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Newfoundland and Labrador, Maritimes, Gulf, Quebec, Central and Arctic Regions

Canadian Science Advisory Secretariat
Science Advisory Report 2021/019

RECOVERY POTENTIAL ASSESSMENT FOR COMMON LUMPFISH (*CYCLOPTERUS LUMPUS*) IN CANADIAN WATERS

*Common Lumpfish (*Cyclopterus lumpus*). Photo provided by C. Nozères (Quebec Region).*

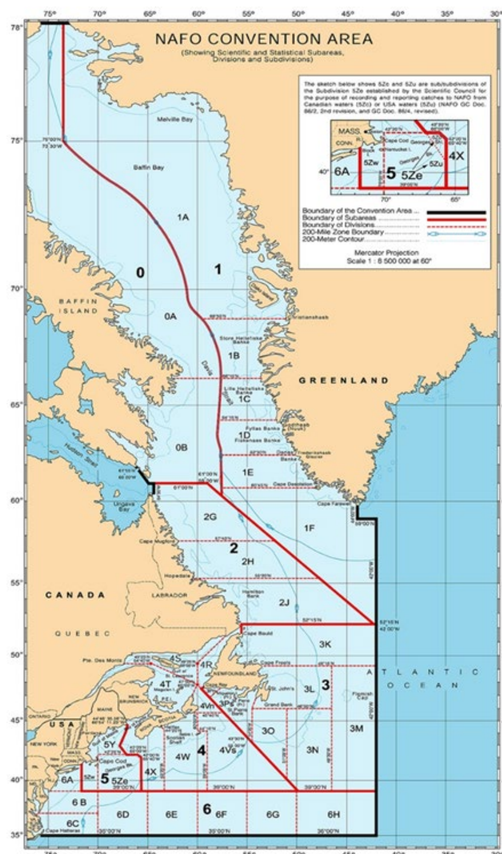

Figure 1. Map of Canadian Atlantic and Arctic waters. Canada's Exclusive Economic Zone is delineated by the thin blue line (emphasized with fish outlines), Northwest Atlantic Fisheries Organization (NAFO) Subareas by thick red lines, NAFO Divisions by dashed red lines, and a 200-meter contour by the blue dashed line.

Context:

*The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) conducted its first assessment of Common Lumpfish (*Cyclopterus lumpus*) in Canadian waters in 2017, and designated the species as Threatened, due to severe declines in abundance/biomass indices in bottom trawl surveys over approximately two decades, in addition to sharp declines in commercial landings.*

May 2021

When a species is assessed as Threatened or Endangered by COSEWIC, Fisheries and Oceans Canada (DFO) undertakes a number of actions required to support implementation of the Species at Risk Act (SARA). Many of these actions require scientific information on the current status of the wildlife species, threats to its survival and recovery, and the feasibility of recovery and this advice has typically been developed through a Recovery Potential Assessment (RPA). In support of listing recommendations for Common Lumpfish by the Minister, DFO Science was asked to undertake a RPA, based on the National RPA Guidance. Advice in the RPA may be used to inform both scientific and socio-economic aspects of the listing decision, development of a recovery strategy and action plan, and to support decision-making regarding issuance of permits or agreements, and formulation of exemptions and related conditions, as per sections 73, 74, 75, 77, 78, and 83(4) of SARA. Advice in the RPA may also be used to prepare for the reporting requirements of SARA s.46 and s.55. Advice generated through this process will update and consolidate any existing advice regarding Common Lumpfish in Canadian waters.

This Science Advisory Report is from the March 12-13, 2019 Zonal Peer Review meeting for the Recovery Potential Assessment – Lumpfish, Atlantic Ocean. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

Biology, Abundance, Distribution and Life History Parameters

- Common Lumpfish *(Cyclopterus lumpus)* is a broadly-distributed, sexually dimorphic globiform teleost fish, ranging in Canadian waters from the Davis Strait to Georges Bank and the Gulf of St. Lawrence (including the Estuary).
- Common Lumpfish are often found both demersally and pelagically in both inshore and offshore waters. They are known for undertaking extensive inshore migrations in the spring to reproduce on rocky bottoms in coastal areas. They also undertake diurnal movements in the water column.
- Abundance and biomass indices for Subdiv. 3Ps (spring survey) and Div. 2J3KL (fall survey) have declined precipitously since the mid-2000s and remain low; these indices are considered to reflect stock status. No discernible trends are present in Div. 4RST, Div. 4VWX5YZ, or Div. 0AB.
- In Canadian waters, most aspects of the species' life history are poorly understood.

Habitat and Residence Requirements

- Common Lumpfish mating/nesting sites would constitute residences which support reproduction, as they are modified by the males and occupied by both adults and eggs/larvae. These inshore sites are typically rocky, structurally complex, and associated with macroalgae.
- It is unknown what specific habitat features are required for successful completion of all life history stages, but Common Lumpfish, especially young individuals, are often associated with eelgrass and a variety of macroalgae in inshore waters.
- Detailed information on the spatial extent and availability of suitable Common Lumpfish habitat is not available, but it is not believed that habitat is limiting for this species.

- There is no evidence of any spatial configuration constraints, as distribution in Canada is continuous and movement is not believed to be limited by physical or oceanographic barriers.

Threats and Limiting Factors to Survival and Recovery of Lumpfish

- The only quantified anthropogenic threat to recovery of Common Lumpfish is fishing mortality from directed commercial fisheries and, to a lesser extent, bycatch (retained/landed and/or discarded) in commercial fisheries directing for other species.
- Other potential anthropogenic threats exist, such as climate change, oil and gas activities, invasive species, infectious agents, aquaculture, coastal development, and pollution.
- Anthropogenic activities that negatively impact benthic nearshore environments suitable for Common Lumpfish nesting and nursery sites could jeopardize survival and recovery of the species. It is not possible to quantify the extent or impact of these activities at present.
- Survival and recovery of Common Lumpfish may be limited by naturally occurring climate and weather events, as well as interspecific interactions such as predation, and infection by parasitic, viral, or bacterial agents. The impact of these factors cannot be estimated or quantified at present.
- The only quantified threat is fishing and a reduction in fishing mortality would reduce harm to this species and co-occurring species. Comprehensive fisheries-dependent and independent monitoring programs have been lacking for this species.

Recovery Targets

- Candidate distribution recovery target for this Designatable Unit (DU) is to increase the distribution to historic levels in NAFO Subdiv. 3Ps and Div. 3KL, and to maintain the current distribution throughout the other areas (e.g., Div. 4RST3Pn; Div. 4VWX5YZ; SA 0).
- The candidate biomass recovery target is 15,831 t, the Upper Stock Reference (USR) level as estimated from the combined survey indices in Subdiv. 3Ps and Div. 3KL. The short-term/medium-term recovery target is to be above the candidate Limit Reference Point ([LRP] 7,915 t). Current biomass is estimated to be 50% of the LRP.
- Due to the lack of a quantitative model, the population trajectories could not be estimated.
- Sufficient suitable habitat is thought to be available to meet the demands of the species both at present and when it reaches the proposed recovery target.
- Current levels of fishing mortality are not thought to jeopardize survival. However, a decrease in fishing mortality may be required to achieve recovery targets.

Allowable Harm

- The reduction of fishing mortality and mitigation of impacts to nesting and nursery habitat can be achieved through a variety of fisheries management and habitat protection measures.

INTRODUCTION

Common Lumpfish (*Cyclopterus lumpus*) is a broadly-distributed, sexually dimorphic globiform teleost fish, ranging in Canadian waters from the Davis Strait to Georges Bank and the Gulf of St. Lawrence, including the Estuary. This species is also found in Hudson and James Bays, and Foxe Basin. It is often found both demersally and pelagically in both inshore and offshore waters, and is known for undertaking extensive inshore migrations in the spring to reproduce on rocky bottoms in coastal areas. It also undertakes diurnal movements in the water column.

In Atlantic Canadian waters, the Common Lumpfish-directed fishery targets females exclusively, which are harvested to collect unfertilized eggs (roe) that are marketed as caviar. The Canadian Common Lumpfish roe fishery exists in Div. 3KL, Div. 3P, and Div. 4RS (Fig. 1). This fishery occurs in shallow coastal waters for a few weeks between April and July, and is conducted primarily by small vessels (i.e., those <35 feet in length) using gillnets. This roe fishery is highly dependent on market conditions. No directed commercial fishery for this species exists in Div. 4TVWX5YZ or in Subarea 0 (Fig. 1).

COSEWIC conducted its first assessment of Common Lumpfish in Canadian waters in 2017, and designated the species as Threatened, due to a severe decline in abundance/biomass indices in bottom trawl surveys over 19-20 years, as well as sharp declines in commercial landings (COSEWIC 2017).

ASSESSMENT

Abundance/Biomass Indices and Distribution

The primary sources of data regarding abundance, biomass and distribution of Common Lumpfish are the DFO research surveys conducted in the regions of interest – Newfoundland and Labrador (NL), Quebec (QC), Gulf, Maritimes (MAR), and Central and Arctic (C&A). These research surveys employed a stratified random design based on depth intervals and location (latitude, longitude), and were designed to provide information on abundance, distribution, and area occupied by numerous demersal and benthic fish, as well as several invertebrate species. Survey abundance and biomass indices for Common Lumpfish were expressed as mean number per standard tow and mean weight (in kg) per standard tow. The timing and type of trawl gear used varied between regions, and across time, making it difficult to infer spatial and temporal trends in some instances.

It is important to note that Common Lumpfish are semi-pelagic during part of their annual cycle, so their catchability in bottom trawls remains unknown, and may vary seasonally. This should be considered when evaluating abundance/biomass estimates or changes in distribution.

DFO-NL (NAFO Div. 2GHJ3KLNO and Subdiv. 3Ps)

Data were obtained during DFO-NL multi-species bottom trawl surveys conducted over the continental shelves of Newfoundland and Labrador, in Div. 3LNOP in winter/spring (1971-2018) and in Div. 2GHJ3KLNO in fall (1977-2017), including areas beyond the Canadian Exclusive Economic Zone ([EEZ] Fig. 1). It should be noted that, due to different trawls being deployed during the spring (Yankee 41.5 in 1971-83; Engel 145 in 1984-95; and Campelen 1800 in 1996-2018) and fall (Engel 145 in 1977-94; Campelen 1800 in 1995-2017) surveys, combined with a lack of conversion factors to account for differences in Common Lumpfish catchability due to these gear changes, the resultant survey time series are not directly comparable. In addition, fall surveys reach deeper maximum depths (~1,400 m) than those in spring (~750 m).

DFO-NL abundance and biomass indices were calculated for spring (Div. 3LNOP) and fall (Div. 2J3KLNO) surveys. The vast majority of Common Lumpfish catches during the spring research survey occur in Subdiv. 3Ps. Since 1996, all 3Ps surveys have used the Campelen trawl exclusively. Abundance and biomass indices for the period 1996-2008 (excluding the incomplete 2006) averaged 1.32 fish/tow and 2.65 kg/tow, respectively; for 2009-2018, they averaged 0.10 fish/tow and 0.15 kg/tow (Fig. 2).

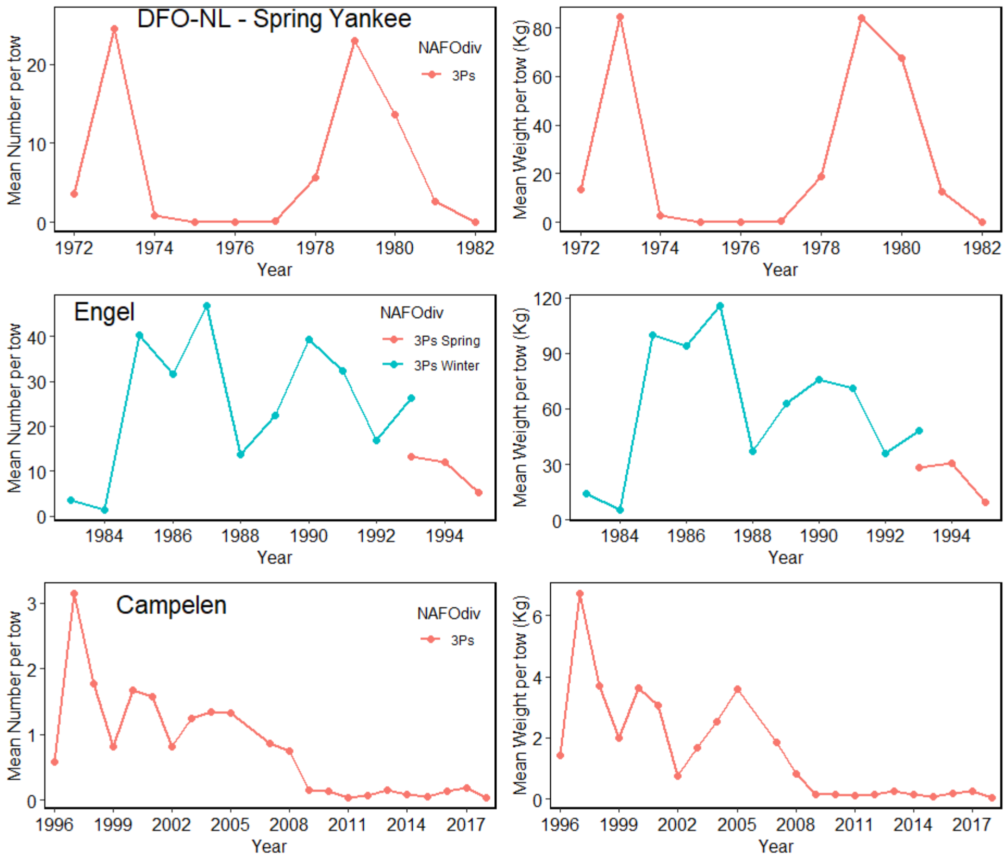

Figure 2. Mean numbers (left panels) and mean weights (kg; right panels) per tow of Common Lumpfish from DFO-NL spring research surveys in Subdiv. 3Ps, 1972-2018 (excluding 2006). Note that Yankee, Engel, and Campelen data are not comparable, and that scales differ dramatically across the series

Over 1996-2009, spring abundance and biomass indices for Div. 3LNO (which is characterized by relatively few catches of Lumpfish) varied without trend, averaging 0.025 fish/tow and 0.056 kg/tow. Both indices declined after 2009, and have since remained near zero. Average abundance from 2010-2018 was 0.001 fish/tow; average biomass for the same period was 0.002 kg/tow (Fig. 3).

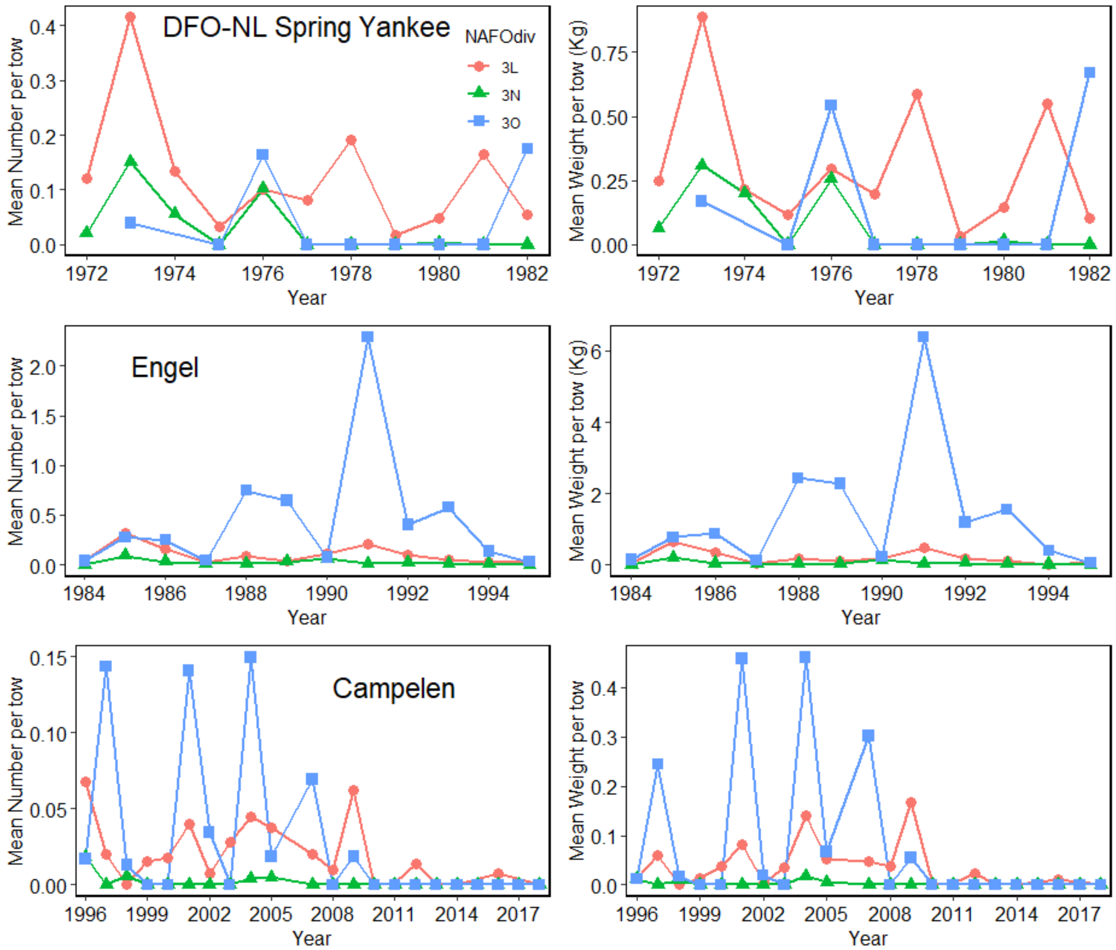

Figure 3. Mean numbers (left panels) and mean weights (kg; right panels) per tow of Common Lumpfish from DFO-NL spring research surveys in Div. 3LNO, 1972-2018. Note that Yankee, Engel, and Campelen data are not comparable, and that scales differ dramatically across the series.

Fall abundance and biomass indices for Common Lumpfish in Div. 2J3KLNO (1977-1994; Engel trawl) varied considerably over time (Fig. 4), due in part to expansion of survey coverage (Div. 3L was added in 1983 and Div. 3NO in 1990; 3L was sampled with the Yankee trawl in 1981-82 but has been excluded). From 1995 (with the introduction of the Campelen trawl) to 2007, abundance and biomass indices averaged 0.45 fish/tow and 0.86 kg/tow, respectively, but have since declined; from 2008 to 2017, they averaged 0.13 fish/tow and 0.26 kg/tow, respectively.

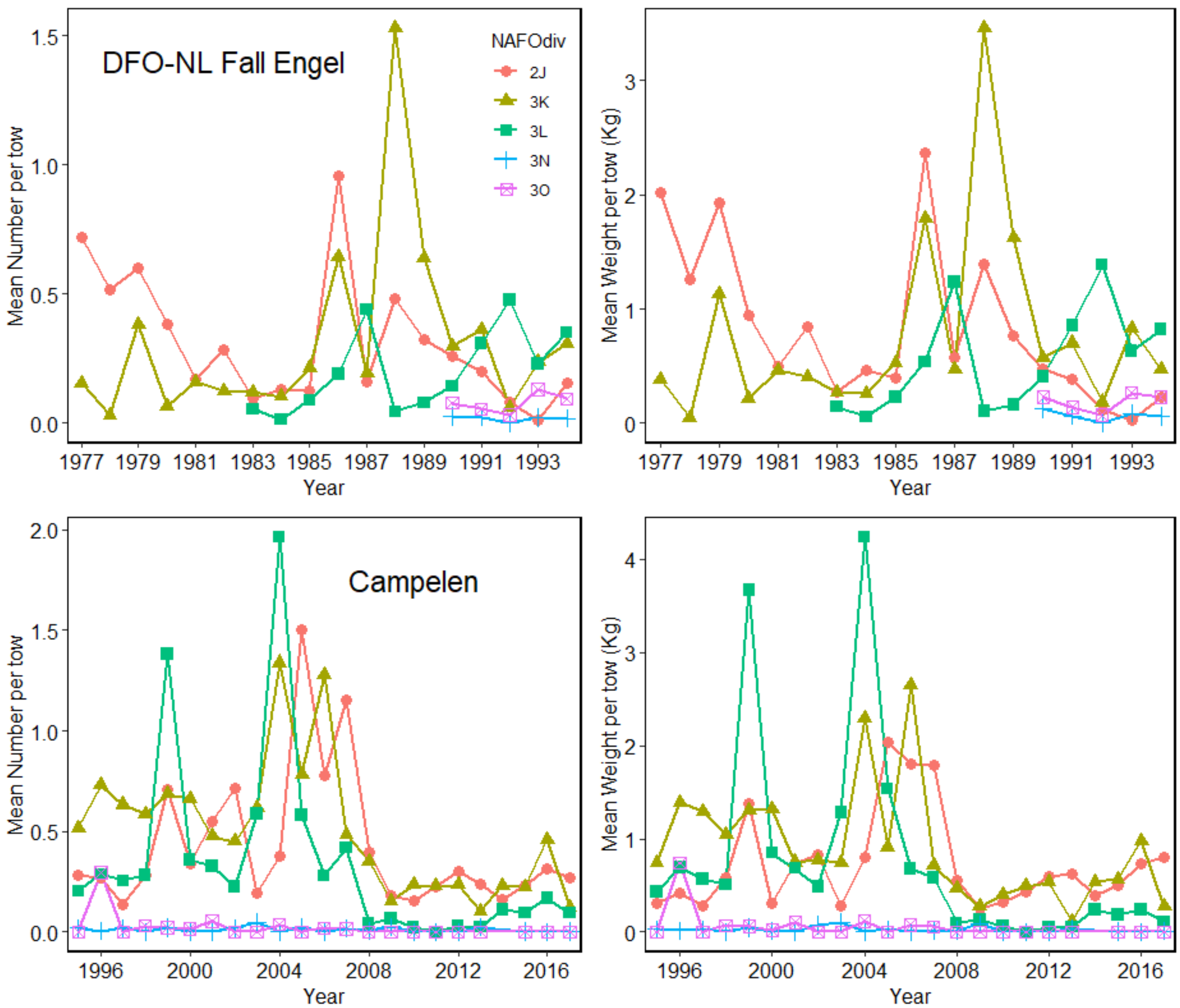

Figure 4. Mean numbers (left panels) and mean weights (kg; right panels) per tow of Common Lumpfish from DFO-NL fall research surveys in Div. 2J3KLNO, 1977-2017. Note that Engel and Campelen data are not comparable.

Point maps of DFO-NL standardized catch rates from spring 2014-2018 and fall 2014-2017 research surveys indicated that Common Lumpfish distribution varied inter-annually (Simpson et al. in prep[1]). This variability may represent seasonal changes related to inshore spawning migrations in spring. Point maps for previous survey years can be found in Simpson et al. (2016).

In addition to DFO-NL research vessel survey data, inshore Common Lumpfish catches/observations from a DFO long-term monitoring program in Newman Sound, Newfoundland, provided a snapshot of Lumpfish abundance (predominantly juveniles) in one of the island's coastal fjords. Newman Sound fish and habitat monitoring has occurred annually

[1]Simpson, M.R., Collins, R., Rockwood, H., Upward, P., Gauthier, J., Tunney, T.D., Themelis, D., Treble, M., Lancaster, D., and C. Miri. In prep. Recovery Potential Assessment of Common Lumpfish (*Cyclopterus lumpus*) in the Atlantic and Arctic Oceans. DFO Can. Sci. Advis. Sec. Res. Doc.

since 1995. The program sampled 12 sites bi-weekly (typically from July to November), with an average of 12 trips per year. A May trip has occurred annually since 2002 to assess over-winter juvenile fish survival. Sites were sampled during a four hour low-tide window with a 25 m demersal seine net deployed ~55 m from shore by boat. Seine hauls covered 880 m^2 per site. All fish species were counted and/or measured, and Common Lumpfish males with breeding colours were recorded. In 2017 and 2018, the Newman Sound monitoring program was expanded to include eight seine sites at four other locations (Sunnyside; Trinity; Fortune Harbour; And Woodford's Arm) across the east coast of Newfoundland. Sampling occurred monthly from August to October using the same methodologies, and data from this expansion were used to verify Newfoundland coastal fjord Common Lumpfish abundance trends, and yielded information on juvenile Common Lumpfish annual abundance, seasonal abundance, seasonal length trends, and male Lumpfish size at maturity.

Common Lumpfish were routinely caught in low numbers (mean 58 fish/year, sd ± 67.2), and annual abundance from July to November increased marginally from 2002 onward, though there was considerable annual variability (Fig. 5). May survey trips began in 2002 and showed annual variability in catches, with no discernible pattern across years (Fig. 6).

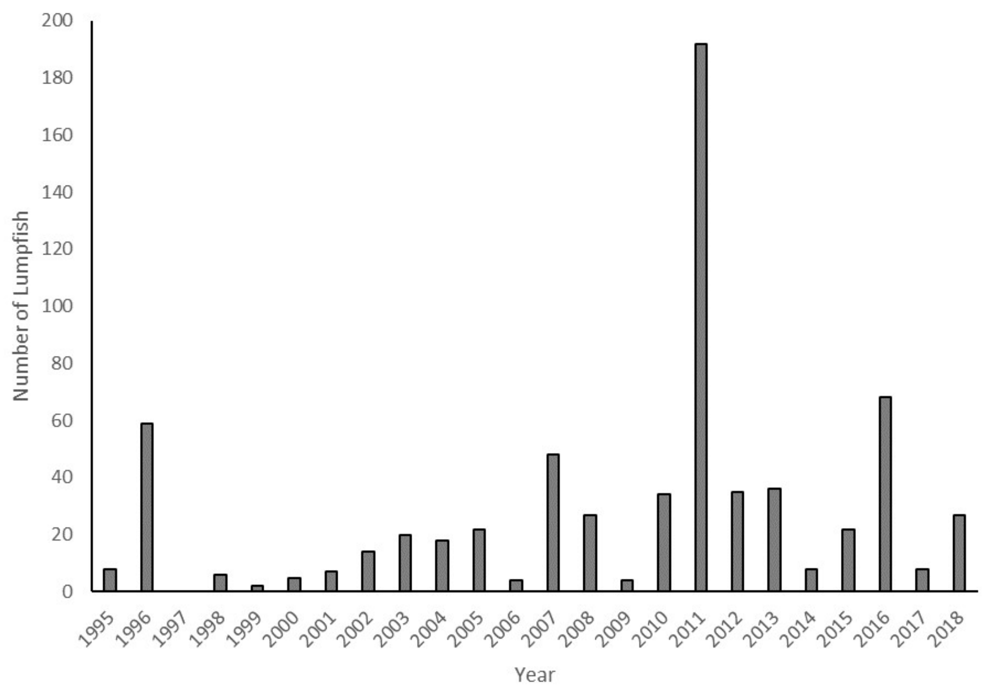

Figure 5. Common Lumpfish annual catch from July to November (1995-2018) in Newman Sound, Newfoundland. No sampling occurred in 1997.

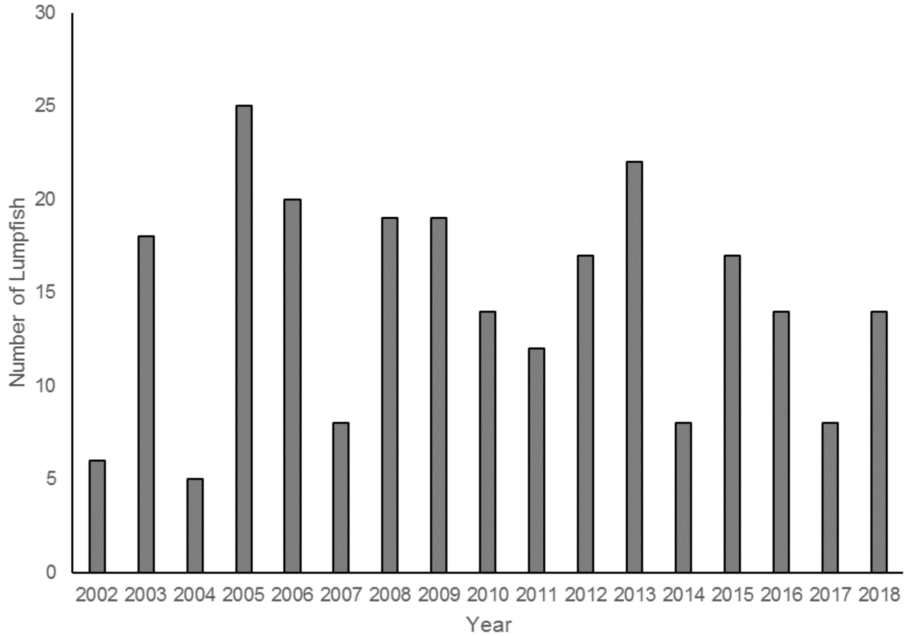

Figure 6. Common Lumpfish catch in May (2002-2018) in Newman Sound, Newfoundland.

Common Lumpfish catches in Newman Sound were highest in May, October, and November (Fig. 7). Catches of larger (185-260 mm) specimens were highest in May, consistent with a seasonal inshore breeding migration. However, the majority of the May catch was composed of juveniles (10-35 mm).

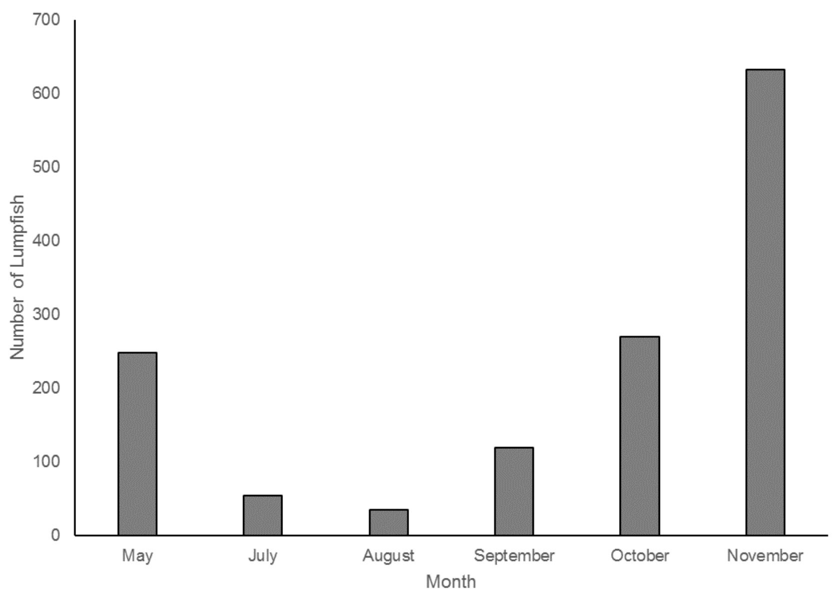

Figure 7. Common Lumpfish cumulative catch by month (1995-2018) in Newman Sound, Newfoundland. June and December data removed as sampling occurs infrequently.

Larger Common Lumpfish were rarely retained in the seines, likely due to the shallow sampling depth. However, seven breeding males (displaying red courtship colouration) have been identified in Newman Sound since 1995. Breeding male size ranged from 190-240 mm. All breeding males were captured in May at the same survey site located at the bottom of Newman Sound. Additionally, the five highest catch sites are located in the more sheltered inner sound. This may suggest breeding Common Lumpfish preferentially select sheltered nest sites, or that nests are more successful in sheltered areas.

Common Lumpfish catches were lowest at the Newman Sound survey site with the least amount of eelgrass coverage. This supports previous studies (Moring 1989; Moring and Moring 1991) which suggest that eelgrass is an important nursery habitat for juvenile Lumpfish.

Common Lumpfish abundance, length, and seasonal trends were consistent across locations in the two-year east coast expansion study, suggesting that Newman Sound is representative of coastal fjord systems across the east coast of Newfoundland.

DFO-MAR (NAFO Div. 4VWX5YZ)

Three research surveys with long time series have been conducted annually using a Western IIA trawl: the DFO-MAR summer research vessel survey on the Scotian Shelf (Div. 4VWX5Yb) since 1970; the March Div. 4VsW research survey on the eastern Scotian Shelf in 1986-2010; and the February/March (winter/spring) research survey on Georges Bank (Subdiv. 5Ze) which commenced in 1986 and is concentrated on the Canadian side of the bank (Subdiv. 5Zc), with some additional sets in American waters outside of, and adjacent to, the boundary of Canada's EEZ.

Common Lumpfish are distributed throughout the Maritimes Region with low abundance. Only 3% of survey tows over 1970-2018 captured Common Lumpfish (882 fish in total); analysis of such sporadic catches was not robust. Areas with the highest frequency of occurrence on the western Scotian Shelf (Div. 4X5Y) are in the Bay of Fundy between Grand Manan and St Mary's Bay, and Browns Bank. Lumpfish occur throughout the eastern Scotian Shelf (Div. 4VsW) both inshore and spread across Banquereau Bank and along the shelf edge. Few were caught on Georges Bank (Div. 5Z). Lumpfish were caught more frequently by the March Div. 4VsW survey conducted on the eastern Scotian Shelf (4VsW) than by the summer survey (Div. 4VWX5Yb), suggesting higher susceptibility to capture in the winter. None of the surveys showed any trends in Lumpfish abundance over the past 40 years.

Common Lumpfish distributions from the summer and winter/spring surveys since 2014 are presented in Simpson et al. (in prep[1]) and maps from earlier periods can be found in Simpson et al. (2016).

DFO-Gulf (NAFO Div. 4T)

The DFO-Gulf bottom trawl survey of the southern Gulf of St. Lawrence (sGSL; Div. 4T) has been taking place annually in September since 1971. The sGSL survey has been conducted by different research vessels and trawls: the *E.E. Prince* (1971-1985) used a Yankee 36 trawl; the *Lady Hammond* (1985-1991), CCGS *Alfred Needler* (1992-2002, 2004-2005), CCGS *Wilfred Templeman* (2003), and CCGS *Teleost* (2004-present); all employed a Western IIA trawl.

Irrespective of trawl used, both abundance and biomass indices were generally low and variable (Fig. 8). The abundance index averaged 0.06 fish/tow over 1971-1985 (Yankee trawl), and 0.07 fish/tow during 1986-2017 (Western IIA trawl). The biomass index averaged 0.09 kg/tow in 1971-85, and 0.06 kg/tow over 1986-2017. Very few Common Lumpfish greater than 34 cm total length have been caught in recent surveys.

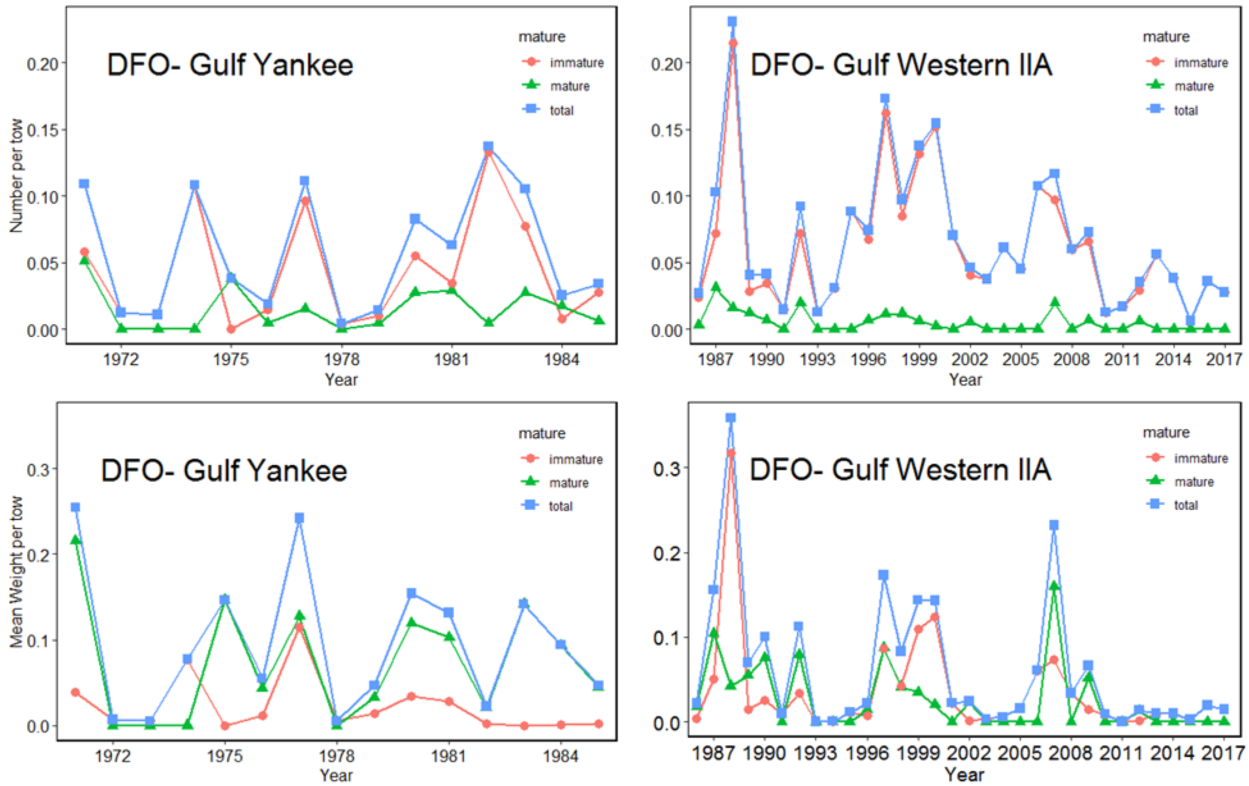

Figure 8. Abundance (mean number per tow; top panels) and biomass (mean weight in kg per tow; bottom panels) indices for all Common Lumpfish (immature, mature and total) in DFO-Gulf research surveys of Div. 4T, 1971-2017.

Common Lumpfish were found infrequently in Div. 4T, with inter-annual variability in catch location and magnitude: largest catches occurred in some years close to the Div. 4S border, or around Prince Edward Island in other years. Most catches occurred near the northern boundary of the surveyed areas (i.e., off of Gaspé Peninsula and in the Baie des Chaleurs). Common Lumpfish distributions from annual surveys that have been conducted since 2014 are presented in Simpson et al. (in prep[1]). Previous distributions may be found in Simpson et al. (2016).

DFO-QC (NAFO Div. 4RST and Subdiv. 3Pn)

For the northern Gulf of St. Lawrence (nGSL; Div. 4RST and Subdiv. 3Pn), data from two annual DFO-QC bottom trawl groundfish surveys were analysed: a winter survey conducted in January 1978-94, and a summer survey in August 1990-2018 (Bourdages et al. 2019). Plots of survey abundance and biomass indices and catch distributions from the winter survey can be found in Simpson et al. (2016). To summarize, in Subdiv. 3Pn, mean number per tow averaged 3.2 fish, and mean weight per tow averaged 7.8 kg overall; in Div. 4R, the abundance index averaged 3.3 fish/tow, and the biomass index averaged 4.5 kg overall. These indices varied without trend over the time series.

In the summer nGSL survey (Div. 4RST), catches of Common Lumpfish occurred regularly but were not abundant, averaging 30 fish over 20 standard tows (out off a total of 180 fishing sets annually). From 1990-2004, abundance and biomass indices were fairly stable, but below the series average. From 2005-2018, the variation in these indices was greater, coinciding with the change of vessel/gear combination for this survey. Both indices are currently above their respective long term averages. The average abundance and biomass for the 1990-2017 period was 0.22 fish/tow and 0.12 kg/tow, respectively (Fig. 9). In 2018, the abundance was 0.37 fish/tow, and the biomass index was 0.22 kg/tow. Very few mature Common Lumpfish (i.e., ≥34 cm) are caught in this survey, and variations in the indices are therefore driven by fish <34 cm.

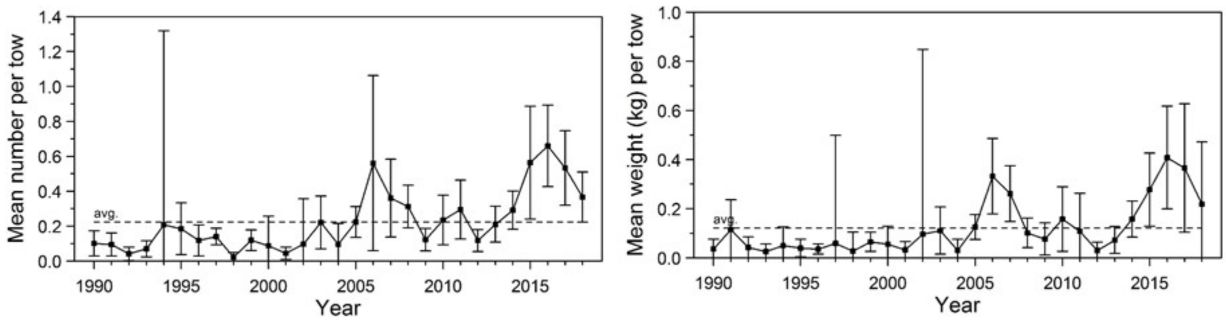

Figure 9. Common Lumpfish abundance (mean number per tow) and biomass (mean weight in kg per tow) indices in DFO-QC summer survey of Div. 4RST, 1990-2018. Error bars represent 95% confidence intervals, and dashed horizontal lines indicate the 1990-2017 series average.

Additionally, data from a Sentinel Program conducted annually since 1995, as a July groundfish mobile gear survey, were also examined. This survey used a sampling methodology similar to DFO-QC nGSL summer survey, and was conducted by commercial trawlers from Newfoundland and Quebec. Estuary strata were not surveyed, but Subdiv. 3Pn was. Over the time series, abundance and biomass indices varied slightly around the series averages of 0.08 fish/tow and 0.09 kg/tow, respectively (Fig. 10). No trends were evident in either indices. Highest values were observed in 2017, but were associated with wide confidence intervals, and both indices decreased in 2018. On average, Common Lumpfish catches occurred in only 5% of the tows conducted for this survey.

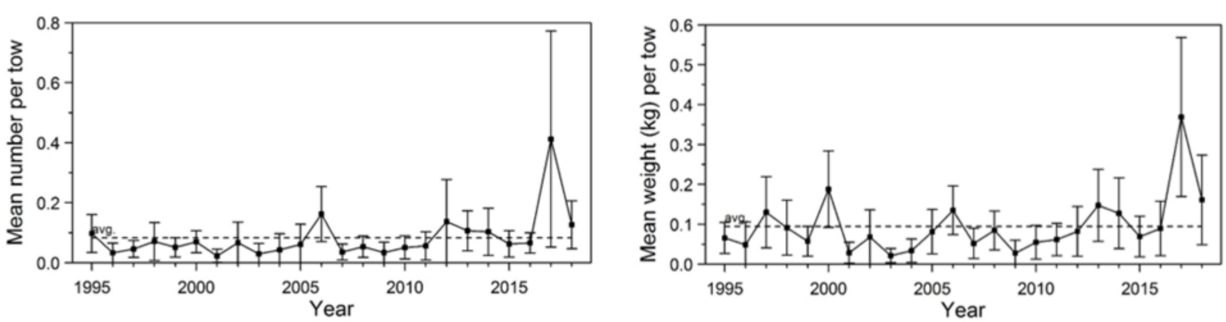

Figure 10. Common Lumpfish abundance (mean number per tow) and biomass (mean weight in kg per tow) indices from nGSL (Div. 4RS and Subdiv. 3Pn) July Sentinel surveys, 1995-2018. Error bars represent 95% confidence intervals, and dashed horizontal lines indicate the 1995-2017 series average.

Annual point maps of DFO-QC standardized catch rates from the nGSL summer survey series for 2014-2018 are presented in Simpson et al. (in prep[1]). Maps from previous survey years can be found in Simpson et al. (2016) and Bourdages et al. (2019). Catches of Common Lumpfish in the August survey were small, and occurred mainly in the Bay of Sept-Îles, northwest and northeast of Anticosti Island, at the head of Esquiman Channel, and in the approaches of the Strait of Belle Isle. In 2015-2018, Common Lumpfish were also found close to the coast on the north side of the Estuary. The Sentinel July mobile gear survey indicated the same Common Lumpfish distribution as the DFO-QC August survey. The Sentinel survey found Common Lumpfish in Subdiv. 3Pn, though only up to 2015, with none having been caught in this subdivision since. It should be noted that summer trawl surveys may not be best suited to obtaining total biomass and abundance estimates for this species, since adults are known to be nesting inshore during this period.

DFO-C&A (NAFO Div. 0AB)

DFO-Central and Arctic (C&A) Region has conducted deep-water bottom trawl surveys using the Greenland Institute of Natural Resources research vessel *Pâmiut* and two gear types, the Alfredo III trawl and the Cosmos 2000 trawl. Surveys in southern Div. 0A (Baffin Bay to 72.5º N) took place in fall 1999, 2001, every second year from 2004-2014, and each year from 2015-2017. Northern Div. 0A (72.5° to 75.5°N) surveys took place in 2004, 2010 and 2012. Div. 0B was surveyed in 2000, 2001, 2011, and annually from 2013 to 2016. All the above surveys used the Alfredo III gear, fishing at depths of 400 to 1,500 m.

The Cosmos 2000 shrimp trawl surveys targeting Northern and Striped Shrimp (*Pandalus borealis*; *P. montagui*) at depths 100 m to 800 m took place in Div. 0A (including Shrimp Fishing Area 1 [SFA 1]) (2006 and 2008), SFA 1 only (2010 and 2012), Div. 0B and SFA 3 (2007, 2009, 2011 and 2013), western Hudson Strait and Ungava Bay (2009), and Resolution Island Shrimp Area (RISA) (2007 and 2009). Furthermore, the Northern Shrimp Research Foundation (NSRF) conducted annual surveys using a Campelen 1800 shrimp trawl in SFA 2EX and RISA, and added SFA 3 (i.e., Western Assessment Zone) to its survey area in 2014.

Common Lumpfish abundance was not estimated for Subarea 0 (Div. 0A or 0B) due to very small annual catches; only 73 fish caught over all surveys and years (1999-2017). No trends were found in total number of Common Lumpfish caught in any of the survey series. All fish were caught south of 67°N at a range of depths (143-1,275 m), with several occurrences in Hudson Strait and in Ungava Bay (Simpson et al. in prep[1]).

Life History Parameters

In Canadian waters, most aspects of the species' life history are poorly understood.

Preliminary aging studies, using otoliths of Common Lumpfish captured in the NL Region, indicated that the mean age at first attainment of sexual maturity in females is 5.6 years, with a range of 4-7 years; this corresponded to a length of approximately 35 cm (Grant 2001). More recent data suggested that Common Lumpfish males attain maturity at much smaller sizes. Data from the nGSL survey estimated total length at which 50% of fish are mature (i.e., L50) at 22.5 cm for males, and 33 cm for females, and seining data from Newman Sound, Newfoundland suggested that some males may reach sexual maturity at 19 cm.

The average number of eggs produced by each female per spawning season is roughly 100,000 and depends on body size: the largest females produce up to 350,000 to 400,000 eggs (Davenport 1985; Muus and Nielsen 1999). A study of fecundity in NAFO Div. 4RS and Subdiv. 3Pn reported an average of 122,000 eggs/female (Gauthier et al. 2017).

Examination of various estimates from empirical relationships, using growth/size and maturity data from several studies of Common Lumpfish, yielded an instantaneous rate of natural mortality (M) of 0.3, and a generation time (G) of seven years, though there is considerable uncertainty associated with these values (COSEWIC 2017).

The maximum age for this species has been estimated as 13 years (Thorsteinsson 1981). Depending on location, maximum size appears to be 60-70 cm (Cox and Anderson 1922; Leim and Scott 1966), and maximum recorded weight is 9.6 kg (Collins 1976).

Habitat and Residence

Habitat

Common Lumpfish occur from shallow coastal waters (< 20 m) to depths of over 1,000 m (Collins 1978; Able and Irion 1985; Collette and Klein-MacPhee 2002; Coad and Reist 2018). Maximum recorded depth is almost 1,300 m (Coad and Reist 2018). They are considered a cold-water species, and appear to prefer temperatures less than 5°C in Canadian waters (Simpson et al. 2016), though they can tolerate temperatures of 18-20°C for short periods (i.e., less than 24 hours; Ern et al. 2016; Hvas et al. 2018). They are able to tolerate reduced salinity, perhaps even as low as 13 ppt (McKenzie 1959; O'Connell et al. 1984; Able and Irion 1985; Davenport 1985).

Davenport (1985) indicated that Common Lumpfish are semi-pelagic/benthopelagic. Using data storage tags, Kennedy et al. (2016) showed that, as spawning approaches, mature Lumpfish migrating to coastal areas displayed a mix of pelagic and demersal behavior. It is unknown what specific habitat features are required for successful completion of all life history stages, but Common Lumpfish, especially young individuals, are often associated with eelgrass and a variety of macroalgae in inshore waters (Moring 1989; Moring and Moring 1991; Collette and Klein-MacPhee 2002).

Detailed information on the spatial extent and availability of suitable Common Lumpfish habitat is not available, but it is not believed that habitat is limiting for this species. There is no evidence of any spatial configuration constraints, as distribution in Canada is continuous and movement is not believed to be limited by physical or oceanographic barriers.

Residence

The *Species at Risk Act* (SARA) defines "residence" as:

"a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating" (s.2(1)).

The 2015 policy document entitled, "DFO's Guidelines for the Identification of Residence and Preparation of a Residence Statement for an Aquatic Species at Risk" (unpublished report) states that the following four conditions should be used to determine whether the concept of residence applies to an aquatic species:

1. There is a discrete dwelling-place that has structural form and function similar to a den or nest or other similar area;
2. An individual of the species has made an investment in the creating and/or modifying the dwelling-place;
3. The dwelling-place has the functional capacity to support the successful performance of an essential life-cycle process such as spawning, breeding, nursing and rearing; and
4. The dwelling-place is occupied by one or more individuals at one or more parts of their life cycle.

Based on these criteria, Common Lumpfish mating/nesting sites would constitute residences which support reproduction, as they are modified by the males and are occupied by both adults and eggs/larvae. These inshore sites are typically rocky, structurally complex, and associated with macroalgae.

Tagging studies (Schopka 1974; Fréchet et al. 2011) strongly suggest homing to inshore spawning grounds in spring, so these sites should be considered as breeding residences. Directed fisheries targeting adults, as well as removals due to bycatch in other fisheries, that occur near or at these breeding/nesting sites in spring/summer, could negatively impact reproduction and recruitment.

Threats

Commercial Fishing

The only quantified anthropogenic threat to recovery of Common Lumpfish is ongoing fishing related mortality resulting from directed commercial fisheries for this species (specifically, in Div. 2J3KLP and Div. 4RS) and, to a lesser extent, bycatch (retained/landed and/or discarded) in commercial fisheries directing for other species. Other potential sources of fishing mortality (i.e., Indigenous food, social, and ceremonial (FSC) fisheries and recreational fisheries) are not believed to pose a significant threat to the species.

In Atlantic Canadian waters, the Common Lumpfish-directed fishery targets females exclusively. The fishery occurs in shallow coastal waters for a few weeks between April and July, and is conducted primarily by small vessels (i.e., those <35 feet in length) using gillnets with 10½-inch mesh. This roe fishery is highly dependent on market conditions, and is conducted primarily in Div. 3P and Div. 4RS. No commercial fishery for this species exists in Maritimes, Gulf, and Central and Arctic Regions (i.e, Div. 4VWX5YZ, Div. 4T, and Subarea 0). The roe is the landed product, and since the carcass has little commercial value it is discarded at sea (Kennedy et al. 2018). With respect to Canadian reported roe landings in the Zonal Interchange File Format (ZIFF) database, no conversion factor exists to convert these landings to whole (round) weight of females. However, a factor of 4 is currently used to derive a round weight equivalent (Stevenson and Baird 1988; Gauthier et al. 2017).

Commercial fisheries removals of Common Lumpfish in Canadian waters were examined for 1970-2017, using the following data sources: NAFO STATLANT-21A landings (1970-2017), as reported by NAFO-member countries; DFO-ZIFF landings (1985-2017), as reported by Canadian fishers (recorded in their logbooks and on fish plants' purchase slips); and Canadian At-Sea Fisheries Observers' (ASO) catch and discard data (1983-2017), collected on a set-by-set basis in a standardized format on board commercial fishing vessels at sea.

Common Lumpfish roe landings were initially low in Div. 3P4RS, then significantly increased from 1976 to a peak in 1987 (Fig. 11). Over 1987-2000, roe landings were variable, but averaged 1281 t annually. Roe landings were significantly lower in 2001-2003 (305 t average), then increased in 2004, but have since declined to a 29 t annual average over 2009-17. Overall, Div. 4S was a minor contributor, while Subdiv. 3Ps dominated roe landings during 1978-2007 (Fig. 12). In recent years, roe landings were predominantly from Div. 4R with a smaller percentage of landings from Subdiv. 3Ps. There were few reported landings of whole Common Lumpfish in NAFO Div. 4RS and Subdiv. 3Pn from 2000-2017. For the same period, annual bycatch reported as roe in other directed fisheries was low.

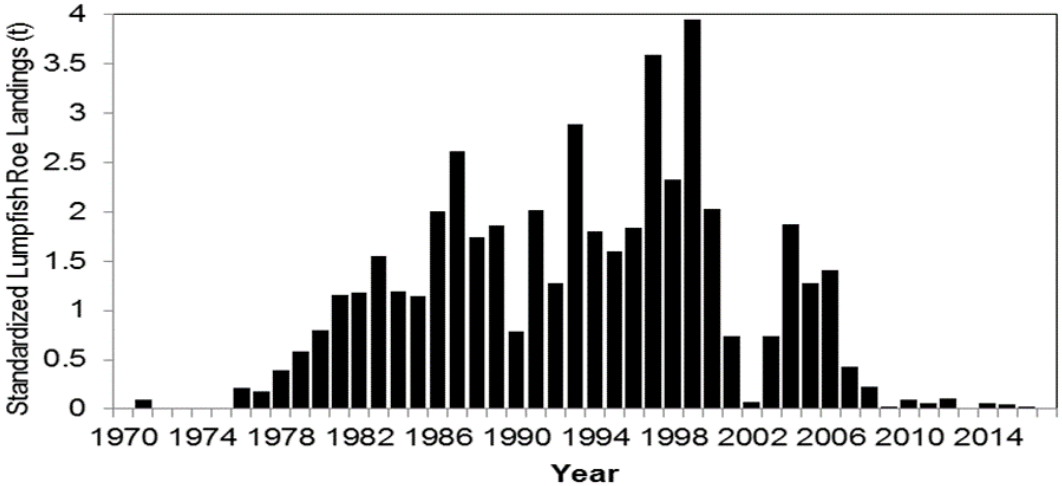

Figure 11. Common Lumpfish roe landings (t) standardized by the mean from Div. 3P4RS, 1970-2017 (Source: NAFO STATLANT-21A and ZIFF).

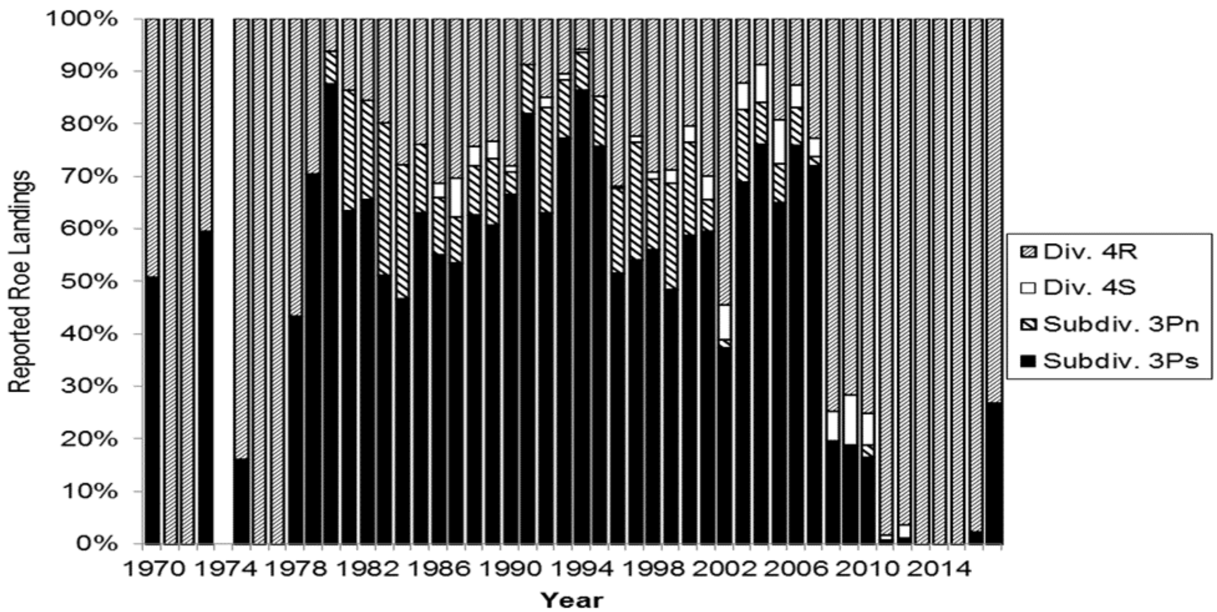

Figure 12. Proportion of Common Lumpfish roe landings by NAFO Division for Div. 3P4RS, 1970-2017 (Source: NAFO STATLANT-21A and ZIFF).

In Div. 2J3KL, Common Lumpfish roe landings increased over 1970-79, declined to low levels in 1980-84, and then increased dramatically to a peak in 1987 (Stansbury et al. 1995; Fig. 13). Roe landings remained relatively high until 1993, and have since declined to very low levels. Roe landings were variable in Div. 3KL and infrequently reported from Div. 2J. From 2004-2012 the proportion of roe landings from Div. 3K increased, and in the past five years the percentages of landings from Div. 3K and Div. 3L have been variable (Fig. 14).

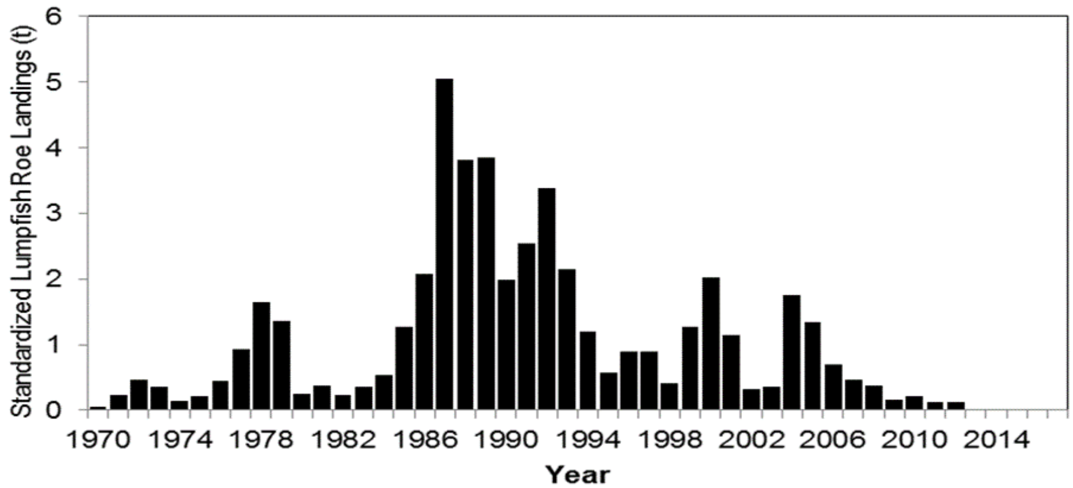

Figure 13. Common Lumpfish roe landings (t) standardized by the mean from Div. 2J3KL, 1970-2017 (Source: NAFO STATLANT-21A and ZIFF).

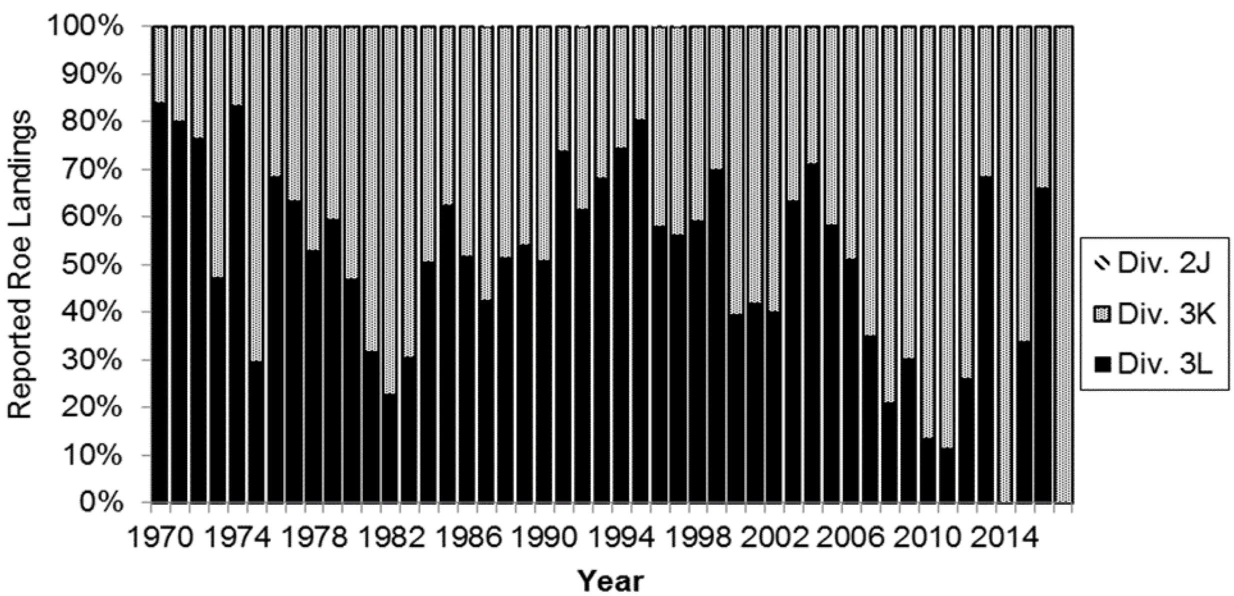

Figure 14. Proportion of Common Lumpfish roe landings from Div. 2J3KL, 1970-2017 (Source: NAFO STATLANT-21A and ZIFF).

In Div. 3KLOP, the Common Lumpfish-directed gillnet fishery landed the majority of reported roe in 1995-2003, while gillnet fisheries targeting Atlantic Cod (*Gadus morhua*) and skates (combined) averaged 2% annually. Since 2004, the directed fishery reported almost all roe landings (312 t annual average).

From 1998-2012, an average of 960 fishers participated in the annual directed fishery for Common Lumpfish in Div. 3KLP4RS. From 2013-2018, the average fell dramatically, to only 29 active fishers per year. Since 1998 (i.e., when 'month' was recorded in NL fishers' logbooks), the timing of roe landings has been recorded. The monthly proportions of landings vary over time and across NAFO Divisions.

Although dependent on the annual percentage of ASO coverage for each fishery, NL ASO data from 1983-2017 indicated that most catches of Common Lumpfish occurred in Subdiv. 3Ps. However, in the NL Region there has been no directed Lumpfish observer coverage since 2010 and therefore there is no way to quantify discards of male and immature fish. However, discard mortality is thought to be low in the directed fishery for Common Lumpfish, due to the shallow depths in which the fishery is prosecuted, and the species' lack of a swim bladder (COSEWIC 2017). The mesh size in the gillnets used in this fishery limits the capture of both mature males (which tend to be smaller than females at a given age) and immature fish of both sexes. In 1983-93, bottom otter trawls targeting American Plaice and Atlantic Cod took the majority of observed Common Lumpfish bycatch: annually averaging 18 t (peak of 63 t in 1990) and 9 t, respectively. During 1994-2006, the Common Lumpfish-directed fishery was observed to annually catch 30 t on average (1999 peak of 73 t) with fixed gillnets, while the Redfish (*Sebastes* spp.) gillnet fishery averaged 5 t in 1994-2003. Observed catches of Common Lumpfish in directed and bycatch fisheries have varied over time, and across fisheries, but became negligible by 2008. Changes in these observed catches may be due to annual variation in ASO coverage of fisheries in Subdiv. 3Ps.

From 2000-2017, the ASO database for Div. 4RS reported 39,826 observed fishing activities, and bycatch of Lumpfish was identified in 372 (0.9%) of these. Common Lumpfish catches were mostly of less than 1 kg per activity and 99% were discarded at sea. Bycatch occurred in fisheries directing for Winter Flounder (*Pseudopleuronectes americanus*), American Plaice (*Hippoglossoides platessoides*), Redfish (*Sebastes spp.*), Northern Shrimp (*Pandalus borealis*), Witch Flounder (*Glyptocephalus cynoglossus*), Greenland Halibut (*Reinhardtius hippoglossoides*), Atlantic Cod (*Gadus morhua*), and Iceland Scallop (*Chlamys islandica*) using gillnets, otter trawls, shrimp trawls, seines and dredges. Except for the shrimp fishery, Lumpfish bycatch was not scaled to the total effort or total landings of the fisheries. When scaled to the total effort of the Gulf of St. Lawrence shrimp fishery, Common Lumpfish bycatch remains low and is estimated at an average of 50 kg for the period 2000-2017.

In Div. 4VWX5YZ, Common Lumpfish are caught as bycatch in groundfish bottom trawl and gillnet fisheries, and discarded from scallop gear and lobster traps. Although all Lumpfish caught in groundfish gear must be landed, only a few have been reported in recent years. At-sea observers have reported low numbers of Common Lumpfish in groundfish trips targeting Redfish, pollock (*Pollachius pollachius*), Silver Hake (*Merluccius bilinearis*), and sculpin; however, observer coverage was low (averaging 3% for pollock and 8% for Redfish in Div. 4VW from 2015-2018). There is also insufficient observer coverage to estimate the amount of interaction between Common Lumpfish and scallop gear and lobster traps.

Relative fishing mortality (Rel. F=[ZIFF-reported commercial Common Lumpfish roe landings]*4/Canadian research survey biomass of female fish >34 cm) was variable and high in Div. 3L over 1996-2006, while remaining low in Div. 3P, and negligible in Div. 3K (Fig. 16). Relative F in Div. 3LP decreased to its lowest levels and has remained low since 2007. For Div. 4RS, catches of mature females in the Common Lumpfish-directed fishery largely exceeded DFO survey population estimates.

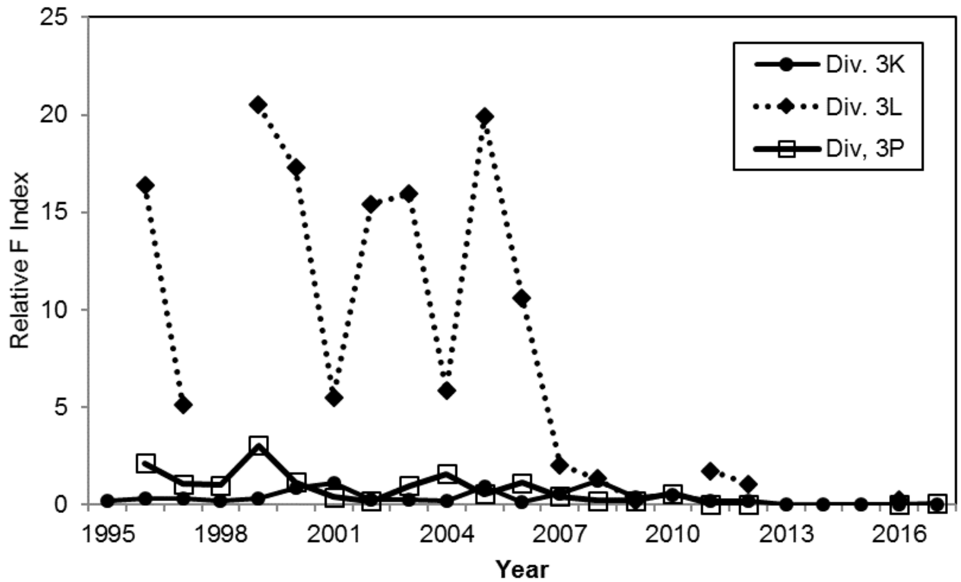

*Figure 15. Relative F index (=(ZIFF-reported landings of Common Lumpfish roe)*4/Canadian Campelen survey biomass of female fish >34 cm) for Div. 3KLP, 1996-2017. Note that fall biomass was used for Div. 3K (1995+), spring biomass for Divs. 3LP (1996+).*

Other Anthropogenic Threats

Activities associated with oil and gas exploration and production, may pose a threat to the survival and recovery of Common Lumpfish. Seismic surveys are widely used in Canadian waters to detect potential drilling locations for oil and gas reserves, and involve sending sound waves down to the sea floor and recording echoes that return from various sedimentary layers. In addition, there are significant drilling license areas in NL waters. Hibernia, Terra Nova, White Rose, Hebron, and North Amethyst oil fields are currently in operation in the Jeanne d'Arc Basin. There is also current interest in the development of the Bay du Nord oil field. Any significant oil pollution could be transported by the Labrador Current and thus potentially impact Common Lumpfish (especially eggs and larvae), and their habitat. There are no data currently available on the impact of oil and gas exploration and drilling, or of oil pollution, on Common Lumpfish life stages or habitat.

The potential for anthropogenic disturbance and negative impacts on marine species is often highest in inshore and coastal areas, as they are more proximal to human population centers and associated activity. Coastal and inshore environment surveying and development may pose a risk to spawning Common Lumpfish and developing larvae and juveniles. In these environments there is the possibility of negative effects due to accelerated eutrophication from other sources. For example, run-off in the form of chemicals/fertilizers from agriculture and other industries is known to result in eutrophication in nearshore waters, as is the domestic use of detergents. Pollution in nearshore environments may cause direct mortality of Common Lumpfish and/or their prey, but may also eliminate valuable habitat features used by early life stages, such as eelgrass.

Climate change is associated with increasing water temperatures. Although Common Lumpfish are tolerant of a wide range of temperatures, they prefer colder waters of less than 5°C. Warmer waters, particularly those in excess of 15°C, are associated with increased mortality, as well as the formation of cataracts and the development of abnormal swimming behaviour (Hvas et al. 2018). Ocean warming as a consequence of climate change may reduce the survival of Common Lumpfish, either directly, or as a consequence of reduction in prey availability.

Recovery Targets (Abundance and Distribution)

With the aim of establishing a biomass target in the form of B_{lim} (i.e., the limit reference point for spawning stock biomass), attempts to model the stocks in Subdiv. 3Ps and Div. 3KL (using a Bayesian state-space implementation of the Schaefer (1954) Surplus-Production model), in Div. 4RS (using a Surplus Production in Continuous Time model; Pedersen and Berg 2017) and in Div. 4T (using a length-based stage-structured model; Swain and Benoit 2017) were all unsuccessful. No attempts to model stocks in other regions were attempted, due to insufficient data.

In the absence of models for this species in Canadian waters, an interim recovery target was proposed based on combined NL survey biomass indices for Subdiv. 3Ps and Div. 3KL. Surveys in these management units target the areas where most of the Common Lumpfish biomass in Canadian waters is concentrated, the combined biomass index for these areas showed contrast, and data from these areas is the main source of information on which COSEWIC based the status of the species. These recovery targets were developed according to the DFO Precautionary Approach (DFO 2006). A proxy of the biomass at maximum sustainable yield (B_{msy}) was estimated at 19,788 t based on a the average biomass of a productive period between 1996-2006. The proposed interim recovery target is set at the limit reference point (LRP) which is estimated at 7,915 t (40% of B_{msy}). The recovery target is set at the upper stock reference point (USR) 15,831 t (80% of B_{msy}). The interim recovery target is to be above the LRP. Current survey biomass is estimated to be 50% of the LRP.

The candidate distribution recovery target for this DU is to increase the distribution to historic levels in NAFO Subdiv. 3Ps and Div. 3KL, and to maintain the current distribution throughout the other areas (Div. 2J; Div. 3NO; Div. 4RST; Subdiv. 3Pn; Div. 4VWX5YZ; and SA 0).

Due to the lack of a quantitative model, the population trajectories could not be projected.

Sufficient suitable habitat is thought to be available to meet the demands of the species both at present and when it reaches the recovery target. Current levels of fishing mortality are not thought to jeopardize survival. However, a decrease in fishing mortality may be required to achieve the recovery targets.

Allowable Harm

Allowable Harm is “harm to the wildlife species that will not jeopardize its recovery or survival” (DFO 2004). Under SARA, activities can be permitted if the cumulative harm (i.e., from all potential anthropogenic sources) which could occur would not jeopardize survival or recovery of the species, and the following criteria from DFO (2004) are met:

1. “The current population is neither so small that random factors threaten population viability nor so concentrated in space that it is vulnerable to elimination by a catastrophic event”.
2. “The recent trajectory of the stock is stable or likely to be increasing, so that survival or recovery is not in jeopardy in the period when the permit is in place.”
3. “The known sources of human-induced mortality are unlikely to increase during the permitting period. This means that there is high confidence that the causes of human-

induced mortality are under management control, monitored, and can be enforced effectively."

4. "There is a relatively high likelihood that recovery goals will be achieved in biologically reasonable time frames with the activity present".

Common Lumpfish in Canadian waters does not consist of a small, concentrated population, given the species' widespread geographic distribution throughout Atlantic Canada and into the Arctic. As well, the movement patterns and spatial distribution in the Northwest Atlantic should make Common Lumpfish relatively invulnerable to localized catastrophic events.

Fishing is the only quantified threat to Common Lumpfish in the Atlantic and Arctic Oceans, through both incidental bycatch in other fisheries and by directed fishing. While directed fishing mortality of Common Lumpfish is under management control and is monitored, it is unclear if the species can sustain a directed fishery in some areas (e.g., Subdiv. 3Ps), particularly when the fishery targets mature spawning females. It should be noted that Subdiv. 3Ps has been undergoing structural changes as observed in ecosystem signals in recent years, which indicate that overall ecosystem productivity may be low. The full impacts of these changes on Common Lumpfish itself are not fully known, but could potentially result in impaired productivity.

As discussed previously, anthropogenic activities that occur in, or proximal to, nearshore environments have the potential to alter or destroy the necessary habitat upon which the species relies for reproduction, or early life-stages.

Therefore, it is probable that recovery of Common Lumpfish can occur in a biologically reasonable time frame, if directed fishing mortality is reduced and the potential for damage to nesting habitats is minimized. A reduction of fishing mortality and mitigation of impacts to nesting and nursery habitat can be achieved through a variety of fisheries management and habitat protection measures (e.g., reductions in amount of gear or season duration; prohibition of nearshore activities that would destroy Lumpfish nesting habitat).

Sources of Uncertainty

As previously mentioned, the semi-pelagic nature of Common Lumpfish, as well as their tendency to undertake inshore migrations in spring make it difficult to estimate total abundance and biomass for the species. In addition, the use of different survey gears among regions and across time precludes comparison of the various survey indices.

As with many other commercial fisheries, there are issues with the accuracy of landings data, which make it difficult to quantify total removals. In addition, the limited observer coverage of fisheries in general, as well as the lack of dedicated ASO coverage in the directed Common Lumpfish fishery since 2010, impedes efforts to understand the full impact of fisheries on the species.

It is unknown what effects, if any, climate change and increasing ocean temperatures would have on Common Lumpfish behavior and/or survival. As mentioned previously, Common Lumpfish are tolerant of a wide range of temperatures, but prefer colder waters of less than 5°C, while warmer waters, particularly those in excess of 15°C, are associated with increased mortality, as well as morphological/behavioural changes. Ocean warming as a consequence of climate change may alter Lumpfish behavior and modify the timing of events required to complete their lifecycle, such as inshore migration for spawning. These conditions may also affect Common Lumpfish survival, either directly by altering thermal demands, or by shifting interactions between Common Lumpfish and their predators and prey.

CONCLUSION

In summary, biomass and abundance indices for Subdiv. 3Ps (NL spring survey) and Div. 2J3KL (NL fall survey) have declined precipitously since the mid-2000s and remain low with no apparent trend in recent years. These indices are considered to reflect stock status. No discernible trends are present in Div. 4RST, Div. 4VWX5YZ, or Div. 0AB. Therefore, precautionary management is advised. Commercial landings remain low throughout all areas. However, since commercial fishing is the only quantified source of anthropogenic mortality, and the directed fishery targets the eggs of mature females, a reduction in fishing mortality may facilitate population recovery.

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SOURCES OF INFORMATION

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