ASSESSMENT OF LOBSTER (*HOMARUS AMERICANUS*) IN LOBSTER FISHING AREA 41 (4X + 5Zc)

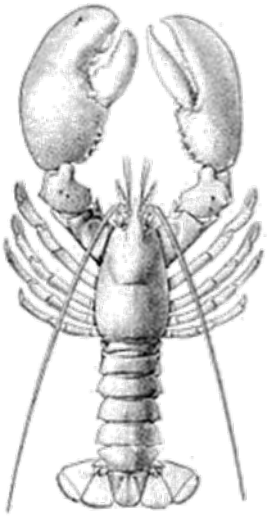


Image: BIO Technographics

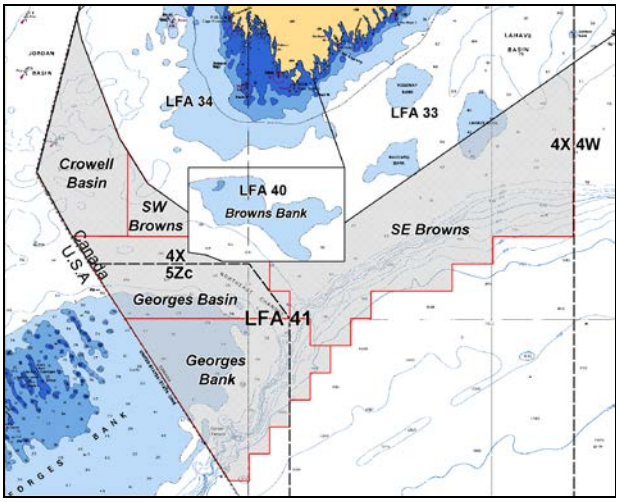


Figure 1: LFA 41 (4X + 5Zc) assessment areas.

Context:

American Lobster (Homarus americanus) is found in coastal waters from southern Labrador to Maryland, with the major fisheries concentrated around the Gulf of St. Lawrence and the Gulf of Maine. Though lobster are most common in coastal waters, they are also found in deeper, warm water areas of the Gulf of Maine and along the outer edge of the continental shelf from Sable Island to off North Carolina.

The status of the Lobster Fishing Area (LFA) 41 offshore lobster resources in the Maritimes was last assessed in 2009. The fishery operates under the Integrated Fisheries Management Plan with 8 licences and a total allowable catch (TAC) of 720 t, and is authorized to fish in the 4X and 5Zc portions of LFA 41 (Figure 1). LFA 41 is the only lobster fishery in Canada that is managed with a TAC. The fishery obtained MSC certification in 2010. Indicators for lobster in LFA 41 are required to remain consistent with Fisheries and Oceans Canada's (DFO) Precautionary Approach and for the evaluation and monitoring of the fishery.

The objectives were to assess the Precautionary Approach and the stock status of the LFA 41 lobster stocks as of the end of the 2012 season by describing the strengths and weaknesses of fishery and survey data inputs, presenting indicators of Fishery Performance, Abundance, Reproduction and Fishing Pressure, reviewing relevant biological and ecological information, presenting the rationale for a series of indicators and their reference levels, and to develop the assessment schedule.

This Science Advisory Report is from the December 3-4, 2013 and January 9, 2014 Review of the Framework and Assessment of LFA 41 (4X + 5Zc) Lobster. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

Fishery

- The Total Allowable Catch (TAC) for Lobster Fishing Area (LFA) 41 was established at 720 t in 1985 based on landings history and has remained unchanged.
- Fishing effort has been declining due to increased catch per unit effort (CPUE) and changes to fishing strategy.
- The size structure has remained relatively stable and dominated by mature sizes indicating a low exploitation level. Relative F (fishing mortality) calculated from landings and biomass estimates from the summer survey is low and declining in recent years.

Framework and Assessment

- A Precautionary Approach proposed for lobster in LFA 41 uses multiple primary indicators with boundaries to guide in setting harvest control rules and secondary indicators to aid in interpreting changes in the primary indicators. There is no single reference point for this fishery.
- When interpreting the primary indicators, if all indicators remain above the upper boundary, the population is considered to be in the healthy zone. The stock would enter the cautious zone only if the abundance declined below the boundary and the size indicators also declined to below the boundary. When upper boundaries have been crossed for the primary indicators, the secondary indicators should be reviewed for further context on what is happening in the stock.
- All indicators are above the upper boundaries and LFA 41 is considered to be in the healthy zone.
- Primary indicators include mean number per tow from the Maritimes Region research vessel (RV) trawl survey (summer 4X, winter 5Z), number per tow of large female lobsters (>140 mm CL) (Summer RV survey 4X; USA NMFS Fall RV Survey 5Z), and median size from trawl surveys and at-sea samples of the commercial catch.
- The large size indicator is a proxy for exploitation rate and changes in reproductive potential. It is based on the mean number per tow of females > 140 mm CL in the Maritimes Region RV summer trawl survey (4X 1999-2013) and the USA NMFS trawl surveys for 5Z (1983-2012).
- Median female size indicators based on trawl surveys and at-sea samples are proxies for exploitation rate and changes in reproductive potential.
- Secondary indicators on proportion of survey sets with lobsters, sex ratio, number per tow of recruit sizes, and trends in adjacent fisheries aid in interpreting changes in the stock. They provide important information about the ecosystem and the fishery, and aid in determining the type of response if the stock entered the cautious zone.

Ecosystem Considerations

- Given the current low biomass levels of some potential lobster predators, there is no expectation of a near-term increase in the natural mortality of lobsters.

- The percentage of the area of LFA 41 contacted by lobster traps was estimated from the effort data. The estimates indicate that a very low and decreasing percentage of the bottom is contacted by traps, with an overall estimate for LFA 41 in 2012 of 0.0005%.
- In 2012, sea surface temperature was above the 1981-2010 average temperature and July bottom temperatures were also well above the 1981-2010 average. For 2013, sea surface temperatures (up to November) and July bottom temperatures were above the 1981-2010 average temperature, but by a lesser extent than 2012.
- LFA 41 at-sea samples record the levels of incidental catch. Estimates of 2012 incidental catch, including discarded and retained catch was 46 t. The overall incidental catch has declined since 2006 (164 t). The end of the directed Jonah Crab fishery (2008) and concentration on areas of highest lobster CPUE are believed to have contributed to the reduced incidental catch. High survival is expected for invertebrates, but survival is lower for some fish species.

BACKGROUND

Species Biology

Most female lobsters mature between 90 and 105 mm carapace length (CL) off southwestern Nova Scotia and the Bay of Fundy. Estimates of the size at 50% size at onset of maturity (SOM50) for the offshore area, Lobster Fishing Area (LFA) 41, is 95 mm CL, based on pleopod method in the late 1980s (Pezzack and Duggan 1989). More recent estimates from the American portion of Georges Bank (Lydonia to Corsair Canyon) (Little and Watson 2005) produced estimates of 92 mm CL using a dissection method. These dissections included data from the more southern portion of the Bank and as a result, are not directly comparable to the SOM50 for the Canadian portion.

Mature females mate after moulting in midsummer, producing eggs the following summer that attach to the underside of the tail. The eggs are carried for 10 12 months and hatch mainly in July or August. The larvae are planktonic for a few weeks to a month or more, depending on temperature. There are 3 larval stages, followed by a post-larval stage (“Stage 4”) that is planktonic for a few days until it begins diving to the bottom to begin the benthic phase of life. Once the post-larvae find suitable shelter on the bottom they tend to remain in or near the shelter to avoid predation. As lobsters moult and become larger, they leave their shelters more often to forage.

Off southwestern Nova Scotia, lobsters are thought to take 8-10 years on average to reach the legal size of 82.5 mm CL. However, lobster age-at-size is variable based on recent studies. Although maximum age of lobsters is unknown, growth information and long term holding studies indicate that 50 years is possible. Growth increments at moult are dependent upon size, sex, and maturity. The mean growth increment for males and immature females is between 12-16%, while mature females exhibit a declining percentage in growth with size as more energy is invested in egg production.

Mature size lobsters seasonally migrate to shallower waters in summer and deeper waters in winter. Over most of the lobster’s range these movements amount to a few kilometres; however, in the Gulf of Maine, the offshore regions of the Scotian Shelf, and off New England, lobsters can undertake long distance migrations of 10s to 100s of kilometres.

The lobster stock structure in the Gulf of Maine is not fully understood and is viewed as a stock complex, meaning there are a number of sub-populations linked in various ways by movements of larvae and adults. Oceanographic conditions promote both retention and dispersal and the

linkages among areas vary over time as wind events alter the drift of planktonic larvae or water mass movements influence migration patterns. Migration patterns are affected by bottom topography, depth, water temperatures and homing characteristics.

Genetic studies show a more heterogeneous population structure in the Gulf of Maine than in areas to the northeast, but the number and distribution of the subpopulations remains uncertain. Lobster densities are highest in coastal regions and lower concentrations are associated in the offshore Browns and Georges Bank areas. Lobsters are found in higher concentrations on the Banks in summer and migrate to deeper water in winter.

Benthic stage lobsters are omnivorous, being mostly predators and scavenging prey items when available. Examination of juvenile and adult lobster stomach contents has found a wide variety of benthic organisms, including gastropods, bivalves (scallops, clams, and mussels), chitons, crustaceans (e.g. Rock Crab), starfish and brittle stars, sea urchins, various marine warms (polychaetes) fish and occasionally plant material. Lobsters are also opportunistic feeding on fish eggs, discarded lobster shells and dead animals including fish, marine mammals and bait in lobster traps.

Known and suspected predators of lobsters include cunners, sculpins, skates, cod, Spiny Dogfish, Sea Ravens, wolfish, Haddock, Hake and crabs. Predation rates are highly size-specific and decline as lobsters get larger.

Fishery

The offshore lobster fishery (LFA 41), established in 1972, fishes from the 50 nautical mile line (92 km) to the upper continental slope. While LFA 41 includes parts of the Northwest Atlantic Fisheries Organization (NAFO) Subareas 4Vs, 4W, 4X and 5Z, lobster fishing is authorized only in 4X and 5Zc.

Management Measures

There are 8 licences to fish lobster in LFA 41, with a Total Allowable Catch (TAC) of 720 t lobster and 540 t Jonah Crab. The fishery is managed by input and output controls including a minimum size of 82.5 mm CL, prohibition on landing egg bearing (berried) or v-notched females, limited entry, and a TAC (Table 1). The TAC was established in 1985 based on landings history; it has remained unchanged, but has been reviewed since then and is considered precautionary. A 720 t TAC for Jonah Crab was established in 1995 and reduced to 540 t in 2010. A box encompassing all parts of Browns Bank <50 fathoms (91.4 m) was closed to lobster fishing in 1979, though other fishing activity still occurs within it. This is referred to as the Browns Bank closed area or LFA 40 (Figure 1).

Table 1. Specifics of some current lobster management measures in LFA 41.

Season:	Year round Quota year January 1st – December 31st
Minimum Legal Size:	82.5 mm CL
Landing of Berried and V-Notched Females:	Prohibited
Trap Limit:	None
Number of Licences:	8
Lobster TAC:	720 t
Jonah Crab TAC:	540 t

ASSESSMENT

Source of Information

1. LFA 41 lobster logbooks (MARFIS)
2. Landings from adjacent fisheries (LFA 34 logbooks, USA landings – Atlantic States Marine Fisheries Council and National Marine Fisheries Service)
3. At-sea samples of commercial catch
4. Canadian Ecosystem Trawl Survey (4X- Summer Survey; 5Z- Winter Survey)
5. Northeast Fisheries Science Center (NEFSC) bottom trawl survey (Spring and fall surveys)

Fishery Performance

Landings

Total landings (Table 2) are limited by the TAC and therefore provide limited insight into overall abundance. It would be informative only if the fleet was consistently unable to catch the TAC. Year-to-year landings are affected by lobster catchability, economics and market forces; with the decision as to when and where to fish influenced in part by lobster sizes, quality, and demand.

Over the history of the fishery the quota-year has varied; being annual up to 1984, then October 15tth – October 14th from 1985-2004 then switching back to an annual period (Figure 2). Higher TAC in 1985-1986 and 2004-2005 were due to extended seasons during transition to new quota periods. The 2004-2005 change in the quota year resulted in7 of the 8 licences having an extended season during the transition and an annual TAC (January-December) during 2006 to 2007, while one licence continued under the October 16th - October 15th TAC during those years. The remaining licence switched to an annual quota year in 2007. For simplicity in this report the landings and TAC are expressed on an annual basis for 2006 and 2007 to reflect the majority of the licences in the fishery. In recent years, TAC has been adjusted to account for allowed carry-over and over runs in some years.

In 2013, a multi-year management system began with a 3 year quota, January 1, 2013 – December 31, 2016, of 2160 t (3x720 t) with no more than 828 t (720+15%) fished in a given year. The provision is only available when the resource is healthy and ceases should there be a decrease in the TAC. The provision will be evaluated at the end of 2015.

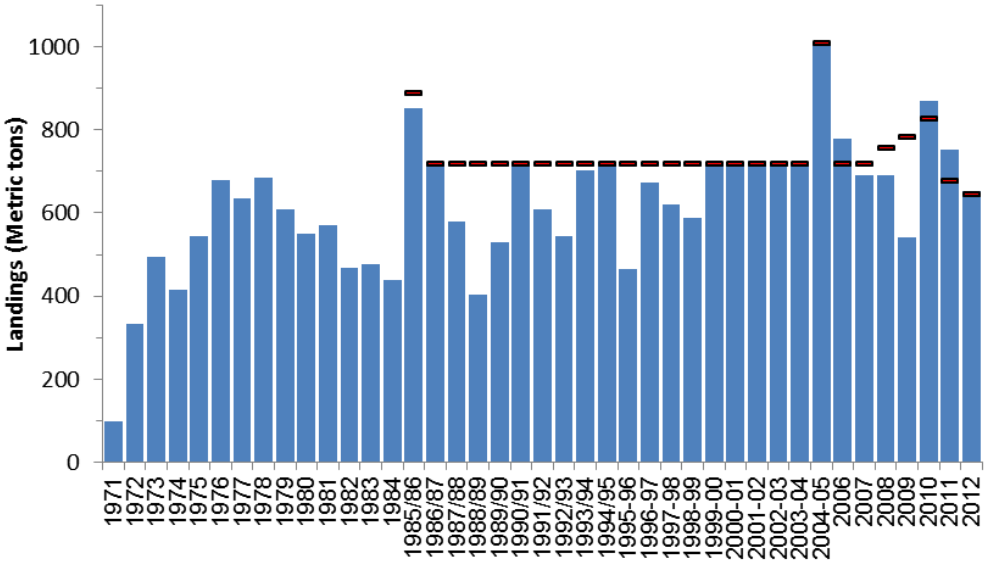


Figure 2. Quota season landings showing adjusted TAC (black dashed line) for the quota period.

Table 2. LFA 41 lobster landings 2001-2012, by NAFO Divisions and fishing season; with TAC and number of vessels. The fishing season is defined as the period for catching the TAC, which has varied over time.

Year	4X	5Zc	Total	TAC	Adjusted TAC	Vessels
2000-01	638	79	717	720	720	8
2001-02	642	83	726	720	720	9
2002-03	650	67	718	720	720	8
2003-04	640	76	717	720	720	8
2004-05	863	150	1013	720	1008	7
2006	675	106	780	720	720	6
2007	560	132	691	720	720	4
2008	568	123	692	720	756	4
2009	414	125	541	720	784	4
2010	706	162	869	720	828	2
2011	584	166	752	720	679	2
2012	501	153	654	720	646	1

Oct. 16th - Oct. 15th for 1986-87-2003-04,
Oct. 16, 2004, to Dec. 31, 2005 (7 of 8 licences with 1 licence retaining Oct. 16th - Oct. 15th), and,
Jan. 1st – Dec. 31st for 2006-2008 (7 of 8 licences with 1 licence retaining Oct. 16th - Oct. 15th year until 2007).

The spatial distribution of landings has varied over time with expansion and contraction of areas fished around core areas that have not changed significantly. A change in fishing strategy can result in a large shift of landings from one area to another. Therefore, year to year changes in landings within an area do not necessarily reflect changes in abundance.

Landings in Adjacent Fisheries

Trends in adjacent fisheries can serve as an indication of pressure on the stocks exploited by both fisheries. While LFA 41 has been capped by the TAC, adjacent fisheries in LFA 34 and the USA are not quota limited and have shown increases over this same time period. The deep water fishery in LFA 34 began in the early 1980s, and has expanded with vessels fishing

adjacent to the 50 mile offshore lobster boundary. The landings of the LFA 34 offshore areas exceeded the total for LFA 41 and are four times larger than the adjacent Gulf of Maine portion of LFA 41 (SW Browns, Crowell Basin and Georges Basin). The LFA 34 offshore and midshore areas produce landings close to 13 times the Gulf of Maine portion of LFA 41. In 1978 LFA 41 landed 684 t representing 21% of the combined LFA 34+41 total of 3331 t landings but in 2012 LFA 41 landings of 654 t represented only 2.7% of the combined landings of 24138 t (Figure 3).

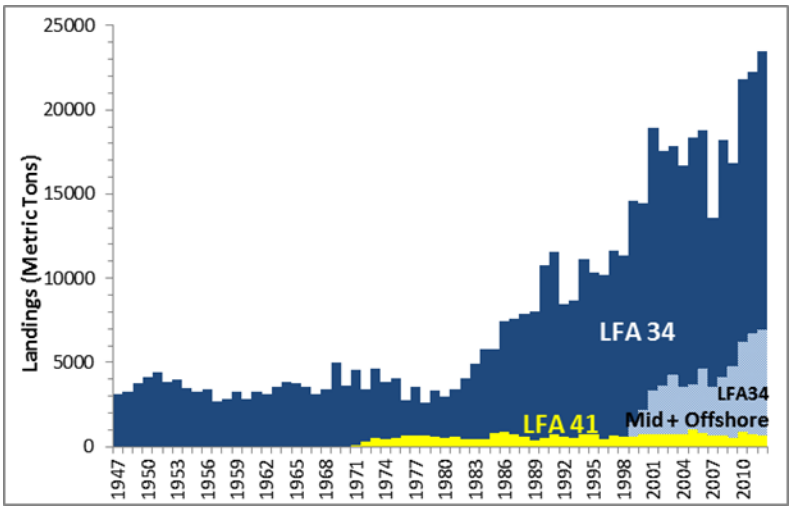


Figure 3. Lobster Landings (1947-2012) LFA 41 and LFA 34 (total and portion from the mid and offshore areas since 1998).

USA landings from NE Georges Bank have increased dramatically in recent years, while Canadian landings have declined slightly. During the 1990s, Canadian and USA landings were similar, but the USA portion averaged over six times that of Canada during the 2000-2007 period (Figure 4).

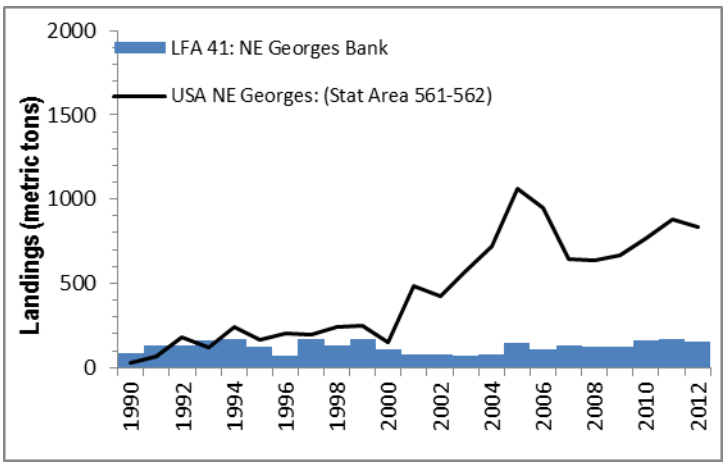


Figure 4. Lobster Landings(metric tons) from 5Z portion of LFA 41 and the adjacent USA portion of NE Georges Bank (Stat Area 561-562).

Effort

Number of vessels has varied over the history of the fishery but originally a share of the quota was assigned to each of 8 vessels. Following the introduction of the Enterprise Allocation in the mid-1980s, the number of vessels was reduced as companies matched operating cost with the

TAC. The number of vessels increased again in the late 1990s with the introduction of the Jonah Crab fishery late in 1995, and some vessels began to target that species. With the decline in Jonah Crab effort in recent years and purchase of the Donna Rae licence by Clearwater Seafoods LP, the number of vessels declined to 4 in 2007. Vessel number was further reduced to two in 2010 and one in 2012.

The recent decrease in total trap hauls (Figure 5) is due to a combination of factors, including the decline in the directed Jonah Crab fishery from 2001 to 2007 (when it ended), higher catch rates due to an overall increase in lobster abundance, and a change in fishing strategy to further optimise catch rates.

Information on changes in trap efficiency, fishing strategy or increased knowledge by the captains is not captured in the log books. Fishermen continually experiment with trap designs and bait to optimize their catch; over time the effectiveness of traps has increased.

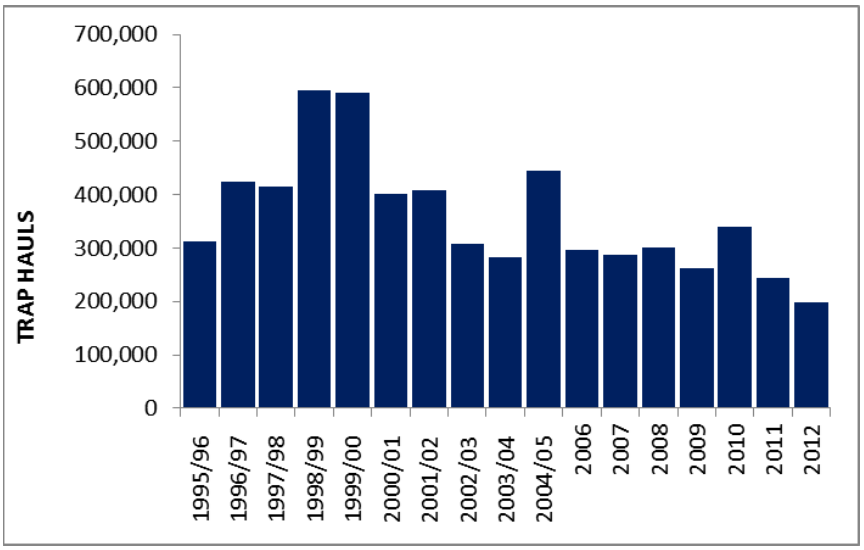


Figure 5. Total reported trap hauls for the quota season 1995-96 to 2012.

Index of Exploitation

Due to the size structure in the catch, traditional methods for estimating exploitation rates are not applicable. Exploitation rate for lobster in LFA 41 has not been directly estimated but is inferred to have been low for many years, and lower now than during the early years of the fishery, as landings have remained constant during a period of increasing abundance. Exploitation of a previously unfished or lightly fished population normally results in a reduction of larger sizes and a truncation of the size frequency. The size structure has remained relatively stable and dominated by mature sizes indicating a low exploitation level similar to that estimated in the USA 2009 lobster assessment of Georges Bank (Fishing Mortality, F = 0.26).

Where absolute estimates of exploitation rates are not available, a relative fishing mortality (Relative F) can be estimated to track trends in fishing mortality. Relative F is calculated from landings and biomass index from the summer survey (Relative F=Landings/Biomass Index). The spatial overlap of the fishery and survey needs to be evaluated to further develop this index of fishing mortality as an indicator for LFA 41 lobster.

Since the mid-1990s, the biomass index has increased (Figure 6) while the TAC has held landings to less than 720 t resulting in a low and declining Relative F.

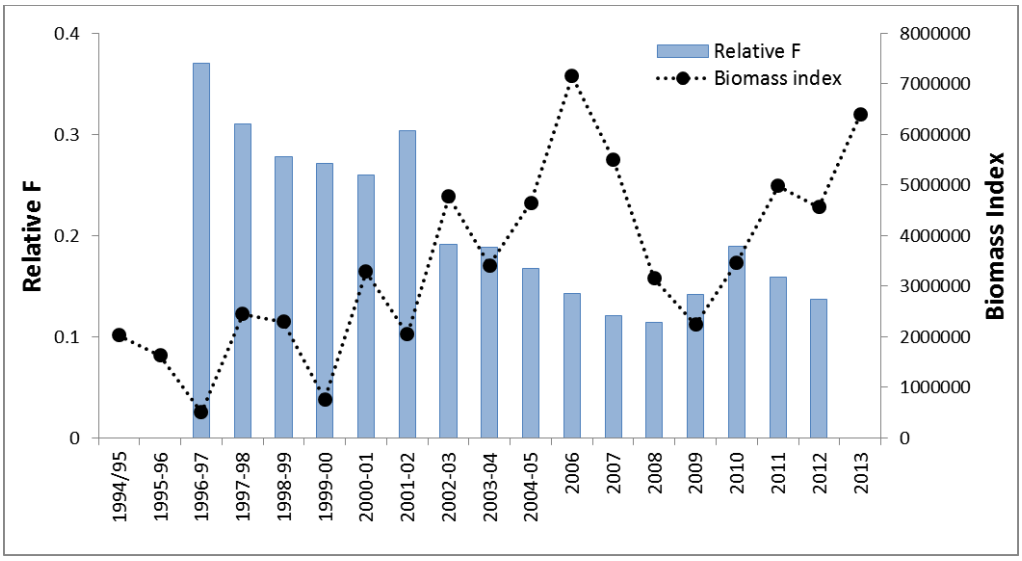


Figure 6. Relative F of the LFA 41 4X lobster fishery and Biomass index from the summer RV survey.

Jonah Crab

The offshore Jonah Crab fishery began in 1995 when a 720 t TAC was established for Jonah Crab in LFA 41 (4X + 5Zc). The species had previously been fished as incidental catch in the lobster fishery but with the introduction of the TAC, some vessels began targeting the crab and resulted in more widespread fishing activity as vessels fished further east, where crab concentrations were present. An experimental Jonah Crab fishery took place in 4W between 1999 and 2002.

Crab landings rose rapidly at the start of the fishery, and the 720 t TAC was caught or nearly caught between the 1996-1997 and 2000-2001 seasons (Figure 7). Landings then declined sharply with only 14 t landed in 2007. During the period when overall landings were high, landings from individual areas rose and fell at different times. Initial landings for Georges Bank dropped in 1997-1998, while landings from areas in the Gulf of Maine increased, especially Crowell Basin in which landings remained high until 2000-2001 and then declined. Landings in Southeast Browns increased in 1999-2000 and were maintained until 2001-2002, when they began to decline. The directed offshore fishery ended in 2007 and no Jonah Crab has been landed since then by LFA 41.

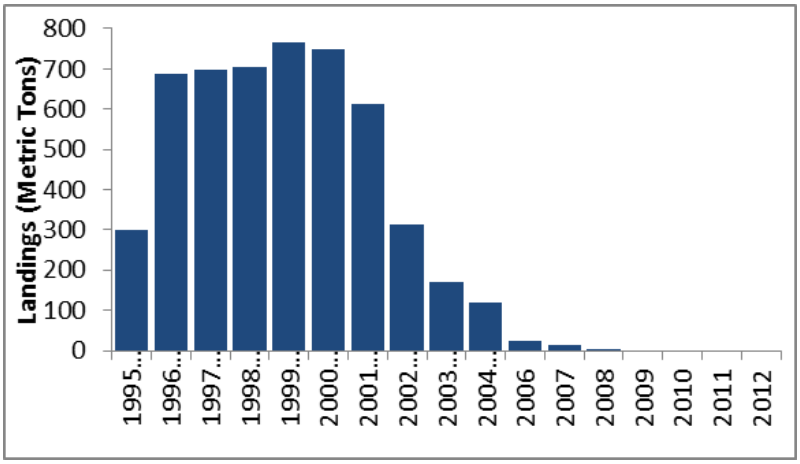


Figure 7. Total Jonah Crab landings for the quota season 1995-2012.

Indicators and Precautionary Approach (PA)

In the absence of direct estimates of population abundance, this assessment has developed a number of indicators that can provide knowledge on trends in the stock and assist in determining appropriate management and harvest strategies.

There is recognition that a single reference point is inappropriate for the lobster fishery as simple abundance level presents only one aspect of stock health and multiple indicators that incorporate a variety of stock health indicators are more appropriate. Abundance, reproductive potential and the related population size structure, recruitment levels and exploitation rates are all important components of stock health.

Precautionary Approach (PA) framework consists of a number of stock health indicators for LFA 41 including primary indicators with defined boundaries that will be monitored and reported on annually. These boundaries were not considered equivalent to Limit Reference Points (LRPs) and Upper Stock Reference (USRs) given the use of multiple indicators to define stock status and precautionary zones, rather than a single biomass indicator as is typical of DFOs PA. These primary indicators are supplemented with a series of secondary indicators that aid in interpreting trends and can provide important information about the ecosystem or the fishery that will aid in determining the type of response if the stock entered the cautious zone.

Many of the indicators below are based on data from trawl surveys. The Maritimes Region surveys and the USA trawl surveys are fishery independent, use standardized gear and procedures, and have long time series (4X 1983-2013; 5Z 1987-2013). The LFA 41 area is largely trawlable bottom and the survey covers the entire fishery and the majority of the lobster habitat, including the Lobster Closed Area on Browns Bank and the shoal waters on Georges where trap fishing does not occur. The Canadian surveys have a shorter time series with size data (4X 1999-2013; 5Z 2006-2013) while the USA data exist for 1982-2012. However, the trawl and the survey design were not originally designed for sampling lobsters so strata and allocation of sets are not optimised for providing precise indices for lobsters. The survey provides a snap shot of the population during one period of the year and the distribution of sets do not in all years match with known distribution of lobsters. The Georges Bank survey only covered depths less than 100 fathoms prior to 2010, though lobster are found in deeper waters. In addition, the catchability of lobsters in trawls on different bottom types is not known.

Primary Indicators

Trait	Indicator	Data Source
Abundance	Level and trends in the stratified mean # of lobsters per tow from Research Vessel (RV) trawl surveys	4X - Maritimes Region Summer RV Trawl Survey 1983-2013 (Strata 477, 478, 480-84). 5Z - Maritimes Region Winter RV Survey 1987-2013 Georges Bank (Strata 5Z1-4)
Abundance of Large size females (indication of exploitation rate)	Level and trends in the mean number per tow of females > 140 mm CL	4X Maritimes Region Summer RV Trawl Survey 1999-2013 (Strata 480-81). 5Z USA Fall RV Trawl Survey for 5Z. 1983-2012 (Strata 16-18, 21)
Size Structure of Population (Reproductive Potential)	Changes in the median size of females in trawl surveys	4X- Maritimes Region RV Summer Trawl Survey 1999-2013 (Strata 480-81). 5Z- USA Fall RV Trawl Survey for 5Z. 1983-2012 (Strata 16-18, 21)
Size Structure of Population (Reproductive Potential)	Changes in the female median size in at-sea samples of commercial catch	4X - SW Browns Spring 4X - SW Browns Fall 4X - Georges Basin Winter 4X - Georges Basin Spring 4X - SE Browns Spring 5Z - Georges Spring

Abundance Indicator: Stratified mean number of lobsters per tow from the Summer DFO Research Vessel (RV) Survey (4X), Winter DFO RV Survey (5Z) trawl surveys. The stratified mean number / tow are widely used as an index of abundance for various species.

The availability of data from both Canadian and the longer running USA surveys provides a check on the quality and consistency of the data. There are some inconsistencies in DFO data from 1983 to the mid-1990s, but both surveys show similar trends in lobster catch rates for this period, indicating that the DFO data quality did not cause a consistent bias.

At the lower abundance levels during the 1980s, the numbers per tow were extremely low. However, this was also a period which sustained a new fishery and provided recruitment which led to the high abundance levels observed today.

A lower boundary for the indicator is recommended at 40% of the median survey catch during the 1983-1994 period. An upper boundary for the indicator is recommended at 50% of the median survey catch of the 1995-2009 period (Figure 8, 9). The rational for this upper boundary is based on concern of the detectability of population abundance changes at lower lobster abundance levels by the surveys and a significant change in abundance levels from those currently observed.

The abundance indicator must be considered along with changes in the size indicators.

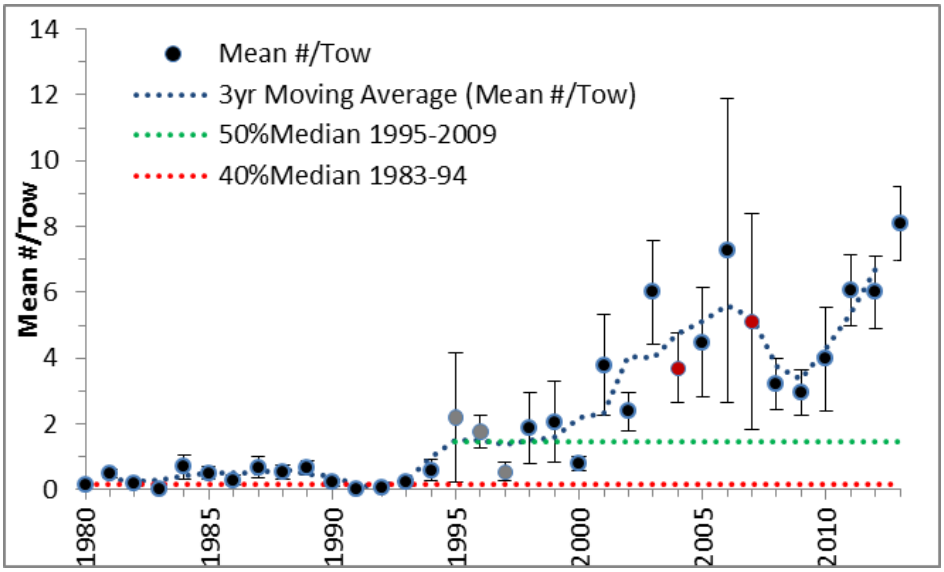


Figure 8. 4X Maritimes Region Summer RV Survey (Strata 477-484): Mean Number per Tow with Standard Errors and a 3 year moving average (red symbols 2004 and 2007 represent surveys with a different vessel, the Teleost, and grey symbols 1995-1997 represent period when count is estimated from the mean weight per tow as count not recorded). Upper boundary (dotted line) set as 50% of the median value 1995-2009 and lower boundary as 40% of the median value 1983-1994.

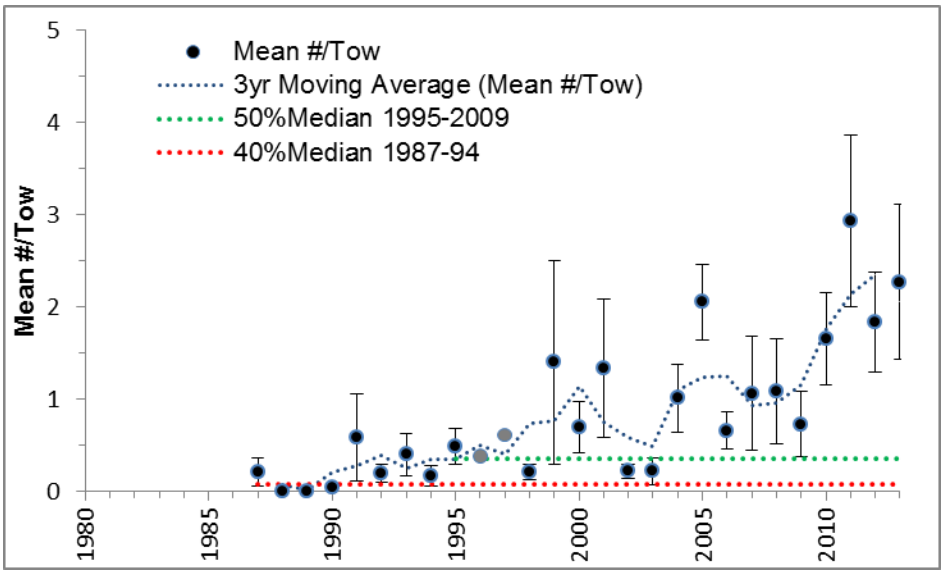


Figure 9. 5Z: Maritimes Region Winter (Georges) RV Survey (Strata Z1-Z4): Mean Number per Tow with Standard Errors and a 3 year moving average (grey symbols (1996-1997) represent period when count is estimated from the mean weight per tow as count not recorded). Upper boundary (dotted lines) set as 50% of the median value 1995-2009 and lower boundary as 40% of the median value 1987-1994.

The **Large Female Size indicator** is a proxy for exploitation rate and changes in reproductive potential and is based on the mean number per tow of females > 140 mm CL in the Maritimes Region Summer RV Survey (4X 1999-2013). The USA NMFS Trawl Surveys for 5Z (1983-2012) provides a longer time series; however, recent changes to the survey reduce their use in the last 4 years until conversion values are applied.

Due to the size structure in the catch traditional methods for estimating exploitation rates are not applicable but it has been inferred to be low based on stability in size structure since the start of the fishery in 1972. Exploitation of a previously unfished or lightly fished population normally results in a reduction of larger sizes and a truncation of the size frequency. Without a direct estimate of exploitation rates, it is proposed that changes in the abundance of larger sizes could serve as an index of the exploitation rate and an early signal of changes in abundance.

The short time series of size data from the Canadian trawl surveys in 4X (Figure 10) and 5Z does not allow for comparison to periods prior to the recent increase in abundance and covers a shorter time period then the overall abundance indictor. Caution is needed on the interpretation of this indicator due to the small sample size in the trawl surveys. The upper boundary is 80% of the minimum value of the time series. No lower boundary is proposed. Upper and lower boundary from USA surveys established 80% and 40% of median value 1983-1994 (Figure 10).

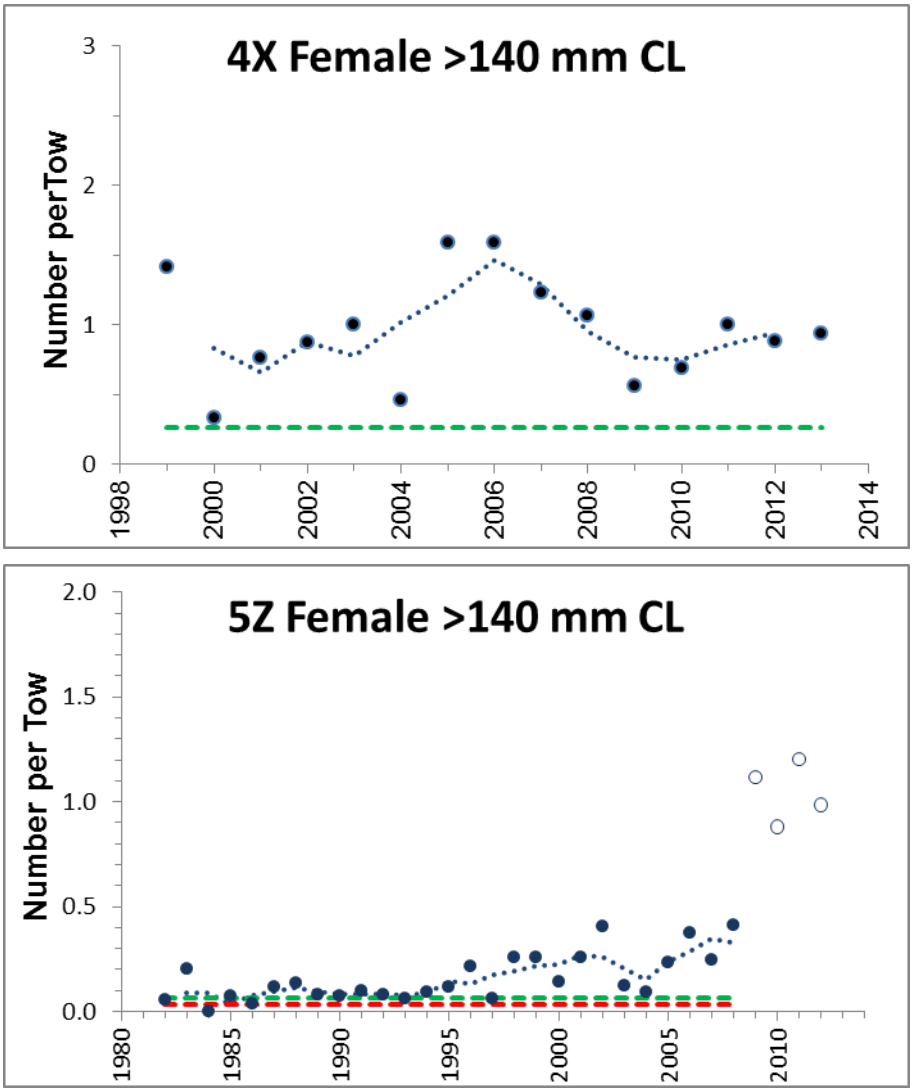


Figure 10. Number/tow of females >140 mm CL with boundaries in 4X Maritimes Region Summer RV Survey, and 5Z NMFS Fall RV Survey. (Data 2009-2012 are from a different trawl and survey design and are not comparable without proper correction factor.)

Median Female Size indicators based on trawl surveys and at-sea samples are proxies for exploitation rate and changes in reproductive potential. The offshore stock is characterised by a large median size with most of the catch of mature sizes which have reproduced at least once and a high proportion more than three times. This high proportion of mature sizes contrasts with adjacent nearshore fisheries which are predominantly recruitment fisheries with the majority of lobsters harvested before maturity. Maintaining a high reproductive potential has been a goal of the LFA 41 fishery since its inception because stock relationships and recruitment sources remain uncertain. A high reproductive potential also reduces the risk of becoming a recruitment based fishery and the vulnerability to recruitment overfishing.

Size structure represents one aspect of the overall reproductive potential with abundance being the second. For this reason, the median size and abundance indicators must be looked at together when interpreting stock status. It is not always possible to distinguish the cause of the changes in median size as it is influenced by changes in large size and recruitment of smaller sizes. Other primary and secondary indicators need to be looked at along with it.

The lower boundary is the size of 50% maturity (historical estimate is 95 mm CL). At sizes below this, the reproductive capacity would be reduced to a level not seen in this fishery, though common in inshore fisheries and it is believed to represent a zone of potential high uncertainty. The upper level is the midpoint between the long term medians and the size at 50% maturity. The historic reference sizes represent a size that has persisted in the fishery and thus represents a productive zone. Setting the upper boundary at the midpoint between the historic size and the size at 50% maturity still provides a buffer, as even at this size it would be larger than that in any other major lobster fisheries.

Median Size based on RV Survey Data: Changes in the median size of females can be tracked using the Maritimes Region RV Survey for 4X 1999-2013 Strata 480-481 and USA Trawl Survey for 5Z 1983-2008. Due to changes in the USA trawl survey protocol and trawl design in 2009, the initial indictor tracks trends up to 2008 and recalibration will be required for data after 2009.

Unlike sea samples, the Lobster sizes in the fishery independent survey are not restricted by the limitations of the traps (i.e. escape vent for small lobsters and entry restrictions for very large sizes) and the surveys cover a wider area of the shelf and banks giving a more complete picture of the sizes present. Sizes are known to vary over the strata surveyed and location of sets could influence the overall median size. The Maritimes Region surveys have a short time series when size data is available.

The lower boundary is the size at 50% maturity (historic estimate is 95 mm CL). The upper boundary is the midpoint between the median size for the reference period (4X- 1999-2012; 5Z- 1983-1994) and the lower boundary size (95 mm CL) (Figure 11, 12).

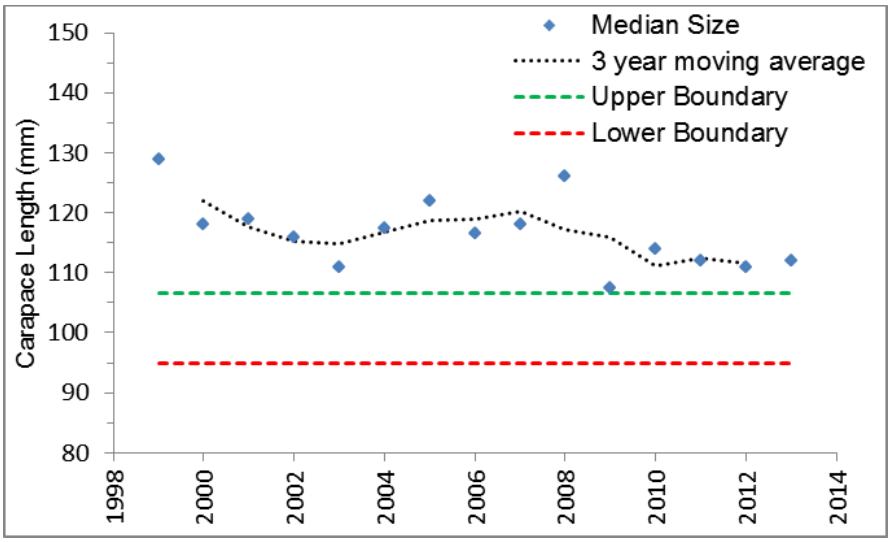


Figure 11. Median size of females from the Maritimes Region Summer RV Survey 4X, with 3 year moving average and upper boundary and lower boundary.

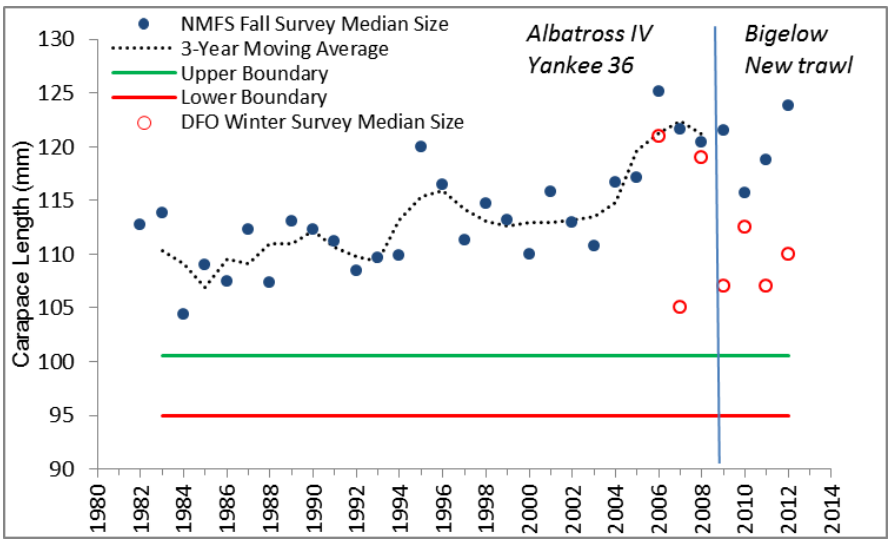


Figure 12. Median size of females from the NMFS Fall RV Survey 5Z, with 3 year moving average and upper boundary and lower boundary, and Median size of females from the Maritimes Region Winter RV survey. Prior to 2009 USA surveys conducted by the NOAA FSV Albatross IV using a Yankee 36 trawl. Since 2009 surveys conducted by the FSV Henry B. Bigelow using a new trawl design.

Median Size based on At-Sea Samples: Size differences on the different fishing grounds have been present since the start of the fishery with large sizes on the outer shelf areas of the Scotian Shelf and Georges and smaller sizes in the Crowell basin, SW Browns areas. The at-sea samples allow monitoring of these site specific differences. The time periods and locations were selected based on their importance to the fishery and availability of a time series of data.

- SW Browns Spring (May-July); Fall (Nov.-Jan.)
- Georges Basin Winter (Feb-April); Spring (May-July)
- SE Browns Spring (May-July)
- Georges Bank Spring (May-July)

The lower boundary is set at 95 mm CL, the historical estimated SOM50. The upper boundary is the midpoint between the median size for the period of sampling (1977-2012) and the lower boundary size (95 mm CL) (Figure 13).

The data has a long time series in most areas with large sample sizes and reflects what the fishery is catching. Historically inconsistent sampling levels and timing results in gaps in the years and changing fishing strategy and emphasis on areas results in years with either no samples or very small samples. Traps are highly size selective towards commercial sized lobsters. Trap caught sizes are influenced by changes in gear and fishing strategies which for the most part are not documented. Given recent changes to the fishery, gear changes and fishing strategies are expected to be more consistent.

Unlike other indicators, a 3 year moving average cannot be applied due to gaps in the data. Changes to the sampling protocol will result in more consistent sampling should allow a moving average to be applied in the future.

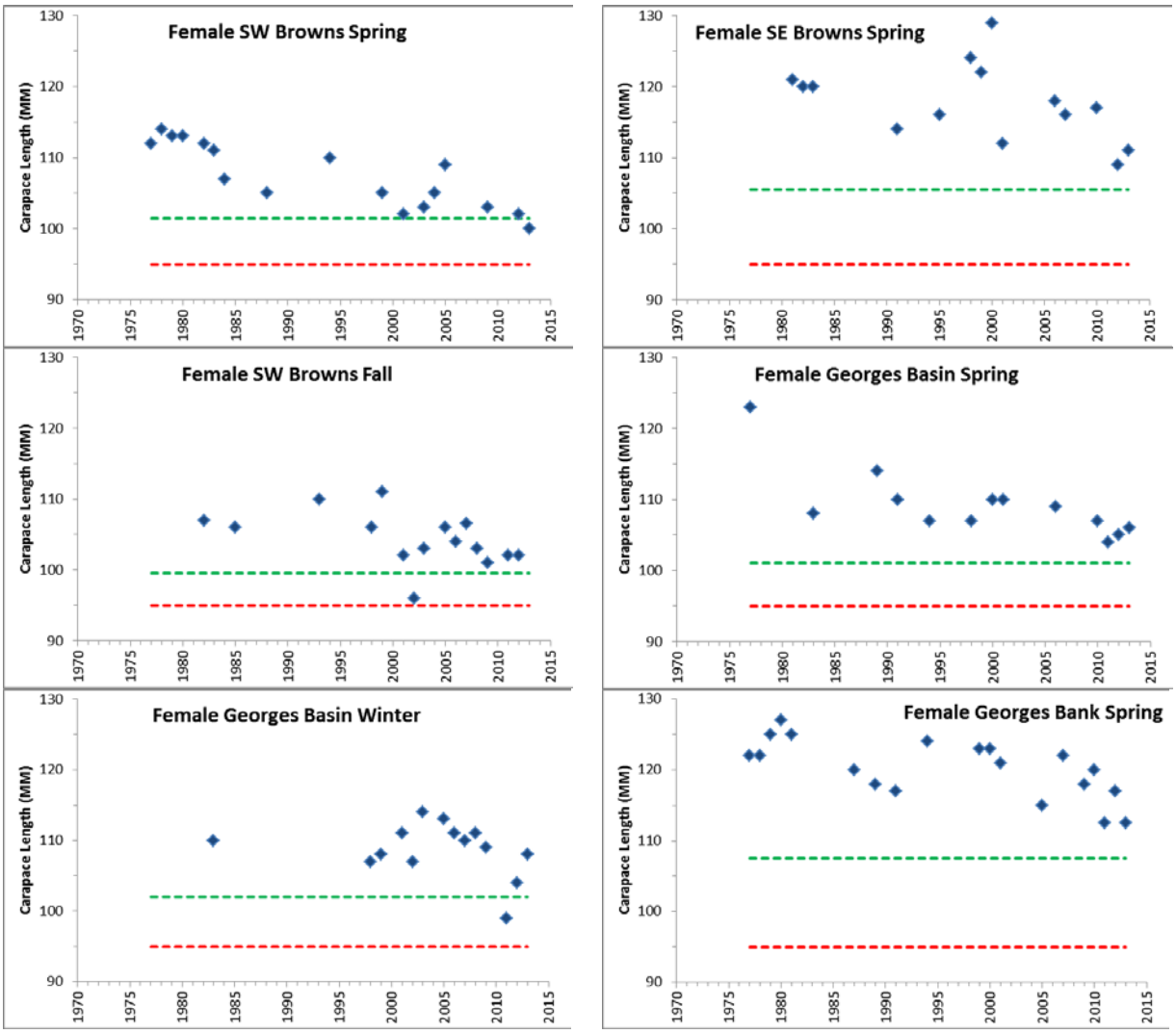


Figure 13. Median size of females from at-sea samples with upper boundary and lower boundary.

Precautionary Approach / Healthy Zone

When interpreting the primary indicators, if all indicators remain above the upper boundary, the population is considered in the healthy zone.

The stock would enter the cautious zone only if the abundance declined below the upper boundary and the size indicators also declined to below the upper boundary.

When the primary indicators are in the cautious zone, the secondary indicators should be reviewed for additional context on what is happening in the stock.

Secondary Indicators

It is recognized that secondary indicators can be helpful to interpret trends and change the perception of stock status, provide important information about the ecosystem or the fishery, and aid in determining the type of response if the stock is in the cautious zone. Secondary indicators also include potential primary indicators which are under development or requiring a longer time series before meaningful boundaries could be applied.

Proportion of trawl survey sets with lobsters

Changes in the proportion of sets with lobsters (non-null sets) can be an indicator of changes in abundance and distribution.

The indicator is based on presence/absence of lobsters in RV survey trawl data in core strata of 4X (477, 478 and 480-483) and 5Z (5Z 1-4). These data would be used to determine if the changes in abundance (primary indicator) are a result of change in distribution or a change in the abundance at a few locations (Figure 14).

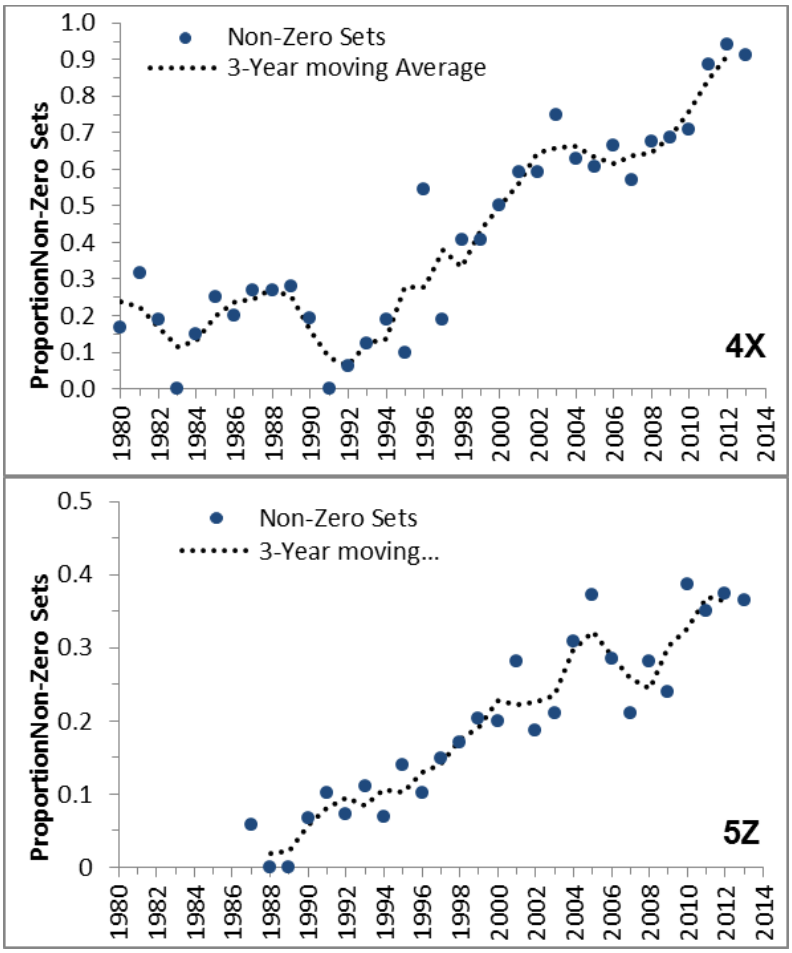


Figure 14. Proportion of non-zero sets in the Maritimes Region Summer RV Survey (4X) and Winter RV Survey (5Z).

Sex Ratio

The sex ratio of sublegal (<82.5 mm CL) and newly recruited lobsters (82.5-94 mm CL) are close to 1:1 (F:M). At maturity the fishery gives greater protection to females through berried female and v-notch protection.

The sex ratio as measured in the Maritimes Region Summer RV trawl surveys show a moderate bias to females in the mature sizes and lobsters >140 mm CL but with a declining trend in recent years.

Both the at-sea and trawl data from Georges Bank show a trend towards higher proportion of the catch being female at sizes >95 mm CL.

The significance of various levels of the sex ratio is not clear, in part because there is no information of what a natural sex ratio would be in an unfished population. Males are able to mate with a large number of females each year and approximately 50% of the mature females are available (33% at sizes greater than 130 mm CL) to mate each year. Thus the present skewed distribution is expected to have little impact on breeding success as long as the wide range of sizes is maintained.

Recruitment

Recruitment is difficult to detect in the offshore areas as the sizes are dominated by large mature sizes.

The number per tow of sublegal (<82.5 mm CL) and newly recruited females (82.5-94 mm CL) as an indicator of recruitment suggests increasing recruitment levels in 4X (Figure 15), matching trends seen in the adjacent areas of LFA 33-38. In 5Z there are no long-term trends noted in the longer time series of the USA Trawl survey.

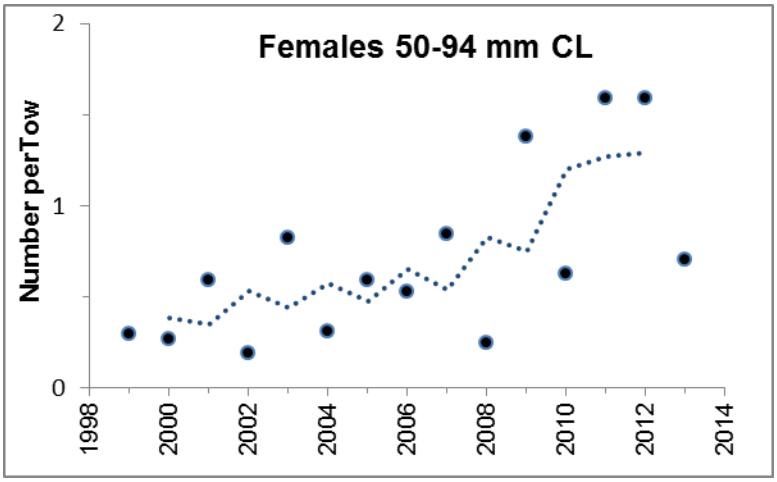


Figure 15. Number per tow of pre-recruits (50-82.5 mm CL) and newly recruited (82.5-94 mm CL) females in the LFA 41 portion of 4X in the Maritimes Region Summer RV Survey. Dotted line is the central moving average.

Ecosystem Considerations

Predation

The increase in lobster abundance in the Gulf of Maine has been hypothesized to be a release from predation by groundfish. The release from predation explanation is plausible in the Gulf of Maine given the sharp decline in the abundance of some key groundfish, but the data to support it are correlative in nature and changing environmental conditions is also a plausible hypothesis.

Quantitative data on the predation impact of fish on lobsters in LFA 41 are not available. A few lobsters have been recorded in the stomachs of fish caught during summer research vessel trawl surveys. The biomass trends in the summer trawl surveys of these species, together with other fish species known to consume lobsters are either trending downwards or slightly above long-term means. Those at low levels are Atlantic Cod, Cusk and Atlantic Wolffish. Those at or above long-term means are Haddock, Longhorn Sculpin, Sea Raven and Spiny Dogfish. The predatory impact of fish is size-related and this is presumably important in the offshore where the average size of lobsters is greater than in inshore areas. Most lobsters in the offshore are vulnerable only to the largest fish predators. As such the average size of fish needs to be considered in evaluating predation impact. It would be expected that species such as sculpins and Sea Ravens could only consume smaller juvenile lobsters.

Given the current biomass levels of the selected potential lobster predators, there is no expectation of a near-term increase in the natural mortality of lobsters due to these species.

Temperature Variability

Temperature is the primary physical factor affecting lobster biology, movements and catchability in traps. With regard to temperature variability, the North Atlantic Oscillation (NAO) has significant impacts on annual variations in the ocean climate of the western North Atlantic and the Gulf of Maine, including LFA 41. In recent years, correlation between NAO and temperature variation on the western Scotian Shelf has not been strong. The NAO for 2010 was lowest on record. It was expected that bottom temperatures would be colder than average by 2012; however, this was not the case.

July bottom temperatures were above the 1980-2010 averages by 1.2°C in 2012 and 0.8°C in 2013 for the shelf portion of NAFO Region 4Vs, by 1.7°C in 2012 and 0.6°C in 2013 for 4W, and by 2.1°C in 2012 and 1.0°C in 2013 for 4X.

In 2012, satellite sea surface temperature was above the 1981-2010 average temperature by 2.0°C for Georges Bank, 2.5°C for the western Scotian Shelf and 1.7°C for Western Bank. For 2013 (up to November), the temperature was above the 1981-2010 average temperature by 1.1°C for Georges Bank, 0.9°C for western Scotian Shelf and 1.3°C for Western Bank.

Temperatures in 2012 were above normal by 1.8°C (3.0 SD) for eastern Georges Bank at 50 m, by 0.5°C for Georges Basin at 200 m, by 0.7°C for Emerald Basin at 250 m and by 1.3°C for Misaine Bank at 100 m.

Footprint

The percentage of the area of LFA 41 contacted by lobster traps was estimated from the effort (annual number of trap hauls) for the last 5 years (2008-12), together with the area of an average lobster trap used in the LFA 41 fishery (4 feet by 2 feet or an area = 0.76 m^2). These estimates do not account for (i) any movement of the traps over the bottom either due to storms or while hauling (ii) any bottom contact by trawl lines and (iii) repeat contact with the bottom. The analysis provides estimates for the average bottom contact over the main fished areas.

The estimates for LFA 41 indicate a very low percentage of the bottom is contacted by traps, with an overall estimate for LFA 41 in 2012 of 0.0005% and estimates for individual subareas all less than 0.006% The SW portion of Browns Bank (the smallest subarea) had the highest estimate. The overall values have declined in the last few years with the decline in number of trap hauls. The risk to bottom habitat from trap contact in the LFA 41 fishery is thought to be low.

Incidental Catch

LFA 41 at-sea samples include recording the levels of incidental catch. All species are identified and weights estimated. Estimates of 2012 non-lobster incidental catch were 46 t. The overall incidental catch has declined since 2006 when it was 154 t. The total incidental catch in 2012 represented 7% of the total lobster landings and only 3% when the Jonah Crab is not included. The ending of the directed Jonah Crab fishery and concentration on areas of highest lobster CPUE are believed to have contributed to the reduced incidental catch.

The incidental catch of all species declined with the exception of hake, Sea Ravens and Haddock (which showed no change) (Table 3). Jonah Crab represents the largest incidental catch in 2012 at 26t. No Atlantic Wolffish or Monkfish were observed in the recent years.

Table 3. Estimated incidental catch (metric tons) of the species or species groups observed in the LFA 41 lobster fishery 2006 and 2012. Also showing the retained and returned portion of the Jonah Crab catch.

Species	2006	2012
Jonah Crab Returned	88	26
Retained	30	
Rock Crab	5.3	0.05
Cusk	26.6	8.6
Atlantic Cod	7.9	4.6
Hake species	4.1	4.8
Haddock	1.1	1.2
Pollock	0.07	0.02
Redfish species	0.40	0.17
Rosefish (black belly)	0.26	0.11
Sea Raven	0.09	0.31
Sea Robin	0.03	0.003
Sculpin species	0.05	0.05
Atlantic Wolffish	0.07	0.04
Total	164	46
Total without Jonah Crab	46	20

DFO conditions require that lobster < 82.5 mm CL, egg bearing females, and V-notches females must be returned to the water and company policy is to return lobster > 6 lb (approx. 150-155 mm CL). Approximately 14% of the lobsters caught are returned to the sea and based on tagging programs post-release survival is known to be high. In 2012 sublegal sizes account for 20% of the returns (4X- 24%; 5Z- 11%), lobsters > 6lb 20% (4X- 20%; 5Z- 20%) and berried females 60% (4X- 56%; 5Z- 69%).

Sources of Uncertainty

The waters of the outer shelf and basins in the Gulf of Maine are influenced by water mass movements caused by larger scale oceanographic events that will influence short term distribution and catchability. The influence these oceanographic events have on indicators of lobster stock status is not fully understood.

The origin of lobster caught in LFA 41 and adjacent areas are uncertain. Genetic work suggests that lobster caught in LFA 41 are a genetically more heterogeneous than adjacent areas. This heterogeneous genetic structure is consistent with multiple areas of origin for lobster caught in LFA 41. The proportion of lobster originating locally and in adjacent areas has not been quantified.

Quantification of stock origin, recruitment patterns, and migration history of lobsters caught in LFA 41 are necessary to fully understand the biological implications of the LFA 41 management unit boundaries.

There is uncertainty as to the source of recruitment to the fishery. Trawl surveys indicate pre-recruits in the offshore and tagging also shows some out migration of mature animals from more coastal areas. The importance of these two sources varies with location and time depending on larval settlement and relative densities of lobsters on the different grounds.

Fishery-dependent data is based on traps that are designed to allow sublegal size lobster (less than 82.5 mm CL) to escape and trap selectivity results in declining catchability with increasing sizes above 140 mm CL. Capture in the traps is dependent upon lobster behaviour and activity that varies seasonally and with temperature, size, sex, and maturity.

Changes in trap design over the history of the fishery are poorly documented and are not accounted for in the analysis. At-sea sample data are grouped by 3 month periods and assessment area to reduce variations caused by timing and location, but smaller scale variations in sample locations and timing of samples and lobster movements cannot be accounted for in the analyses.

The trap data is only available from the fishing grounds, with no samples from shallower areas of the banks where smaller sized lobsters have been found to be more abundant and where mature lobster move during the summer months.

Fishery independent trawl data used for abundance and size indicators are snapshots from a single month. The surveys are not optimized for catching lobsters. Trawl surveys sample all areas but the gear is not designed to catch or retain the smaller sizes. The selectivity of the gear for lobsters is not known, but the trawl design and vessels have remained the same over the majority of the time period. A change in the USA survey vessel, gear and survey protocol in 2009 has created uncertainty as there is an apparent change in the catchability of lobster in that survey. Correction factors have been developed and will be used to adjust the values in future assessments.

CONCLUSIONS

A series of primary indicators (Table 4) for LFA 41 Lobster were chosen, and boundary levels were set for each of these. These boundaries were not considered equivalent to LRPs and USRs given the use of multiple indicators to define stock status and precautionary zones, rather than a single biomass indicator as is typical of DFOs PA. A combination of abundance and size indicator values is used to define the cautious zone. Currently the primary indicators are all above the proposed upper boundary indicating the stock is in the healthy zone. The stock continues to show positive signs of increase, there has been no change in size structure, and the fishing mortality on the stock is low and has declined in recent years.

The primary indicator for abundance (mean number per tow in RV trawl surveys) has been increasing since the mid-1990s, with signs of continued increase, and is at all-time high for the 30 year time series. The lowest values are considered to correspond with a healthy and productive state. As a result, there is no “low” point from which to judge potential for recovery.

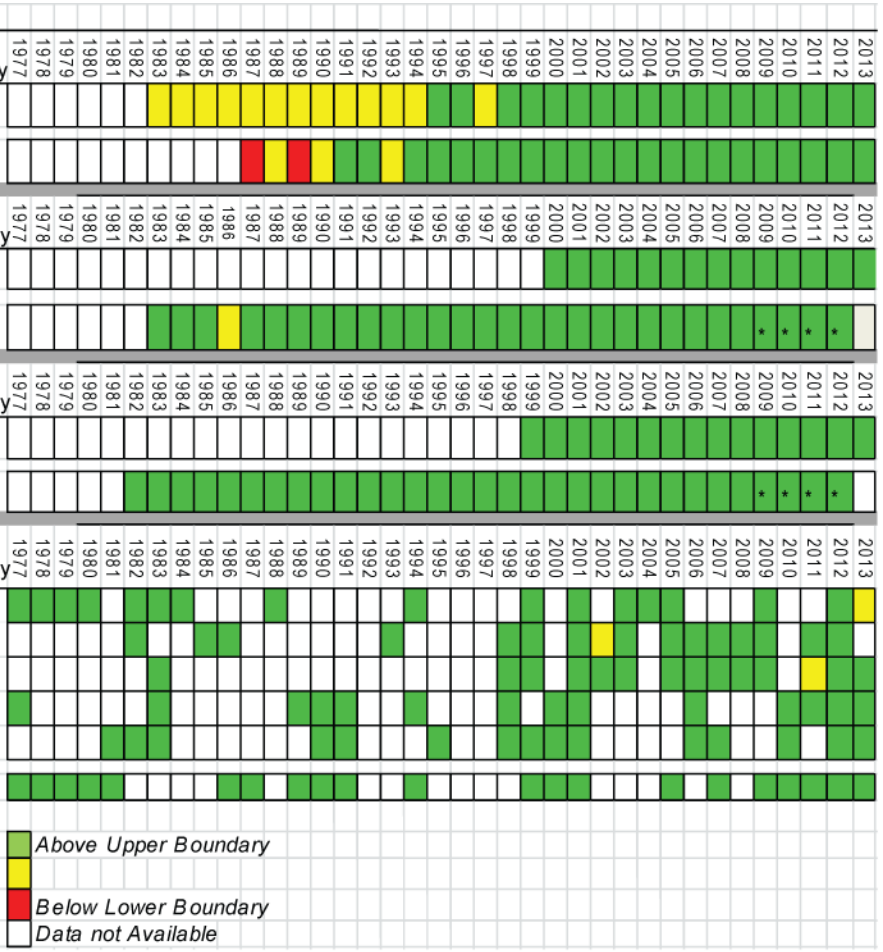
Size based primary indictors show shifts in the median size and abundance of large sizes but all are within the healthy zone and the population maintains a size structure dominated by mature sizes.

Based on the current indicators of abundance, fishing pressure and production, the current TAC of 720 t (in place since 1985) has had no detectable negative impacts on the lobster in LFA 41 overall and is considered to represent an acceptable harvest strategy at this time.

Assessment and review of the PA and indicators are scheduled every 5 years and values of the primary indicators will be updated annually. Earlier assessment would be considered if abundance and size indicators both go below the upper boundaries identified, therefore indicating that the population has moved into the cautious zone. An update and consideration of the secondary indicators will be required in new assessments.

Table 4. Primary indicators[1] in the offshore lobster (LFA 41) fishery.

			Upper Boundary	Lower Boundary
Abundance	Mean#/Tow	Mean #/Tow 4X Maritime Region Summer RV Survey	1.48	0.16
		Mean #/Tow 5Z Maritime Region Winter RV Survey	0.35	0.07
Abundance	Large Size Females >140		Upper Boundary	Lower Boundary
		Mean #/Tow 4X Maritime Region Summer RV Survey	0.27/tow	
		Mean #/Tow 5Z NMFS Fall RV Survey	0.12/tow	0.06/tow
Median Size	Female Median Size Trawl based		Upper Boundary	Lower Boundary
		Median female 4X Maritime Region Summer RV Survey	106	95
		Median female 5Z NMFS Fall RV Survey	97	95
Median Size	Female Median Size At-sea sample Based		Upper Boundary	Lower Boundary
		4X-SW Browns Spring	101	95
		4X-SW Browns Fall	99.3	95
		4X-Georges Basin Winter	102.3	95
		4X-Georges Basin Spring	102	95
		4X-SE Browns Spring	106.5	95
		5Z Georges Spring	108	95



[1] Female median size at-sea sample based upper boundary values were revised August 15, 2014.

SOURCES OF INFORMATION

This Science Advisory Report is from the December 3-4, 2013 and January 9, 2014 Review of the Framework and Assessment of LFA 41 (4X + 5Zc) Lobster. Additional publications from this meeting will be posted on the *Fisheries and Oceans Canada (DFO) Science Advisory Schedule* as they become available.

Little, S.A., and W.H. Watson. 2005. Differences in the size at maturity of female American lobsters, *Homarus americanus*, captured throughout the range of the offshore fishery. Journal of Crustacean Biology 25(4): 585-592.

Pezzack, D.S., and D.R. Duggan. 1989. Female size-maturity relationships for offshore lobsters (*Homarus americanus*). Can.Atl.Fish.Sci.Adv.Comm.Res.Doc. 89/66: 9.

Tremblay, M.J., D.S. Pezzack, J.Gaudette, C. Denton, M. Cassista-Da Ros, and J. Allard, 2013. Assessment of lobster (*Homarus americanus*) off southwest Nova Scotia and in the Bay of Fundy (Lobster Fishing Areas 34-38). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/ 078 . viii + 125 p.

THIS REPORT IS AVAILABLE FROM THE:

Centre for Science Advice (CSA)
Maritimes Region
Fisheries and Oceans Canada
PO Box 1006, 1 Challenger Drive
Dartmouth, Nova Scotia
Canada B2Y 4A2

Telephone: 902 426-7070
Fax: 902 426-5435
E-Mail: XMARMRAP@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087

Correct Citation for this Publication:

DFO. 2014. Assessment of Lobster (*Homarus americanus*) in Lobster Fishing Area 41 (4X + 5Zc). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/034 (Revised).

Aussi disponible en français :

MPO. 2014. Évaluation du homard (Homarus americanus) de la zone de pêche du homard 41 (4X + 5Zc). Secr. can. de consult. sci. du MPO, Avis sci. 2014/034 (Révisé).