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Canadian Science Advisory Secretariat
Quebec Region | Science Advisory Report 2016/054

ASSESSMENT OF THE GREEN SEA URCHIN FISHERY IN THE NORTHERN ESTUARY AND GULF OF ST. LAWRENCE IN 2015

Photo: Claude Nozères

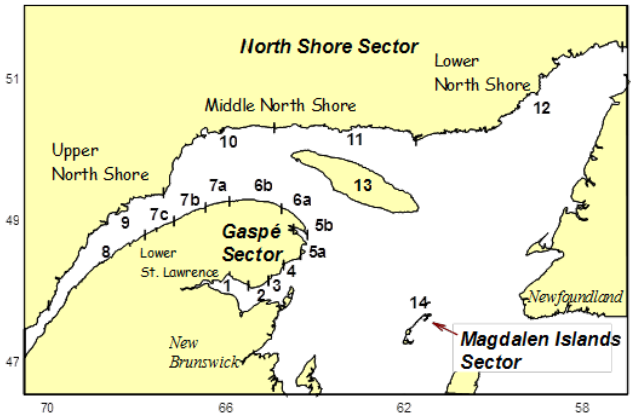

Figure 1. Green Sea Urchin Management Areas in the Estuary and Gulf of St. Lawrence.

Context:

The commercial Green Sea Urchin (Strongylocentrotus droebachiensis) fishery began in the Estuary and northern Gulf of St. Lawrence in 1991. Fourteen areas were created (Figure 1); however, many are still unfished or underutilized. Although trap fishing is permitted, green sea urchins are mainly collected by diving. Current management measures include a limited number of licences per area, a minimum catch size of 50 mm test diameter and dive fishing seasons generally set from the end of March to the end of December. Harvesting takes place once the ice cover opens up and the gonad yield increases from the end of March to May and from September to December.

Fishing effort in Quebec is concentrated in Areas 8 and 9 in the St. Lawrence Estuary. Green sea urchin landings fluctuated between 7 and 187 tonnes (t) until 2005, when they surged to 684 t and 762 t in 2006 and 2007 (Figure 2). This was primarily due to the increase in fishing effort at the mouth of the Saguenay in Area 9. Landings then stabilized somewhat between 500 and 600 tonnes per year.

The resource is usually assessed every three years to determine whether recent changes in the status of the resource provide a rationale for adjusting the conservation approach and management plan. The last assessment of this fishery dates back to 2012 and focused primarily on Areas 8 and 9. This Science Advisory Report is from the June 9, 2016 meeting on the Assessment of the Green Sea Urchin Fishery in the Northern Estuary and Gulf of St. Lawrence in 2016. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada Science Advisory Schedule as they become available.

SUMMARY

- Annual green sea urchin landings along the North Shore were sporadic and generally low (<145 t) until 2005. Since 2006, they have remained above 150 t and peaked at 698 t in 2007. Most of these landings came from Area 9. Although landings have been reported for Areas 3, 7, 10, 11, 12 and 14 since 1991, they have been either intermittent or insignificant. Area 11 was the only one of these areas that reported landings for the 2016 spring season. Since 2004, 44 to 91% of total landings in Quebec came from subarea 9-1.

Area 9

- Since 2012, landings have fluctuated around 420 t and come almost exclusively from Batture aux Alouettes in subarea 9-1. The total number of fishing days authorized in this area has been used every year since this regulation came into force in 2010. However, the number of diver-hours (dh) has been increasing since 2010, except in 2015 when there was a slight decrease. The average catch per unit effort (CPUE) (kg/dh) is relatively stable and has been above the historical average since 2010. The average commercial size of landed sea urchins has been stable since 2010.

Area 11

- Preliminary landings for spring 2016 were 23 t. It was the first year since 2009 where landings increased. Average CPUE for spring 2016 was comparable to those in 2006–2008 when fishing effort was relatively high.

INTRODUCTION

Species biology

Green sea urchins have separate sexes that cannot be distinguished based on external characteristics. Both male and female sea urchins are harvested for their gonads. The five gonads undergo significant changes in volume, firmness and colour over an annual reproductive cycle. In winter, gonad weight may account for as much as 25% of the sea urchin's total weight. During spawning in May or June in the St. Lawrence Estuary, gonad weight drops below 10% of the urchin's total weight and remains low throughout the summer. The sea urchin loses its commercial value during this period. However, gonad weight increases once again in the fall, restoring the species' commercial value.

The green sea urchin reaches sexual maturity with a test (shell) diameter ranging from 25 to 30 mm at approximately three to four years of age. Fertilization is external and produces pelagic larvae that drift in the surface water from one to four months and then settle on the bottom. In the early benthic phase, juvenile sea urchins barely measure 0.5 mm in diameter. They reach the 50-mm minimum legal size when they are between five to seven years of age and can live several more decades. Sea urchin growth rate may vary considerably and depends primarily on the quality and quantity of available food. Sea urchins grow more rapidly along the edges of kelp beds or in areas where there is a regular supply of drifting algae.

In more favourable areas, green sea urchins form feeding fronts or high-density aggregates and strip the algae from the substrate. When large sea urchins are removed from feeding fronts, they can be replaced by sea urchins already present in the area or sea urchins that have migrated from deeper waters.

The green sea urchin survival rate is usually quite high in the absence of fishing. The main causes of natural mortality among sea urchins are osmotic stress, predation and disease. Larvae and juveniles are especially sensitive to low salinity and it has been suggested that recruitment in the upper St. Lawrence estuary can be episodic due to unfavourable salinity conditions that sometimes impact larval survival. Along the Quebec coastline, the main green sea urchin predators include lobster, crab, large starfish, wolfish, and seabirds.

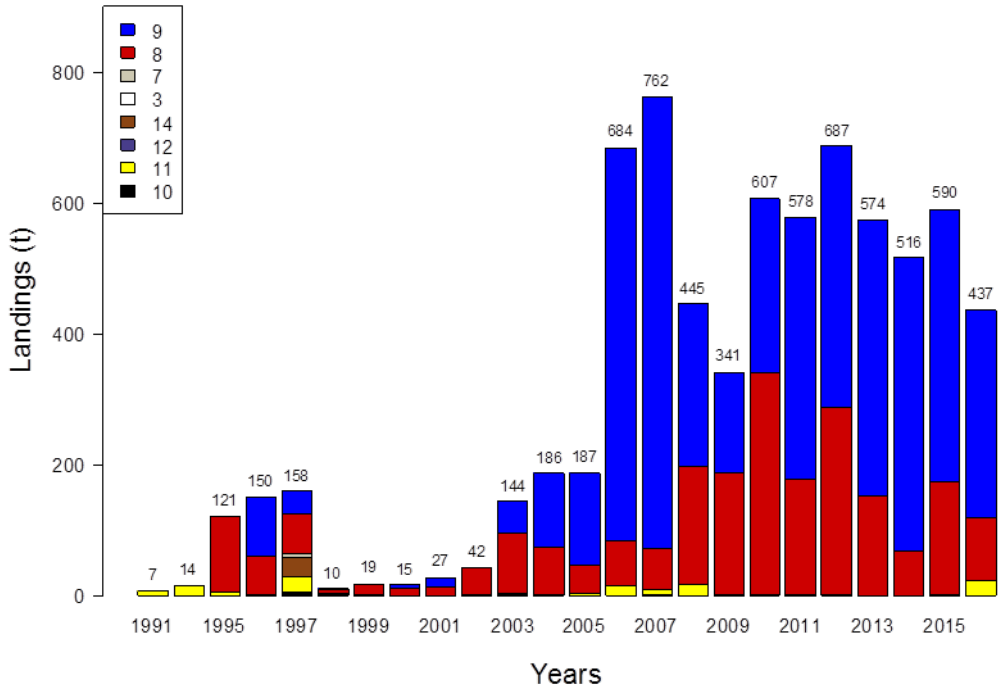

Figure 2. Green Sea Urchin Landings for all Areas in Quebec, starting in 1991. Figures indicate total landings in Quebec for each year. 2015 and 2016 data are preliminary and 2016 does not include spring fishing data.

Description of the fishery

The Quebec coastline is divided into 14 main green sea urchin fishing areas. Areas 9 to 12 of the North Shore area are much larger than areas in the Gaspé region (Figure 1). This advisory report focuses primarily on Areas 9 and 11. Area 9 extends from Pointe-au-Pic to Pointe des Monts. Since 2010, the subarea 9-1 boundary has been set at the mouth of the Saguenay to better monitor more intensive fishing operations in this area. This subarea includes Batture aux Alouettes, Baie Ste-Catherine and Batture de la Pointe aux Vaches. Area 11 begins east of the Rivière Sheldrake bridge and extends to the tip of Natashquan.

There are two authorized methods for harvesting green sea urchins in the Quebec region: underwater diving and whelk traps. The trap fishery has never been widespread. Traps were primarily used in Area 9 and have not been used since 2007. Towed fishing gear is prohibited in the commercial fishery outside culture sites.

Green sea urchin management measures in effect in the Quebec region are designed to protect reproductive potential by controlling fishing effort. The number of exploratory licences, divers and traps is limited in each fishing area. The minimum legal size is a 50 mm test diameter in all fishing areas. Underwater diving for sea urchins is permitted almost all the time, but the use of traps is usually prohibited from spring to fall.

Logbooks are mandatory in the Quebec region. They indicate fishing trip duration and landings, harvesting method, locations where catches were made and, if applicable, the number of divers or traps and their immersion time, as well as the duration, depth and composition of the sea floor at each dive.

Seven licences have been issued for Area 9, five of which have been permanent since 2009. Permanent licence holders have exclusive use of subarea 9-1, but are limited to a total of 80 boat days (bd). They are also entitled to fish for an additional 12 days in the Saguenay–St. Lawrence Marine Park and another 12 days outside the park, but still in Area 9. Two exploratory licences may be issued for trap fishing, but this type of fishing has not been practised since 2007. The maximum number of divers per licence is four; however, only three can dive at once while the other diver waits aboard the vessel. The number of traps (maximum 0.3 m3 volume, minimum 102 mm mesh size with mandatory escape vents) is limited to 100 per boat. In 2016, dive fishing was authorized from March 20 to December 31. Trap fishing is prohibited within the boundaries of the Saguenay-St. Lawrence Marine Park and during the whelk fishery. Mandatory dockside monitoring and the Vessel Monitoring System were added in 2015.

A total of 10 exploratory licences are authorized in Area 11. Fishing effort is limited to 40 bd for all licence holders. Over the past 10 years, only one to three fishermen have been active each year. The number of divers is limited to four per boat, three of whom can dive at once while the other waits aboard. There has been no trap fishing since 1999.

With the exception of Area 8, Area 11 was the only other area to report landings in the spring of 2016.

ASSESSMENT OF THE RESOURCE IN AREAS 9 AND 11

Various commercial fishery indicators were used to assess the status of the resource in Areas 9 and 11. These indicators provide information on spatial distribution, fishing effort and success, as well as green sea urchin abundance and size.

Commercial fishery statistics are used for estimating fishing effort and calculating catches per unit effort (CPUE). Effort and CPUE are expressed in diver-hours (dh) and kilograms per diver-hour (kg/dh). The CPUE is a good indicator of sea urchin abundance in fishing areas. A second index in boat-days (bd) and kilograms per boat-day (kg/bd) is also considered when fishing effort (number and duration of dives) is not recorded.

Area 9 resource status

Landings and fishing effort

The fishery began in 1996 with landings of 89 t. Landings then fell to between 1 and 14 t between 1998 and 2002. They then increased to a peak of 690 t in 2007 (Figure 3). Since 2005, virtually all fishing has been conducted in subarea 9-1 at the mouth of the Saguenay, specifically at Batture aux Alouettes, where the area of the fishing grounds is only 1.67 km^2. In 2006, fishing effort and landings increased significantly, which led to the implementation of management measures to limit landings in subsequent years. A seasonal closure was implemented in 2008, then subarea 9-1 was created, the number of licences was restricted and fishing effort controls were introduced in 2010, which decreased landings starting in 2008. Since 2011, landings have been stable at approximately 420 t. In 2014, a catch limit of 6000-kg per fishing day per boat was introduced. Since 2004, subarea 9-1 alone has accounted for between 44 and 91% of landings in Quebec.

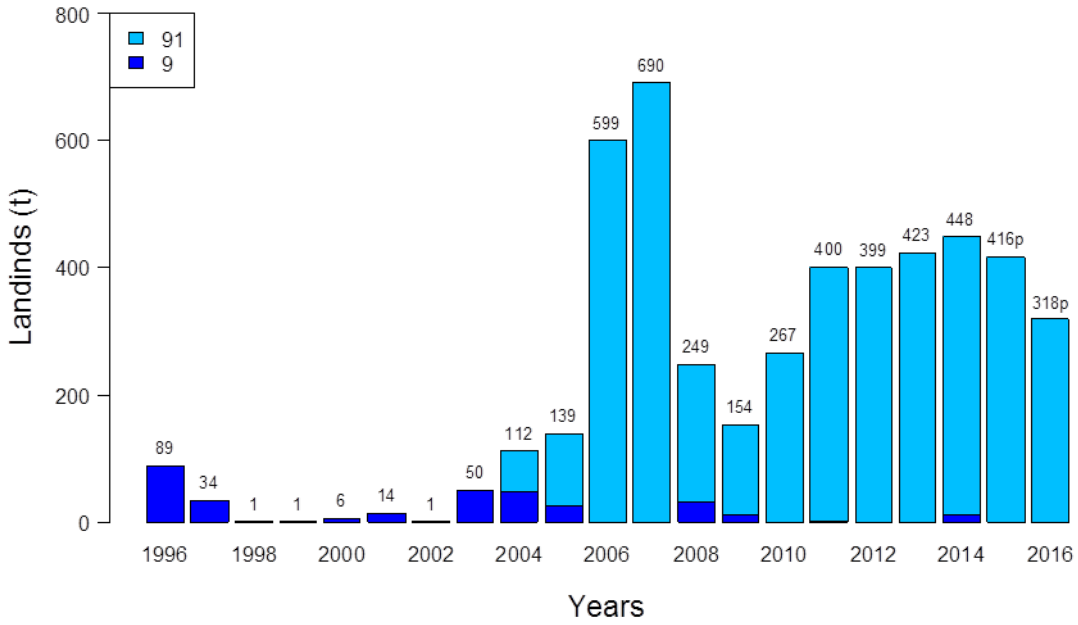

Figure 3. Green Sea Urchin Landings in Area 9 from 1996 to 2016. Subarea 9-1 has existed only since 2010; however, the section covered by this subarea is indicated for previous years to show its significance compared to the rest of Area 9. The figures indicate total landings in Area 9 for each year. 2015 and 2016 data are preliminary and 2016 does not include spring fishing data.

From 1996 to 2004, fishermen primarily harvested sites near Forestville and Saint-Siméon. Figure 4 shows the distribution of positions shown on purchase slips from recent fishing years. The three areas at the mouth of the Saguenay were regrouped to form subarea 9-1. Since 2005, most green sea urchins have been harvested in this subarea, especially in the bed in the Batture aux Alouettes area.

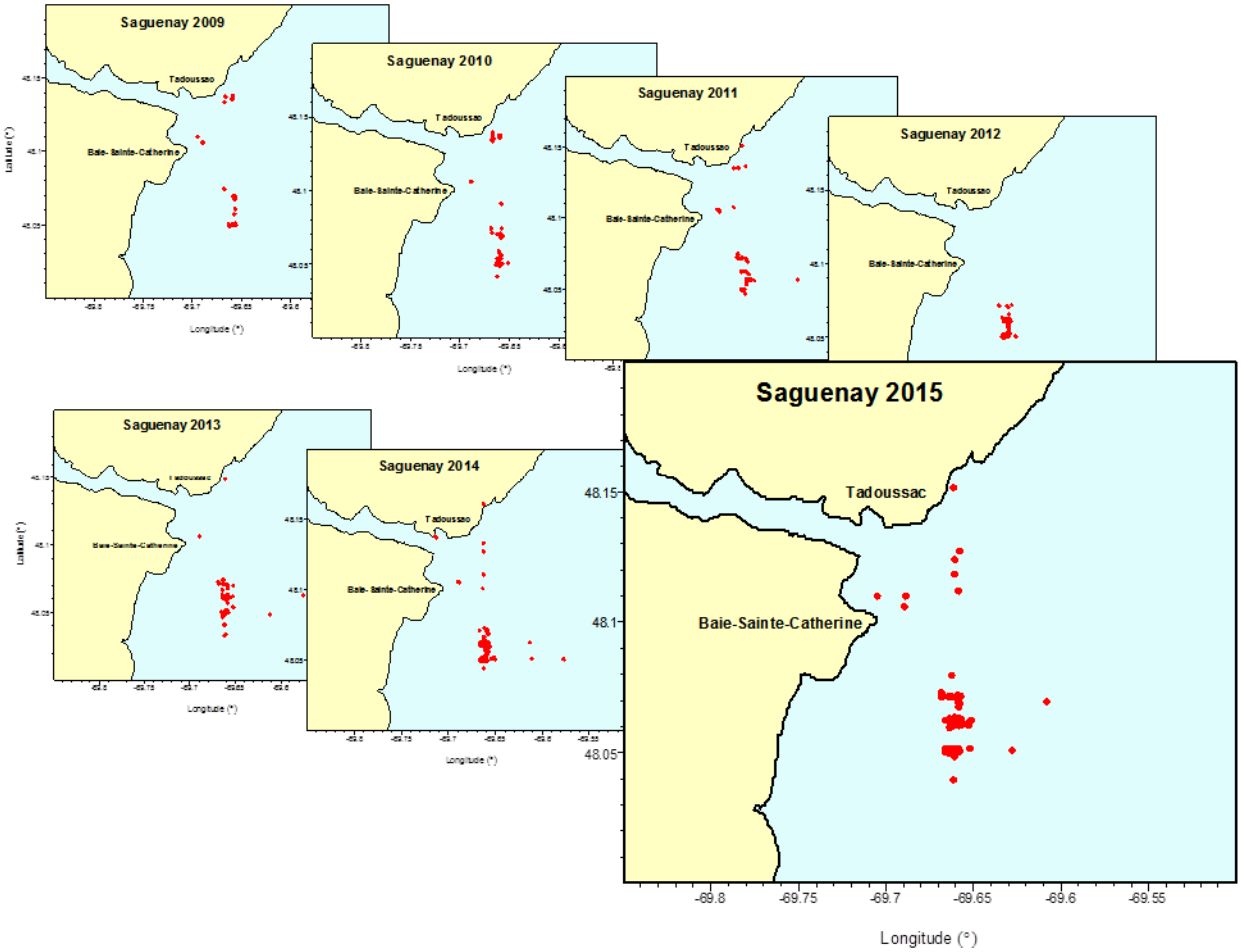

Figure 4. Distribution of Fishing Effort from 2009 to 2015 in Subarea 9-1 at the Mouth of the Saguenay. BA = Batture aux Alouettes; BPV = Batture de la Pointe aux Vaches; BSC = Baie Sainte-Catherine. No fishing position data were available for 2016 at the time of the assessment.

Fishing effort measured in bd stabilized starting in 2010 when an 80 bd limit was introduced (Figure 5). All authorized days are used every year. This fishing effort limit has proved to be extremely effective in maintaining landings at a more reasonable level. Since this management measure was introduced, fishermen have nevertheless been able to increase their fishing effort measured in dh by 67% between 2010 and 2014, from 657 to 1100 dh.

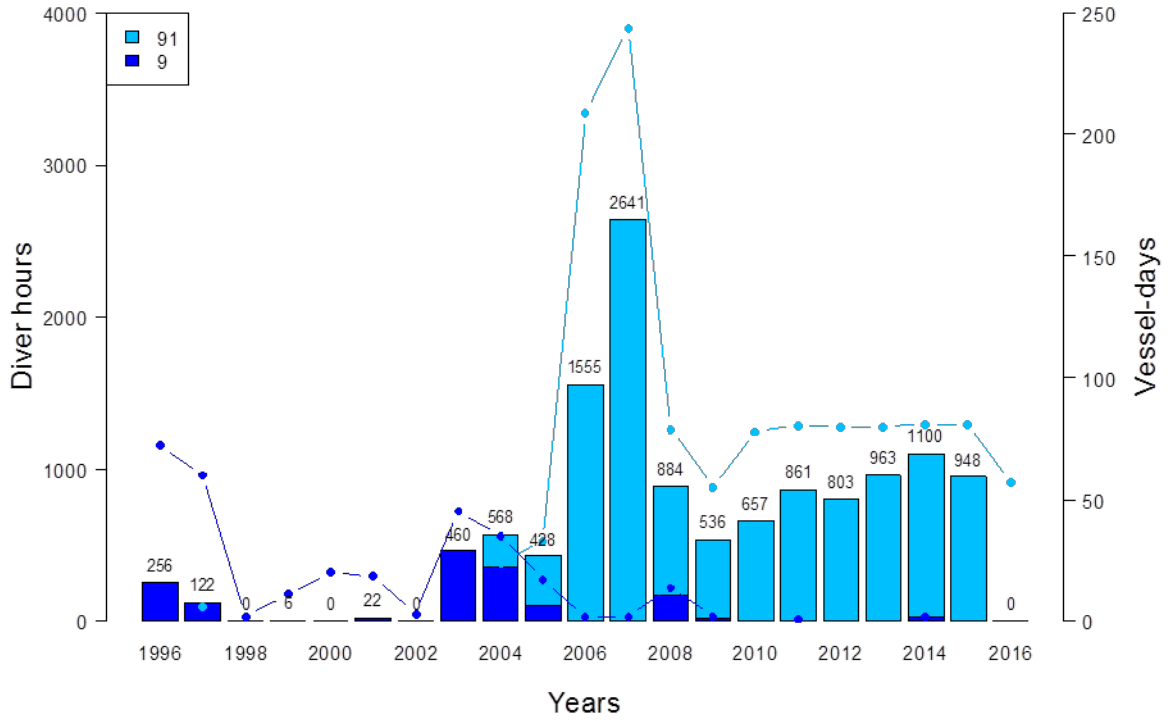

Figure 5. Green Sea Urchin fishing effort in Area 9 measured in dh (histogram) and bd at the mouth of the Saguenay (subarea 9-1 in light colour) and in the western and eastern portions of Area 9 (solid dotted line) from 1996 to 2016. The figures shown above the bars indicate the total effort in Area 9 for each year. 2015 and 2016 data are preliminary because there was no information on 2016 fishing effort.

Catches per unit effort (CPUE)

Following a decrease in CPUE from 2005 to 2007, the adoption of management measures in subarea 9-1 in the fall of 2009 appears to have promoted an increase in CPUE starting in 2010, peaking at 499 kg/dh in 2012 (Figure 6). Despite the decrease which began in 2013, the values remain above the historical average. There are no discernible CPUE trends between spring and fall (Table 1). The spring and fall CPUE increased in 2011, exceeding the 419.1 kg/dh spring average calculated for 2008 to 2015 and the 424.5 fall average. The CPUE decreased in 2013 and 2014, but there was a slight increase in 2015. The average spring CPUE increases to 433.2 if the spring 2009 value is excluded, when there was no fall fishery. Because the 2016 preliminary data did not include any information on fishing effort, the CPUE could not be calculated.

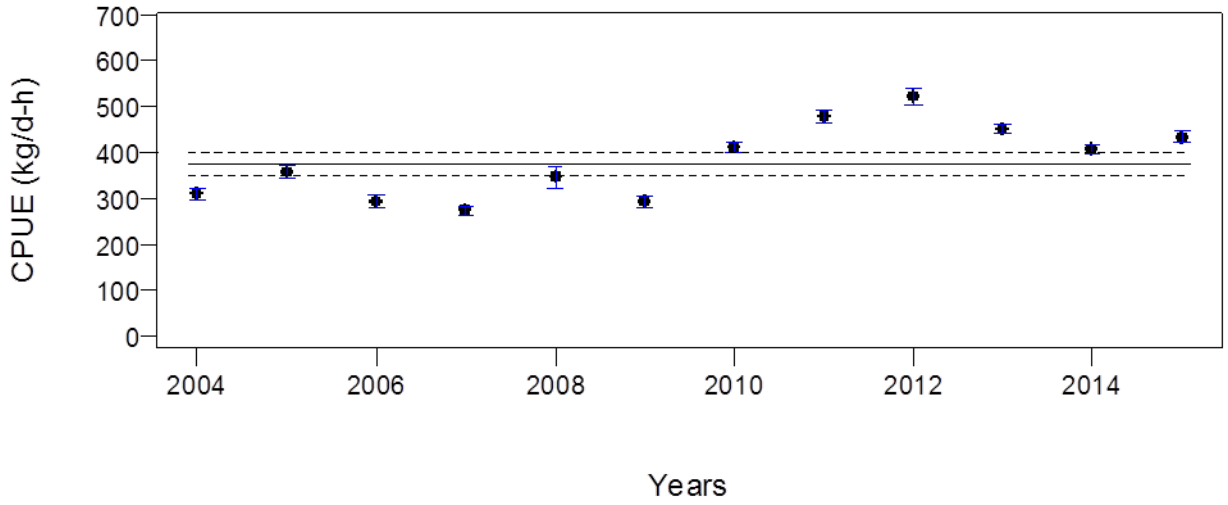

Figure 6. CPUE for Green Sea Urchin in Subarea 9-1 Measured in kg/dh from 2004 to 2015. The vertical bars over each dot represent standard deviation. Subarea 9-1 has only existed since 2010, but the data were extracted from georeferenced positions to obtain a longer fishing history.

Table 1. Average (± one standard deviation, SD) catch per unit effort measured in diver-hours (kg/dh) in subarea 9-1 in the spring of 2009 and the spring and fall of 2008 and 2010 to 2015. The average for all years and the percentage of fishing effort in the spring are also listed.

Sub-area 9-1		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean 08-15**
Spring	Mean (SD)	322,2 (23,0)	286,2 (10,5)	402,9 (11,1)	502,4 (14,6)	513,7 (106,5)	434,7 (36,3)	423.4 (17.1)	467.5 (22.9)	419,1
	% of total effort	100	100	82	73	71	73	70	70	
Fall	Mean (SD)	363,6		425,5 (27,0)	433,3 (25,8)	482,4 (93,0)	470,4 (74,8)	393,8 (14.8)	402,3 (11,1)	424.5

Size structures

Since 2005, commercial catch sampling campaigns in Area 9 have only collected samples from subarea 9-1. These samples represent sorted and landed sea urchins. The average size of all samples (Figure 7) and the commercial portion of samples (Figure 8) has been relatively stable from year to year since 2010. Minimum and maximum sizes and the percentage of sub-legal-sized individuals do not vary much from year to year. Approximately 6% of landings are below legal size.

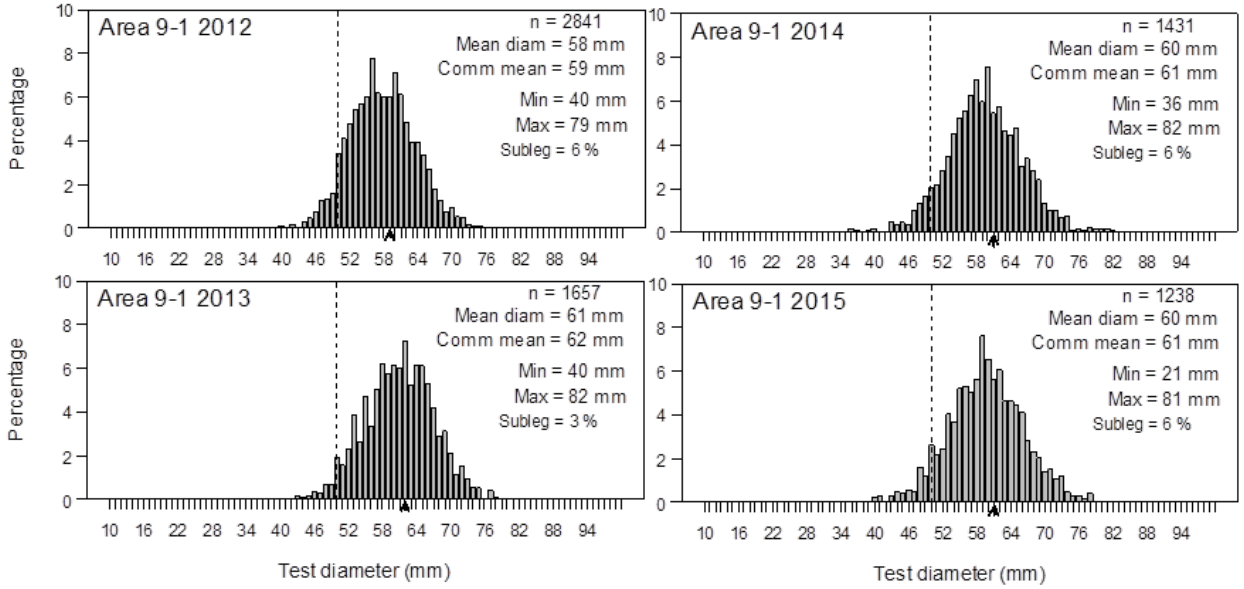

Figure 7. Size Structures of Green Sea Urchins from Subarea 9-1 based on Commercial Sampling from 2012 to 2015. The number (N), average size (Avg. size), minimum size (Min.) and maximum size (Max.) and the percentage of sub-legal-sized individuals (SL) are based on all sea urchins landed, whereas the average commercial size (Avg. com.) is 50 mm in diameter and over. The dotted line represents the minimum legal size.

Average commercial sizes in subarea 9-1 have not varied much in recent years (Figure 8). This stability does not foreshadow the arrival and migration of new cohorts of sea urchins. Rather, this suggests that sea urchin catches were offset by local growth or migration of individuals from peripheral sites.

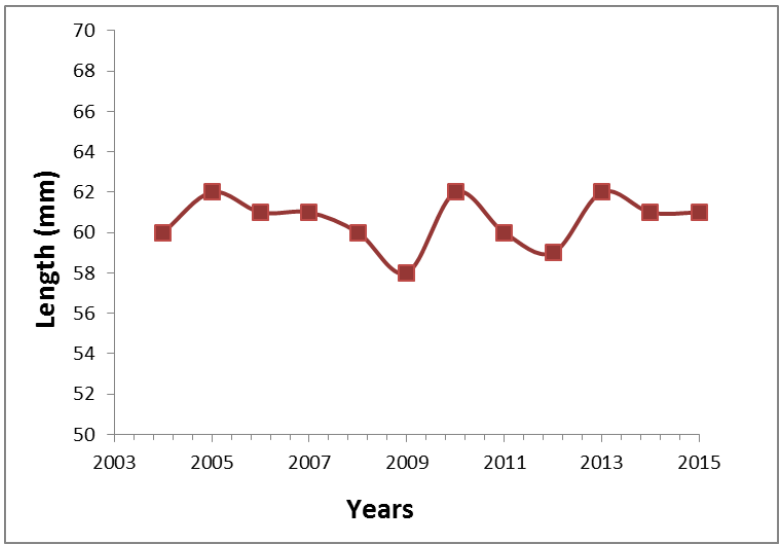

Figure 8. Average Commercial Size of Green Sea Urchins based on Commercial Sampling in Subarea 9-1 from 2004 to 2015. Only the 2004 dot includes sizes measured outside subarea 9-1, i.e. Area 9 near Saint-Siméon.

Area 11 resource status

Landings and fishing effort

To date, landings in Area 11 have been sporadic and low, with a maximum of 24 t landed in 1997 (Figure 9). Preliminary data for the 2016 spring fishery indicate 23 t were landed. It should be noted that results for some years can be slightly underestimated due to incomplete data.

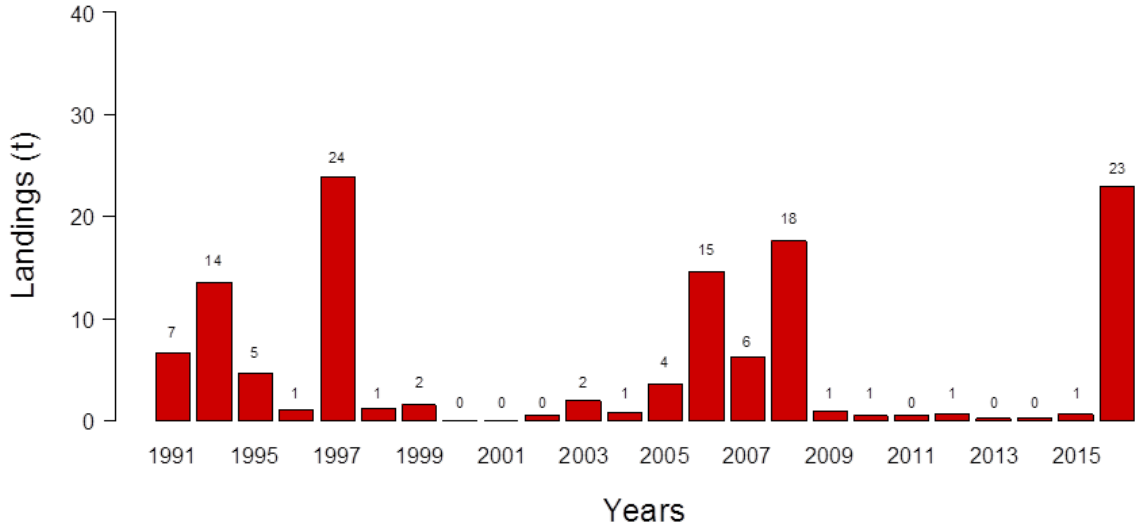

Figure 9. Green Sea Urchin Landings in Area 11 from 1991 to 2016. The figures indicate total landings each year. 2015 and 2016 data are preliminary and 2016 does not include spring fishing data.

Two distinct areas are visited most years, near Havre-Saint-Pierre in the western part of the area and near Natashquan at the east end of the area (Figure 10). Eleven fishermen have reported landings since 1991, but very few have participated in the fishery in recent years. Figure 11 shows fishing effort in dh and bd.

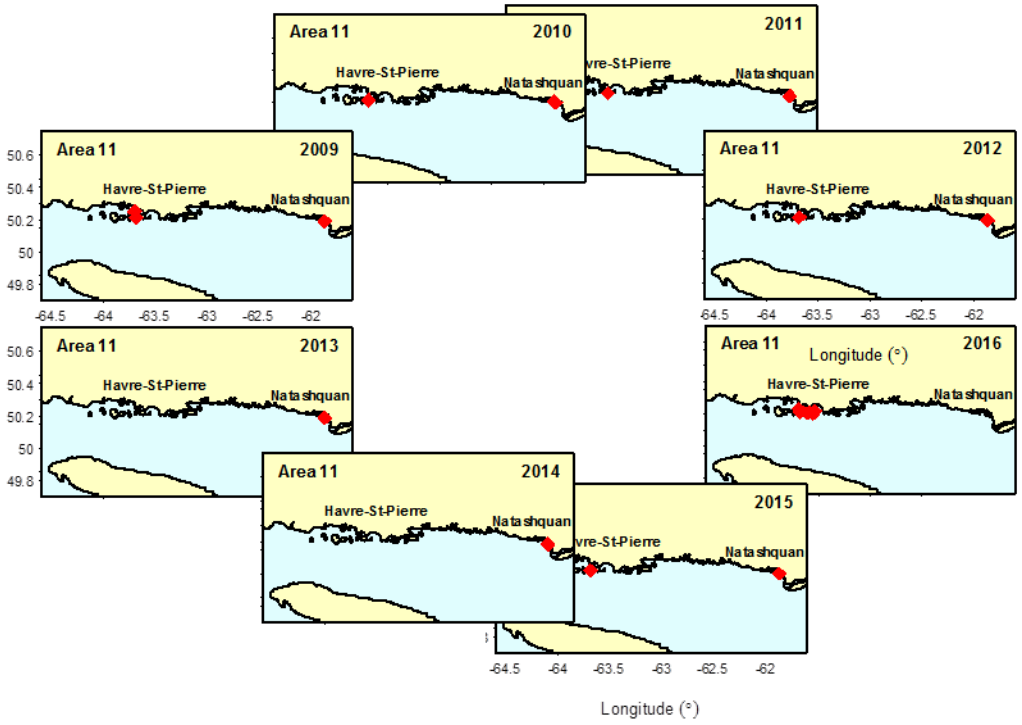

Figure 10. Distribution of Fishing Effort from 2009 to 2016 in Area 11. The 2016 data only include the spring fishery.

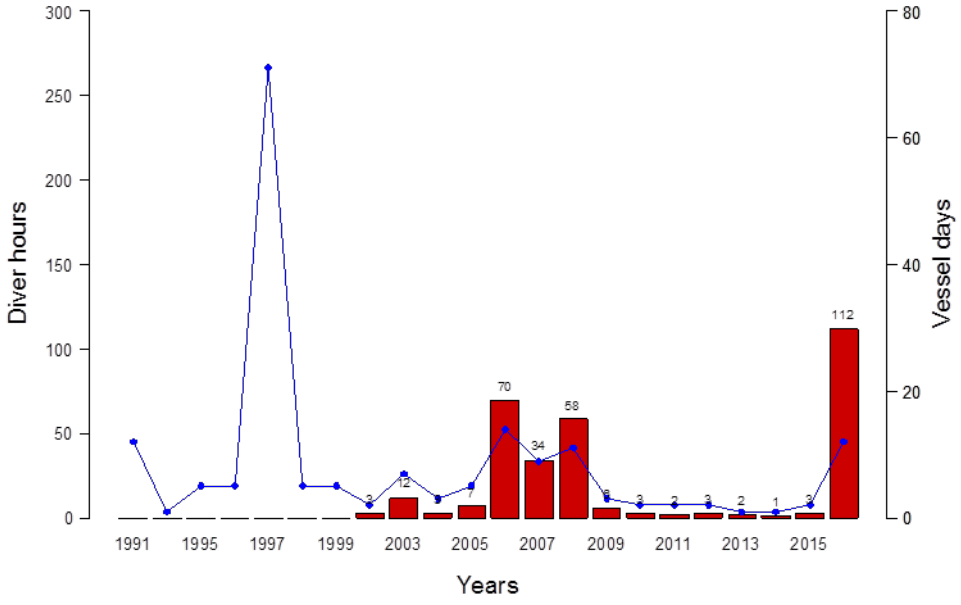

Figure 11. Green Sea Urchin Fishing Effort in Area 11 Measured in DH (histogram) and BD (Line) from 1991 to 2016. The figures shown above the bars indicate fishing effort measured in dh for each year (this information is not available for the initial years). 2015 and 2016 data are preliminary and the 2016 data only include spring fishery values.

Catches per unit effort (CPUE)

Average CPUE varied significantly from year to year (Figure 12), which may reflect low fishing effort. Yields were relatively high in 2008 and above average between 2010 and 2015, except for 2013.

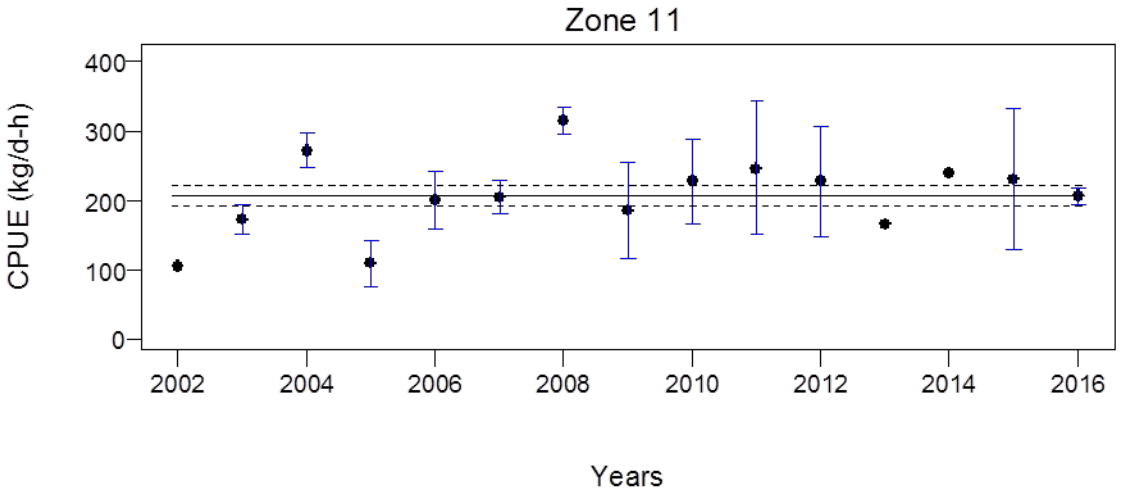

Figure 12. Average and Standard Deviation of Catches per Unit Effort Measured in kg/dh from 2002 to 2016 for Green Sea Urchins in Area 11. 2015 and 2016 data are preliminary and 2016 does not include spring fishing data.

Sources of uncertainty

In the short term, an assessment of the age structure of landed urchins and the population as a whole would provide interesting information that could lead to a better understanding of green sea urchin dynamics. This information would provide a way to measure growth rates and determine time and recruitment patterns. However, methods for estimating sea urchin age based on the urchin's mouth (Aristotle's lantern), or the calcified plates of the urchin's shell, known as the test, would not be reliable and representative of actual sea urchin aging.

Green sea urchin recruitment is likely dependant on salinity conditions in the estuary and may be increasingly more sporadic moving upstream from Pointe-des-Monts into the St. Lawrence.

Studying the movements of sea urchins is very helpful in providing a better understanding of the significance of migration versus growth in replacing sea urchins that have been harvested from urchin beds. It would be especially interesting to inventory sinks (that sea urchins enter but do not exit) and the ways in which replenishment alters the density and distribution of neighbouring sea urchins.

The spatial variability of sea urchin gonad quality is still unknown within the main harvesting areas. In an area where sea urchin populations are abundant, only a portion of sea urchins inventoried may meet harvest quality requirements. We know that sea urchins that do not have access to kelp in their diet have gonads of lesser quality. However, the time required in nature to condition gonads following migration of a sea urchin in an area of the sea floor rich in nutrients is still unknown. Sea urchin quality may also vary based on their position in the feeding front.

Catches are sorted at sea on a grid to eliminate sub-legal-sized individuals. It would therefore be appropriate to examine the indirect mortality of sub-legal or legal-sized sea urchins linked to harvesting activities. In addition, legal-sized sea urchins are sometimes released if their gonads are not of sufficient quality. The survival of sea urchins that have been discarded might depend on sorting conditions, the location where the sorting occurred and where they were discarded.

Finally, it would be helpful to establish specific mass-diameter relationships for the green sea urchin at the main sites harvested for the different seasons of the year.

CONCLUSION

For subarea 9-1, management measures in force helped stabilize fishery indicators and a cautionary approach should be adopted if we intend to amend management measures.

We cannot comment on the status of the resource in Area 11 due to a lack of information.

OTHER CONSIDERATIONS

Dive fishing is not considered harmful to the environment. However, the green sea urchin is a key organism in the ecosystem and when it is abundant it can determine the nature and diversity of benthic communities in shallow waters. Severe green sea urchin population depletion, either from disease or harvesting, can therefore lead to significant changes in the coastal ecosystem. In addition, certain ducks may depend on the green sea urchin for part of their diet.

Recruitment to the fishery in very dynamic systems, such as subarea 9-1, may depend on the growth rate of sea urchins in fishing grounds, the migration rate of sea urchins pre-recruited and recruited from various areas to fishing grounds that promote high growth, and possibly storms that primarily transport or eliminate the largest urchins. Fishing effort control (bd quota, limit on the number of divers per boat, limit on extraction technology) appears well-adapted to ensure sustainable harvesting of the resource.

SOURCES OF INFORMATION

This Science Advisory Report is from the June 9, 2016 Assessment of the Green Sea Urchin Fishery in the Northern Estuary and Gulf of St. Lawrence in 2015. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada Science Advisory Schedule as they become available.

DFO. 2012. Assessment of the Green Sea Urchin Fishery in the Estuary and Northern Gulf of St. Lawrence in 2011. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/055.

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