitment (abundance of Redfish <15 cm) since 2000 was above the long term average with a time-series high in 2014. The fishery remains under moratorium, and average bycatch (including discards) since 2006 has been approximately 500 t. The meeting was neither able to validate nor invalidate existing reference points (DFO 2012) derived from production models due to substantive concerns about input data and an incomplete documentation of the rationale for model formulation.

In the absence of a LRP, it is not possible to identify what zone of the PA framework this stock is currently within. It is recommended that adaptive and cautious management be applied to any reopened fishery.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Darrell Mullowney (Chair)	DFO Science
Jim Meade (CSA Office)	DFO Science
Shelley Dwyer	NL Department of Forestry, Fisheries and Aquaculture
Monty Way	FFAW – Corner Brook
Dave Coffin	DFO-FAM
Brian Healey	DFO Science
Dawn Maddock Parsons	DFO Science
Danny Ings	DFO Science
Karen Dwyer	DFO Science
Dennis Slade	Icewater Seafoods
Joanne Morgan	DFO Science
Don Power	DFO Science
Joel Vigneau	IFREMER Science
Eugene Colbourne	DFO Science
John Brattey	DFO Science
Rick Rideout	DFO Science
Erin Carruthers	FFAW
Roland Hedderson	FFAW
Wayne Masters	Fish Harvester, Red Harbour
Jeff Roberts	Fish Harvester, Hermitage
Brian J. Careen	Fish Harvester, St. Bride's
Kris Vascotto	GEAC
Peter Shelton	DFO Science
Emilie Novaczek	MUN (rapporteur)
Margaret Warren	DFO-Science
Corina Busby	DFO Science-NHQ
Nadine Wells	DFO Science
Geoff Evans	DFO Science
Bob Verge	CCFI-MI
Kevin Hedges	DFO Science - C&A
Margaret Treble	DFO Science - C&A
Paul Regular	DFO-Science

SOURCES OF INFORMATION

This Science Advisory Report is from the October 19-21, 2016 Assessments of Redfish in Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, Subarea 2 and Division 3K. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule]() as they become available.

DFO 2011. Recovery potential assessment of Redfish (*Sebastes fasciatus* and *S. mentella*) in the Northwest Atlantic. DFO Can Sci. Advis. Sec. Advis. Rep. 2011/044.

DFO 2012. Reference points for Redfish (*Sebastes fasciatus*, *S. mentella*) in the Northwest Atlantic. DFO Can Sci. Advis. Sec. Advis. Rep. 2012/004.

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Valentin, A., Power, D., and J.-M. Sévigny. 2015. Understanding recruitment patterns of historically strong juvenile year classes in Redfish (*Sebastes* spp.): the importance of species identity, population structure, and juvenile migration. Can. J. Fish. Aquat. Sci. 72: 774-784.

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Telephone: (709) 772-8892
E-Mail: DFONLCentreforScienceAdvice@dfo-mpo.gc.ca
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Aussi disponible en français :

MPO. 2020. État des stocks de sébaste dans la sous-division 2 et la division 3K de l'OPANO. Secr. can. de consult. sci. du MPO, Avis sci. Rép. 2020/021.

APPENDIX 5

Retroactive Analysis

Redfish Bycatch in the Northern ShrimpFishery

Prepared for:

CAPP
Bruce Chapman

Prepared by:

Pisces Consulting Limited
(902) 497-4134
pisces@ns.sympatico.ca
PiscesConsult.ca

August 12, 2021

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1. BACKGROUND

CAPP, and other northern shrimp harvesting groups, commenced having independent monitoring of redfish bycatch in the northern shrimp fishery in December 2020. Until late July detailed information regarding various grid sizes, angles and styles was collected and reviewed by the MI. The objective ofthis phase of the study was to determine the relationship, if any, between shrimp capture and bycatch capture using various gear configurations.

Commencing late July 2021, a simplified data collection method has been adopted by the vessels operators and observer companies, both of which provided information independently to the MI. Analysis of detailed data was inconclusive on either a spatial of temporal basis, though further analysis may be completed. Ongoing data analysis will be completed by Pisces Consulting Limited using the simplified reporting format that focuses almost exclusively on redfish bycatch for specified time periods

Data collection and analysis completed to date was transferred to Pisces in order to continue the data set until the beginning of the new contract period with Pisces. This data and analysis was reviewed and found to be quite comprehensive, though the methodology to determine the period bycatch percentages was questionable[1]. Given the potential for this questionable method to misrepresent the results, a retrospective analysis was completed. Review of line data indicates a moderate number of reporting errors and numerous data omissions (no catches reported). These errors and omissions were removed from the data set if they could not be verified from independent observer source documents.

The data limitations are that the entire data set is based on reported results, and there are likely some limited reporting omissions. For future reporting the reporting for each week will be quantified by comparing observer reports to the vessel reports. Missing vessel reports will be solicited to ensure a complete data set going forward.

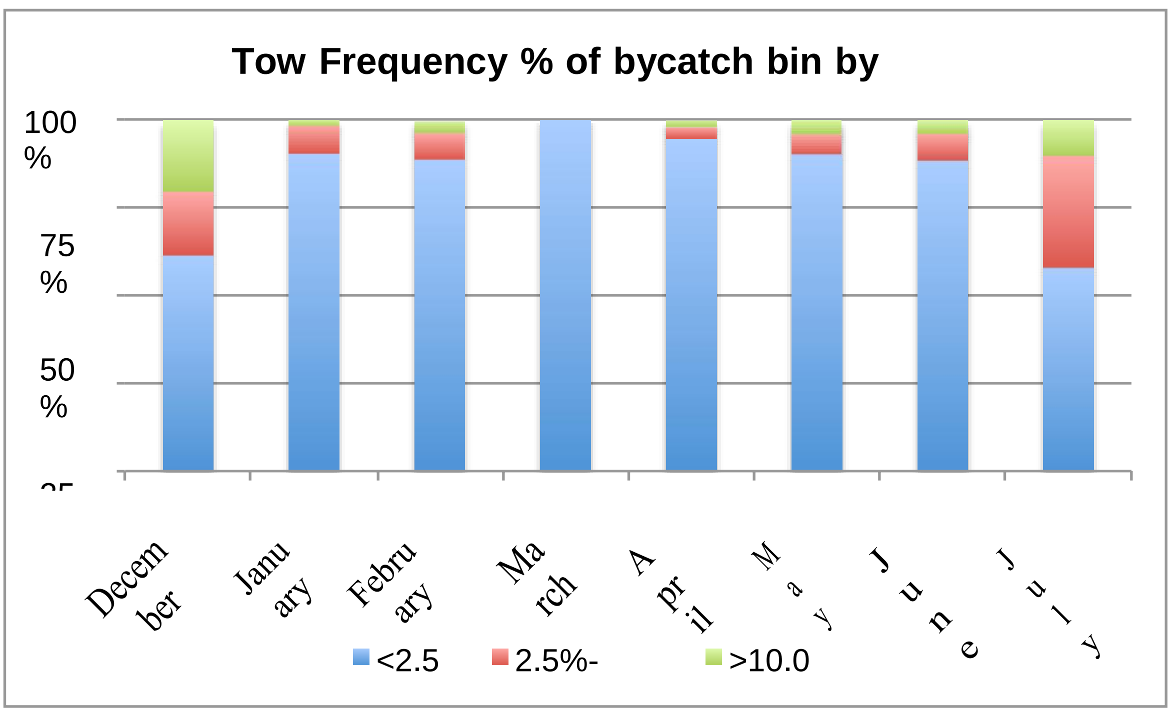
[1] The period bycatch percent was a straight average of the individual tow bycatch percent rather than a weighted average.

2.0SUMMARY RESULT

Results by month: The data set results indicate 19,132mt of shrimp were captured with 318mtof redfish bycatch. The months on highest encounters were December and July.

Month	Shrimp (kg)	Redfish (kg)	Redfish	Tow Frequency <2.5%	2.5%-10.0%	>10.0%
December	1,819,807	92,358	5.1%	213	63	71
January	3,546,167	39,707	1.1%	432	38	8
February	1,502,107	21,300	1.4%	188	16	8
March	804,573	1,398	0.2%	72	0	0
April	2,286,706	13,825	0.6%	231	8	5
May	3,316,328	45,640	1.4%	415	26	19
June	3,963,109	48,496	1.2%	464	40	21
July	1,893,360	56,227	3.0%	147	81	26
Total YTD	**19,132,157**	**318,951**	**1.7%**	**2,162**	**272**	**158**

Management measures have permitted various redfish bycatch allowances (2.5%, 10.0%). The following graph illustrates the tow frequency of when these bin thresholds occurred.



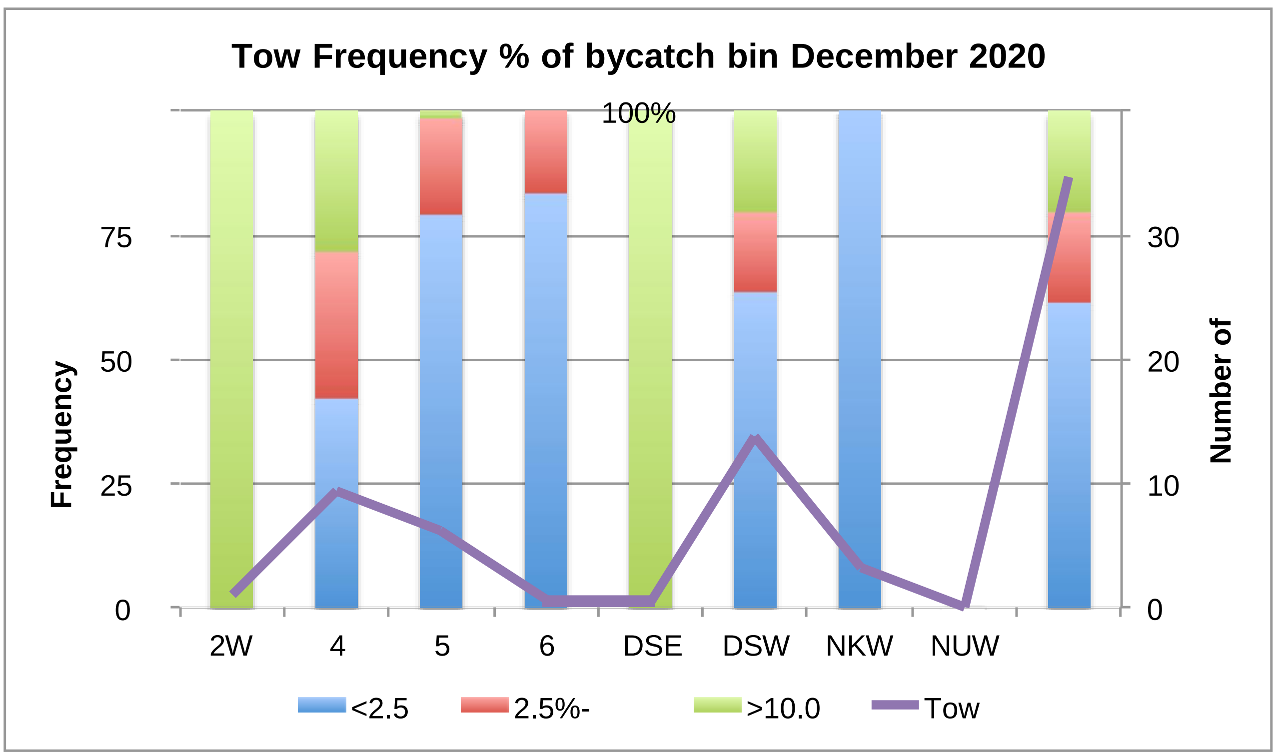
The monthly results by area are provided in the following table. Further examination of effort and bycatch levels by month are provided in Section 3.0.

Area	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
2W	535.5%							
4	6.5%	2.5%	6.2%	0.0%	0.0%	1.8%	0.9%	1.8%
5	1.9%	1.0%	0.6%	0.2%	0.8%	0.9%	1.3%	2.3%
6	0.9%	0.3%	0.3%	0.1%	0.1%	0.0%		
DSE	2002.0%						96.6%	0.0%
DSW	8.4%					1.5%	5.0%	7.8%
NKW	0.1%						1.1%	0.0%
NUW							0.3%	0.0%
Total	**5.1%**	**1.1%**	**1.4%**	**0.2%**	**0.6%**	**1.4%**	**1.2%**	**3.0%**

3.0MONTHLY RESULTS BY AREA

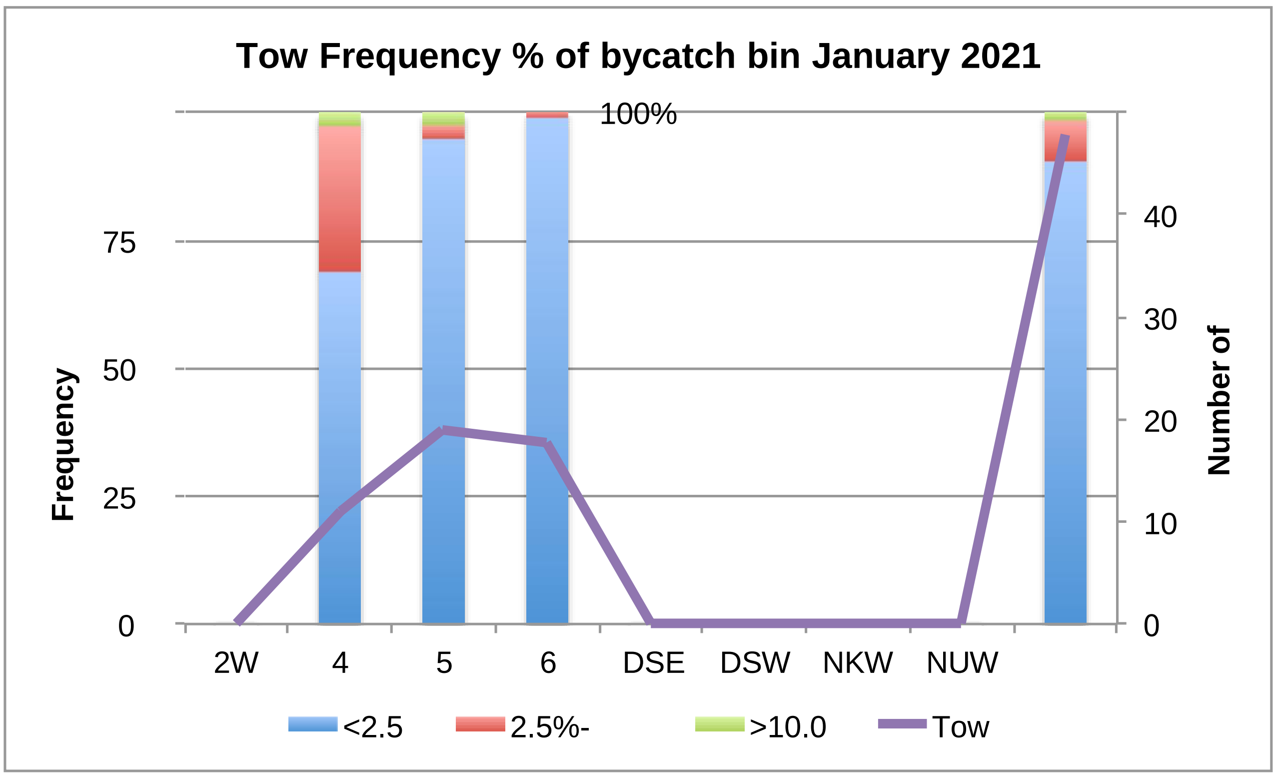
December 2020

Area	Shrimp (kg)	Redfish (kg)	Redfish %	Tow Frequency <2.5%	2.5%-10.0%	>10.0%
2W	453	2,426	535.5%	0	0	10
4	642,694	41,562	6.5%	40	28	27
5	331,792	6,468	1.9%	49	12	1
6	19,766	180	0.9%	5	1	0
DSE	252	5,045	2002.0%	0	0	5
DSW	430,750	36,268	8.4%	87	22	28
NKW	394,100	409	0.1%	32	0	0
NUW						
Total	**1,819,807**	**92,358**	**5.1%**	**213**	**63**	**71**



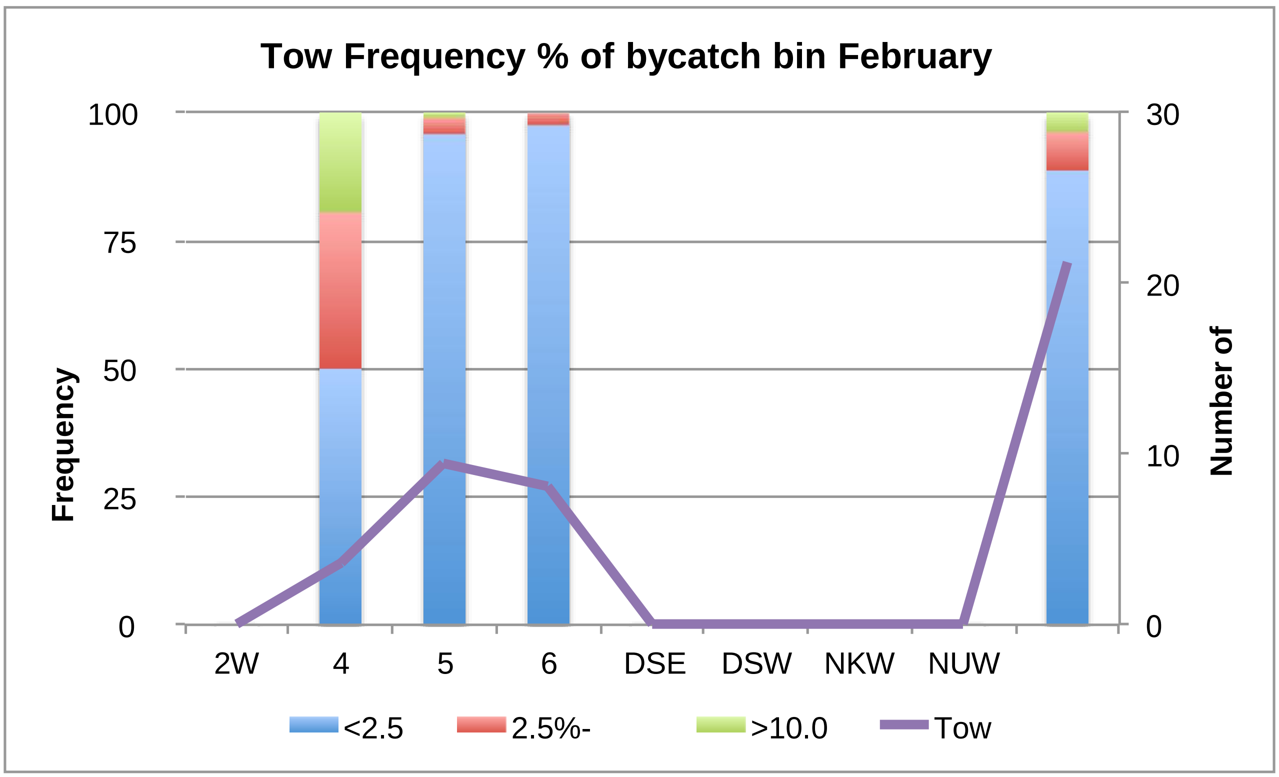
January

Area	Shrimp (kg)	Redfish (kg)	Redfish %	Tow Frequency <2.5%	2.5%-10.0%	>10.0%
2W						
4	823,340	20,416	2.5%	75	31	3
5	1,569,369	15,273	1.0%	181	5	5
6	1,153,458	4,018	0.3%	176	2	0
DSE						
DSW						
NKW						
NUW						
Total	**3,546,167**	**39,707**	**1.1%**	**432**	**38**	**8**



February

Area	Shrimp (kg)	Redfish (kg)	Redfish %	Tow Frequency <2.5%	2.5%-10.0%	>10.0%
2W						
4	250,049	15,403	6.2%	18	11	7
5	672,900	3,880	0.6%	91	3	1
6	579,158	2,017	0.3%	79	2	0
DSE						
DSW						
NKW						
NUW						
Total	**1,502,107**	**21,300**	**1.4%**	**188**	**16**	**8**

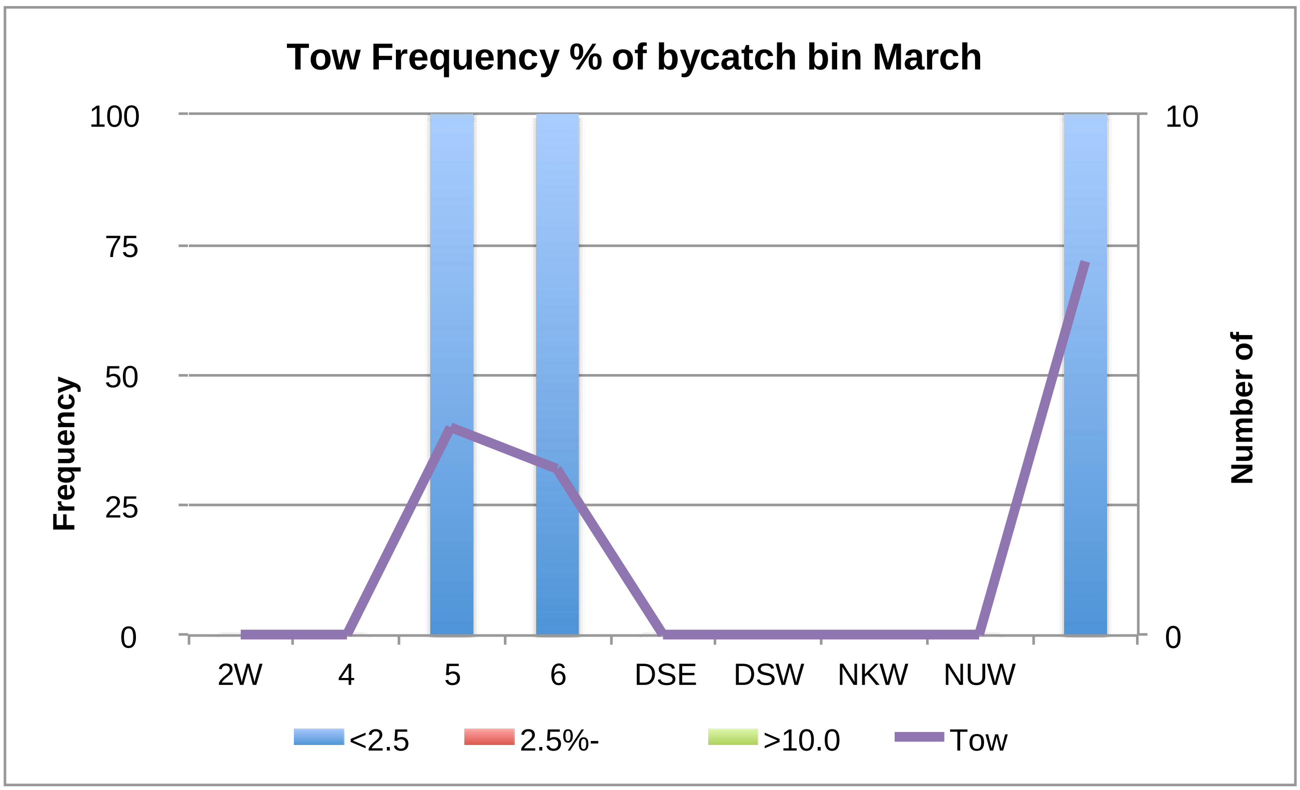


March

4						
5	523,250	1,194	0.2%	40	0	0
6	281,323	204	0.1%	32	0	0
DSE						
DSW						
NKW						
NUW						
	Total 804,573	**1,398**	**0.2%**	**72**	**0**	**0**

March

Are	Shrimp (kg)	Redfish (kg)	Redfish	Tow Frequency		
				<2.5%	2.5%-10.0	>10.0
2W						

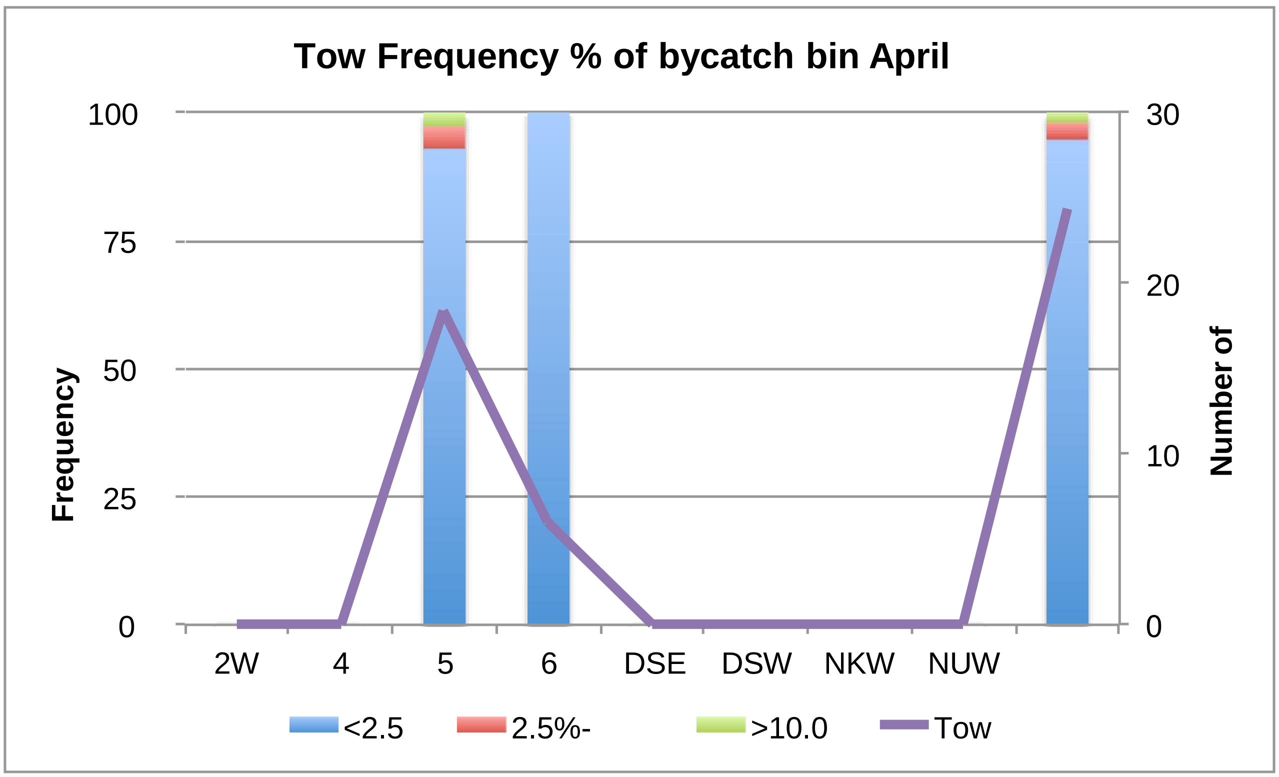


April

4						
5	1,658,582	13,011	0.8%	171	8	5
6	628,124	814	0.1%	60	0	0
DSE						
DSW						
NKW						
NUW						
	Total 2,286,706	**13,825**	**0.6%**	**231**	**8**	**5**

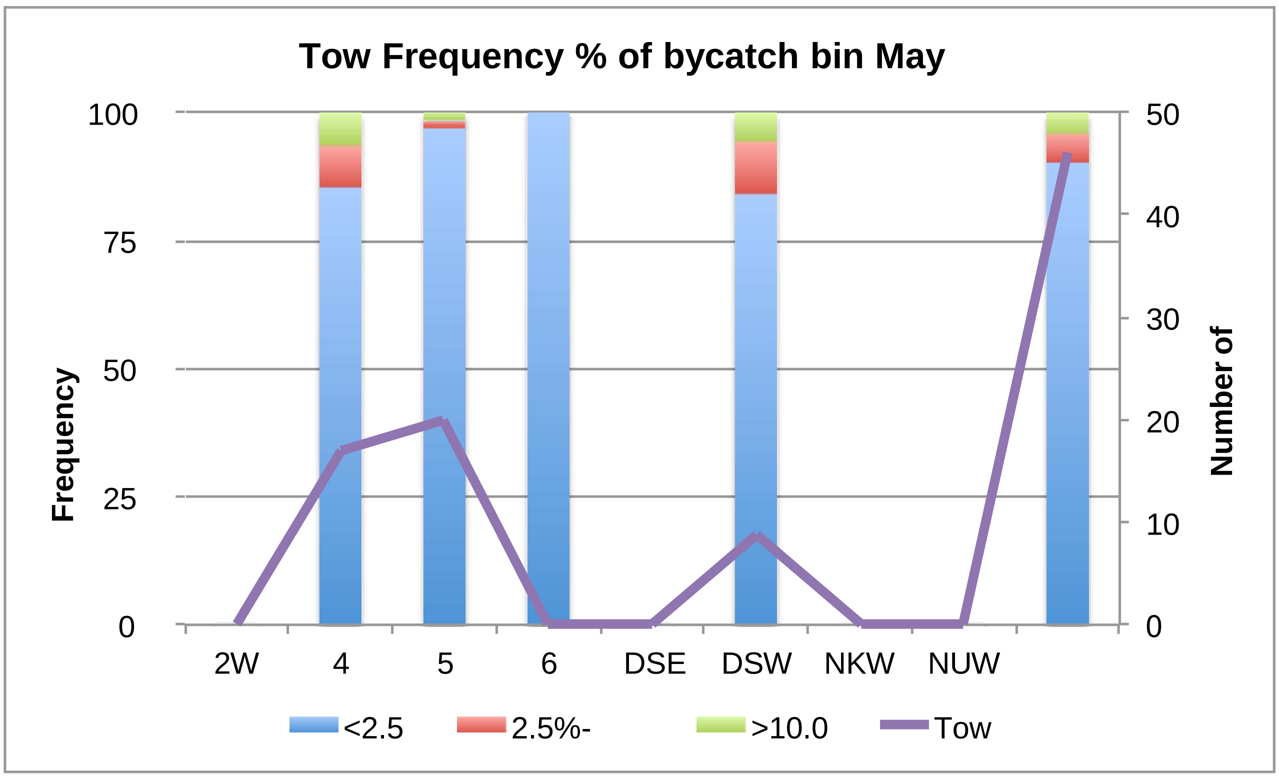
April

Are	Shrimp (kg)	Redfish (kg)	Redfish	Tow Frequency <2.5%	2.5%- 10.0	>10.0
2W						



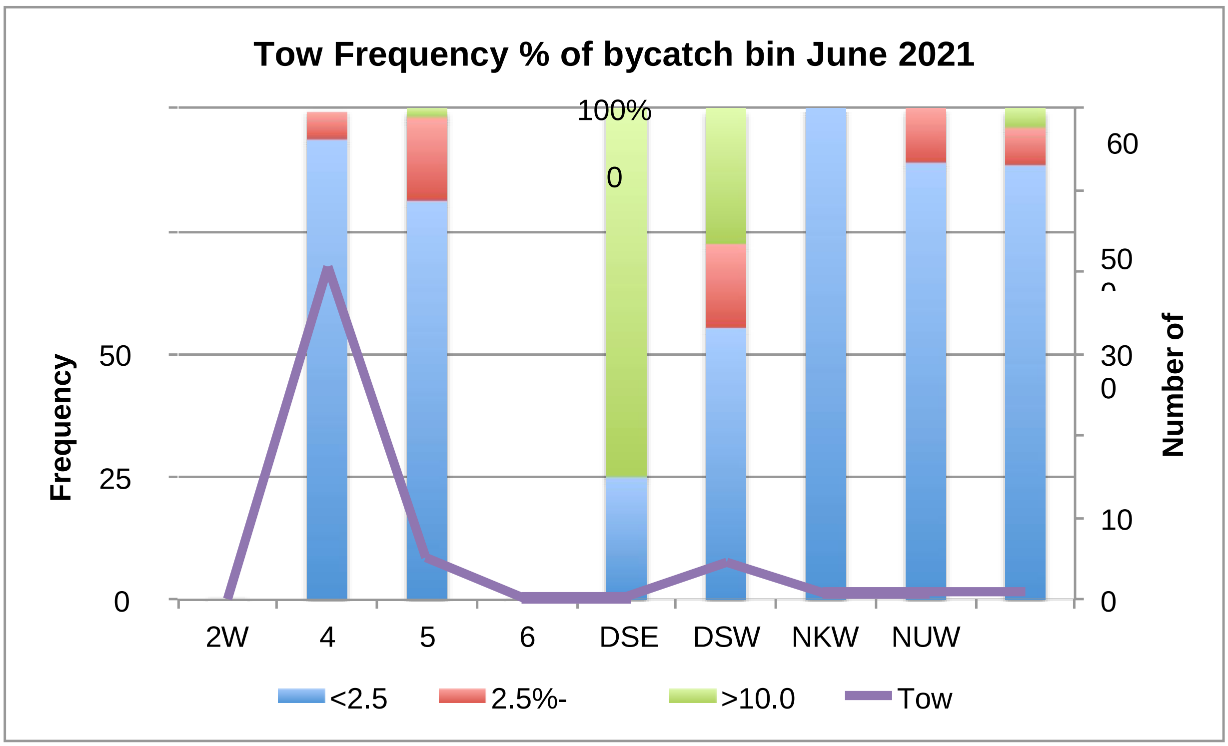
May

Area	Shrimp (kg)	Redfish (kg)	Redfish %	Tow Frequency <2.5%	2.5%-10.0%	>10.0%
2W						
4	1,352,628	24,749	1.8%	146	14	11
5	1,438,228	13,337	0.9%	194	3	3
6	5,020	1	0.0%	1	0	0
DSE						
DSW	520,452	7,553	1.5%	74	9	5
NKW						
NUW						
Total	**3,316,328**	**45,640**	**1.4%**	**415**	**26**	**19**



June

Area	Shrimp (kg)	Redfish (kg)	Redfish %	Tow Frequency <2.5%	2.5%-10.0%	>10.0%
2W						
4	3,248,266	29,872	0.9%	380	22	4
5	366,341	4,754	1.3%	43	9	1
6						
DSE	580	560	96.6%	1	0	3
DSW	257,279	12,800	5.0%	26	8	13
NKW	31,615	350	1.1%	6	0	0
NUW	59,028	160	0.3%	8	1	0
Total	**3,963,109**	**48,496**	**1.2%**	**464**	**40**	**21**



Are	Shrimp (kg)	Redfish (kg)	Redfish	Tow Frequency <2.5%	2.5%-10.0	>10.0
2W						
4	673,933	11,887	1.8%	73	13	4
5	925,809	21,469	2.3%	46	52	1
6						
DSE						
DSW	293,618	22,871	7.8%	28	16	21
NKW						
NUW						
	Total 1,893,36 0	56,227	3.0%	147	81	26