St. Georges Bay Fish Harvesters' Ecological Knowledge and White Hake (*Urophycis tenuis*) Predation on Juvenile American Lobster (*Homarus americanus*): Comparative Analysis of Research Results

SRSF Research Report #7

Prepared by

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in Collaboration with

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Summary of Findings

White hake (*Urophycis tenuis*) is a demersal fish species that inhabits the nearshore waters of the Southern Gulf of St. Lawrence (sGSL). Recently, many St. Georges Bay fishermen have expressed concern that the white hake is a predator of juvenile American lobster (*Homarus americanus*). Standard research surveys do not support these concerns. Fishermen maintain that these surveys were conducted at inappropriate sampling times and locations. To address these concerns, a multiphase collaborated study was developed where groundfish were sampled in St. Georges Bay during a time of year and in locations selected by fishermen. Six sampling sites covering two depth zones of 15-30 and 30-40 meters were sampled with gillnets. A total of 3452 groundfish stomachs were collected, including 3093 of white hake. American lobster were identified in the stomachs of Atlantic cod and shorthorn sculpin, and not in the stomachs of white hake. This research has significantly increased our knowledge of the feeding habits of groundfish in St. Georges Bay. It has shown that incorporating fish harvesters' ecological knowledge will enhance the design and conduct of research aimed at exploring groundfish ecology. It has also demonstrated the willingness for fish harvesters to engage enthusiastically, and to share their knowledge in a study that is inclusive, sincere, and respectful.

Acknowledgements

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Introduction

Recently, numerous St. Georges Bay fish harvesters have expressed a concern respecting the effects of groundfish predation, particularly that of white hake (*Urophycis tenuis*), on the abundance of juvenile (sub-legal) American lobster (*Homarus americanus*). In particular, fish harvesters are concerned that as groundfish populations recover as a consequence of the fishing moratorium there will be increased predation on juvenile American lobster. This presumed increased predation is thought to reduce the recruitment of juveniles into the harvestable size-classes, thereby jeopardising the economic viability of the American lobster fishery. This concern is amplified by the fact that the groundfish moratorium has reduced the numbers of fisheries to which fish harvesters have access, thus accentuating livelihood dependency on the lobster fishery. Intensifying these concerns is the fact that lobster landings have been declining in some areas since the early 1990s (DFO 2002a).

The results of recent seasonal feeding studies (e.g., Hanson & Lanteigne 2000) do not support the concerns (e.g., predation on American lobster by demersal fishes, especially white hake) of St. Georges Bay fish harvesters. Fish harvesters argue that the feeding studies were conducted in the wrong places at inappropriate times of the year. To address these concerns, a research collaboration was formed between Interdisciplinary Studies in Aquatic Resources (ISAR) and Social Research for Sustainable Fisheries (SRSF) at St. Francis Xavier University, Fisheries and Oceans Canada (Gulf Region, Moncton, N.B.), and the Gulf Nova Scotia Bonafide Fishermens Association (GNSBFA). The research program employed St. Georges Bay fish harvesters' local ecological knowledge respecting the seasonal distribution of groundfish, particularly white hake, in the design of the current study to quantify predation on juvenile American lobster.

One goal was to sample a sufficient number of groundfish stomachs, at the appropriate times and in the appropriate places, to assess accurately the extent of groundfish predation on juvenile American lobster. A second goal was to explore the extent to which social research methodologies designed to document fish harvesters' local ecological knowledge might contribute to effective collaboration in the design and conduct of a fisheries science study of marine ecological dynamics.

This report evaluates the results from three feeding studies conducted in September 2001, July 2002, and September 2002 (see Watts 2002, Watts and MacPherson 2002a, Watts and MacPherson 2002b). We first review and summarize published studies on the key growth, ecological, and fishery attributes of American lobster and white hake populations. Secondly, we describe the research design and methods, with an emphasis on describing the utility of social science techniques for documenting local ecological knowledge and sample site selection. Finally, we synthesize the results of the three studies to evaluate how well local ecological knowledge predicted the feeding patterns of white hake with a view to addressing concerns respecting predation on juvenile lobster.

This research has been designed, funded and completed for the primary purpose of systematically responding to the concerns of St. Georges Bay fish harvesters respecting white hake predation as an important source of mortality for juvenile American lobster. While addressing these concerns, this study also identified all of the prey eaten by white hake, filling an important void in our knowledge of the feeding patterns of this species. In addition, the stomach contents of the other groundfish we sampled were identified and recorded.

American lobster in the Southern Gulf of St. Lawrence

American lobster is a marine decapod crustacean that inhabits the Atlantic coast from North Carolina to Labrador. In the southern Gulf of St. Lawrence (sGSL), most American lobsters are found in waters < 40 meters deep. There are two phases in the life history of American lobster, the planktonic phase and the benthic phase. The former includes a three to ten week period, depending on environmental conditions, where the newly hatched larvae are free swimming in the water column. American lobsters spend the majority of their life in the benthic phase, which begins when the larvae start to settle on the substrate. Females mature at 5 to 6 years of age while males reach maturity at younger ages (DFO 2002a). In the sGSL, 50% of females become sexually mature at carapace lengths of 70 to 72mm (Moriyasu et al. 2001).

There are 3,180 lobster license holders in the sGSL (LFA 23, 24, 25, 26A, 26B) (DFO 2002a). This number has remained relatively stable since 1967 when regulations first came into place to limit access to the lobster fishery. In the sGSL, lobster landings account for almost 50% of the total landed value in the fishing industry. In 1990, lobster landings in the sGSL (Gulf Region only) peaked at 22,215 t, worth a landed value of $220 million (based on $4.50/lb). Despite the moratorium on harvesting groundfish that began in September 1993, there has been an increase in landed value of lobster due to increased prices. Since the 1990 peak, landings have shown a slow but steady decline. In

2001, Gulf Region lobster license holders caught approximately 17,000 t of lobster with a landed value of more than $200 million (DFO 2002a).

White hake in the Southern Gulf of St. Lawrence

White hake is a demersal fish that occurs in continental waters of the western Atlantic Ocean. In the sGSL, white hake are largely found on soft bottom habitats in waters 5 to 11°C. There are two distinct subpopulations in the sGSL. One population occurs in the deep, warm (5 to 7º C) waters of the Laurentian Channel. The second is confined to the coastal waters (i.e., < 40 m deep) of the sGSL (Hurlbut & Clay 1998). The cold (< 1º C) intermediate layer of the sGSL contacts the bottom for much of the area between 40 and 100 m deep, and white hake largely avoid this cold-water zone. Coastal waters in the sGSL often reach temperatures > 20 °C during summer and the entire sGSL is usually ice-covered from January to March or April. The decline in water temperatures during autumn appears to cause all adult white hake to make a seasonal migration out of the shallows to overwinter in the Laurentian Channel (Clay 1991). Many small white hake enter estuaries to feed during late summer and early autumn (Hanson & Courtenay 1995; Bradford et al. 1997). These small white hake then leave the estuaries in November and presumably overwinter in the Laurentian Channel (Hurlbut & Clay 1998). Male and female white hake become sexually mature at lengths of 40 and 44 cm and at ages of 2 and 5 years, respectively. White hake spawn during June, producing several million eggs per individual (DFO 2001b).

White hake are harvested throughout their geographical range, but the fishery in the sGSL is the most directed (Hurlbut & Clay 1998). White hake are caught using gill nets, trawls, and longlines. In the 1960s and 70s white hake landings ranged between 3,600 and 7,200 t. With an increase in fishing effort in the early 1980s, white hake landings peaked at 14,039 t in 1981. A steady decline in landings occurred thereafter, with an all time low of only 1,000 t landed in 1994. In 1995 a fishing moratorium was placed on sGSL white hake (Hurlbut et al. 1998) and will likely remain in place into the foreseeable future. Annual trawl surveys show that very few white hake are present in several historically important spawning locations such as Baie Verte, NB (reviewed by Hanson & Lanteigne 2000). Currently, the distribution of white hake (ice-free season) is limited to the eastern end of the Northumberland Strait. The only known remaining spawning area is in St. Georges Bay (Poirier et al. 2000; Hurlbut & Poirier 2001). White hake numbers are not expected to recover unless mortality from fishing is kept very low (DFO 2002b).

White Hake Diets

The only published data we know of on the diets of sGSL white hake is that of Hanson & Lanteigne (2000). This study sampled white hake in 1996, between August and October. The results did not support the idea that white hake were an important predator of American lobster. However, the authors noted that they may have underestimated predation by white hake on juvenile American lobster because sampling did not include fish in shallower waters (< 20 meters).

Elsewhere, white hake exhibit a pronounced ontogenetic diet shift (Bowman & Micheals 1984; Garrison & Link 2000), and prey selection is largely dependent on mouth morphology (particularly mouth size) (Bowman & Micheals 1984). White hake diet studies conducted in the Gulf of Maine and Georges Bank suggest adult white hake (>45 cm) are primarily piscivores (Vinogradov 1984; Garrison & Link 2000), while smaller white hake (<45 cm) eat mostly small crustaceans such as shrimp and mysids (Tyler 1972, Bowman 1981; Bowman & Micheals 1984; Garrison & Link 2000).

Methods and Materials

Research Design

Two sampling designs were developed to document fish harvester's local ecological knowledge with regard to white hake predation on juvenile American lobster. The first consisted of an informal roundtable discussion held in early July 2001 with volunteer fish harvesters (i.e., general meetings with stakeholders). During this discussion, the participants were asked to identify on nautical charts, the specific locations, times of year, and other factors that have to be considered in order to carry out the sampling necessary to document accurately white hake predation on juvenile American lobster. The second sampling framework was conducted between September 2001 and May 2002 by SRSF staff. Here, information was gathered from systematic interviews of local fish harvesters who were identified by their peers in an earlier stratified random sample survey as 'knowing a lot about the local fishing grounds'. These interviews allowed for the documentation of a broad range of ecological knowledge and experiences, including the places and times of year when white hake either had been observed or were most likely to prey on juvenile American lobster. Established social research techniques, e.g., the construction and cross-association of map-referenced fishing biographies, were employed for this purpose. In order for a site or area to be included in the sample framework, its key characteristics (daily and seasonal distribution characteristics, environmental factors such as tides and currents) had to be independently verified by a minimum of three local experts.

Sample site selection

Commercial fish harvesters identified six sites in St. Georges Bay, Nova Scotia, (Figure 1) where large numbers of white hake would be found and where juvenile American lobster would most likely be preyed upon by these fish. Three of these sites (numbered 1, 2, 3 – Figure 1) were located in waters 30 to 40 meters deep, with the remainder (numbered 4, 5, 6 – Figure 1) located in waters 15 to 30 meters deep. Phase I of this study, sampling sites recommended from the stakeholders' roundtable was conducted between 4 and 20 September 2001, and captured white hake in sites 1, 2, and 3. Phase II sampling sites recommended by local experts, was conducted between 14 and 30 July 2002, and captured white hake in sites 4, 5, and 6. Phase III was conducted between 3 and 11 September 2002, and sampled white hake from all six sites, allowing concurrent collection of white hake stomachs from the two depth zones.

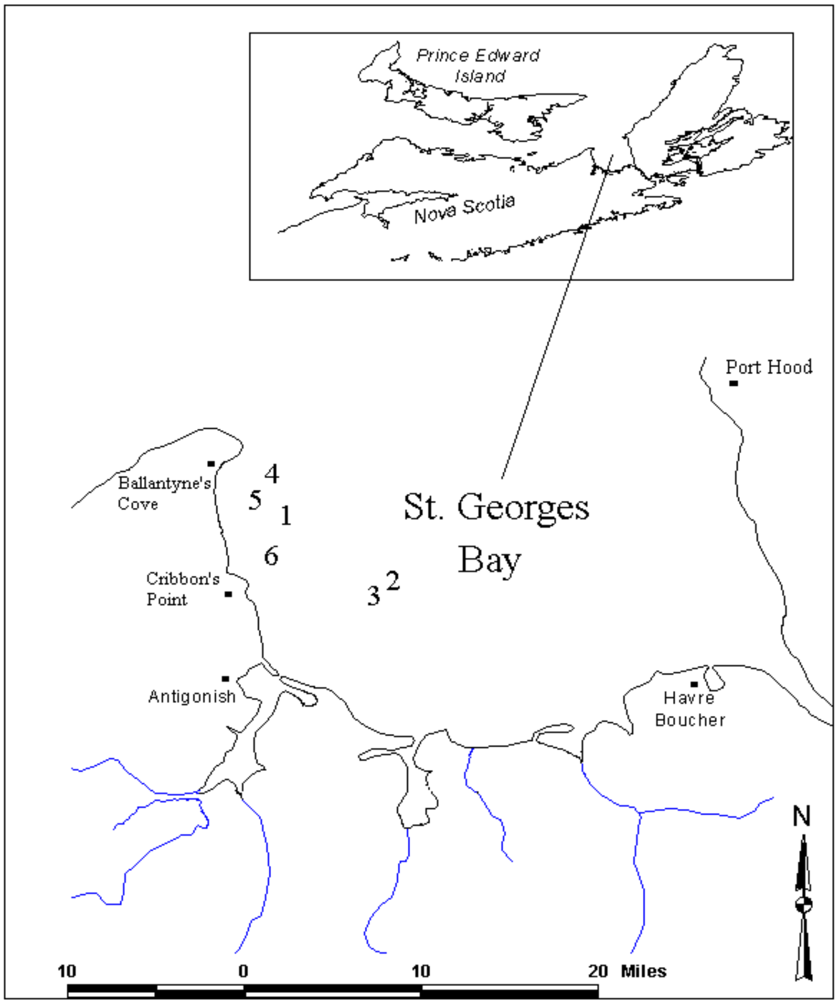

Figure 1. Map of St. Georges Bay showing sites where groundfish were sampled in the 3 Phases. (1= Site 1, 2= Site 2, 3= Site 3, 4= Site 4, 5= Site 5, 6= Site 6).

Sampling procedure

The fish were captured using gillnets because most white hake caught in gillnets are dead when brought aboard the vessel. Earlier studies have shown when fishes, such as white hake, are rapidly hauled to the surface, the expansion of gas in the swim bladder of live fishes often causes food to be regurgitated (Bowman 1986).

Each of the six sites was sampled with 1 string of gillnets. Each string was composed of 4 nets, and each net was 100 fathoms in length. These strings had alternating nets of 5 ½ and 6 inch stretched mesh. For Phase III, an additional 4 ½ inch mesh size net was added to each string for the purpose of collecting smaller fish, thereby increasing the range of fish sizes sampled. The smaller meshed net was inserted in each string at random. With only three strings of gillnets in use during Phase III sampling, two strings were rotated through sites 1, 2, and 3, while the remaining gillnet set was rotated through sites 4, 5, and 6.

Stomach sampling

All fish were taken out of the nets on board the vessel, and their stomachs were removed and placed in individual plastic bags. Each stomach was labelled with site, date, species, length of fish (to the nearest cm), and sex of fish. The plastic bags were immediately placed on ice and stored in insulated boxes. Upon return to the wharf, stomachs were placed in a freezer and later taken to the laboratory for analysis. Each stomach was thawed in cold water, cut open and prey were identified to species level (if possible), blotted wet weight recorded (usually to the nearest mg), and (when possible) length of fish prey was measured (to the nearest mm).

Results and Discussion

Overview of first three reports

Following stakeholder consultations in early July 2001, the fish stomachs were first collected during September 2001 at sites 1, 2, and 3 (water 30 to 40 m deep). We sampled the stomachs of 1618 white hake, mainly fish > 45 cm long. No American lobster was found in these stomachs (Watts 2002). Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) were the principal prey of the white hake sampled.

The timing and location of the second phase of this study was based on consultations with experts identified by their peers. These local experts indicated that white hake collected in waters 15 to 30 meters deep during July were likely to prey upon American lobster, and that large numbers of fish would be found in waters of this depth at this time. These observations were associated with the descriptions of white hake spawning behaviours. Despite intensive fishing efforts, only 159 white hake (mainly fish > 45 cm long) were caught, indicating large numbers of white hake were not present in waters 15 to 30 meters deep during July 2002. In addition, no American lobsters were found in the white hake stomachs (Watts and MacPherson 2002a). Again, the most important prey of the white hake sampled was herring and mackerel.

Phase III of the study was conducted in September 2002 when stomach contents of white hake were collected and compared for both the 15 to 30 m and 30 to 40 m depth zones. Phase III sampled 1,316 white hake (mainly fish > 45 cm long), with greater numbers of fish per unit effort being caught in the inside sites (Table 1). While the sampling indicated that large numbers of white hake were present in water 15 to 40 meters deep during September, no American lobsters were found in the stomachs of white hake. As in the preceding cases, the most important prey of the white hake sampled was herring and mackerel (Watts and MacPherson 2002b).

White hake size distribution

A total of 3093 white hake were sampled during the three sampling phases. The catch per unit effort in the September 2002 survey was almost twice that of the September 2001 survey while the catch per unit effort was very low during July 2002 (Table 1). Many of the few fish caught in July were in spawning condition, which suggests spawning activities may have affected their vulnerability to the gear.

Table 1. Number of white hake sampled in each phase including number of sets.

Phase	Date	Number of sets	Number of white hake	Catch per unit effort	Mean length (cm)
1	Sept. 2001	42	1618	38.5	63.4
2	July 2002	42	159	3.8	60.4
3	Sept. 2002 (outside)	14	781	55.8	59.8
3	Sept. 2002 (inside)	7	535	76.4	58.0

There were smaller white hake caught in September 2002 than in September 2001 (Table 1). This is consistent with the inclusion of a small-meshed net in each string during the September 2002 phase. Consequently, the average lengths of white hake sampled differed between September 2001 and September 2002 (t-test, $P < 0.05$). There were differences in the size distribution of white hake between those fish caught in outside sites versus inside sites (Figure 2). These differences illustrate the tendency for smaller white hake to occur more frequently in shallower water than is the case for larger-sized white hake.

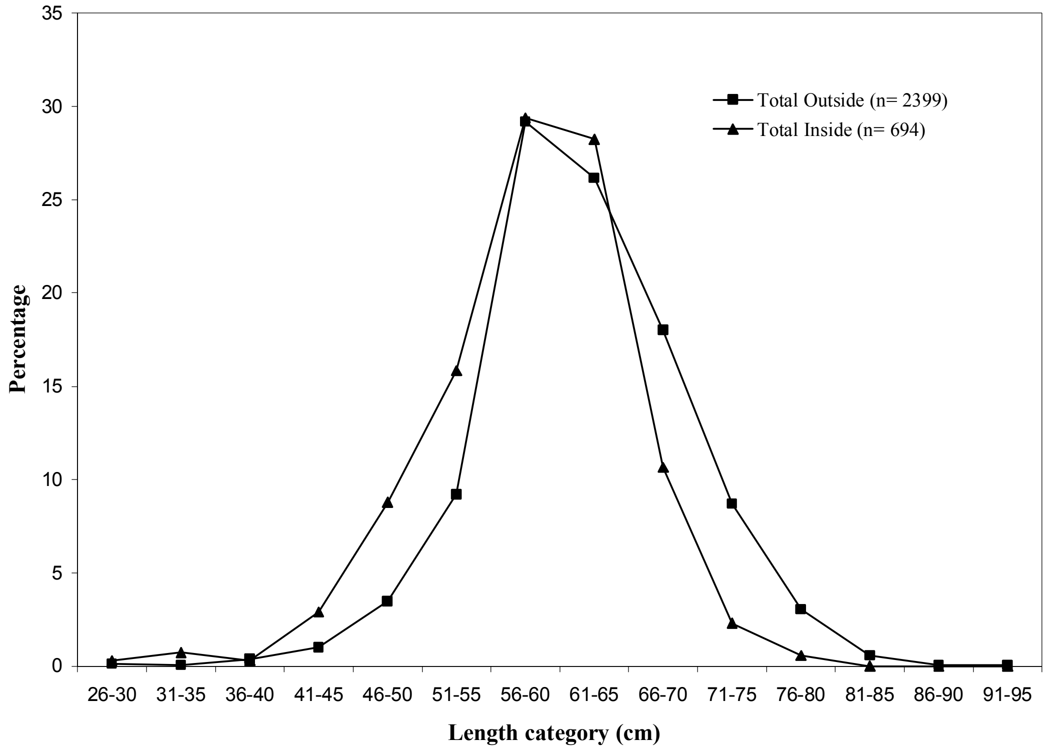

FIGURE 2. Length distribution of white hake from outside and inside sites in St. Georges Bay during the 3 phases of sampling.

There were differences in the number of white hake sampled in the inside sites between the July 2002 and September 2002 phases (Table 1, Figure 3). These differences suggest a general movement of fish back to the "inside grounds" between the two sample dates. As there is little previous work illustrating local white hake migration, we cannot suggest this is a normal event or if the timing is the same every year. There was a decrease in the abundance of the largest (>70 cm) size-classes of white hake caught in outside zones in the September 2001 and September 2002 surveys (Figure 4). If these differences represent a trend, the number of large white hake in St. Georges Bay may be decreasing.

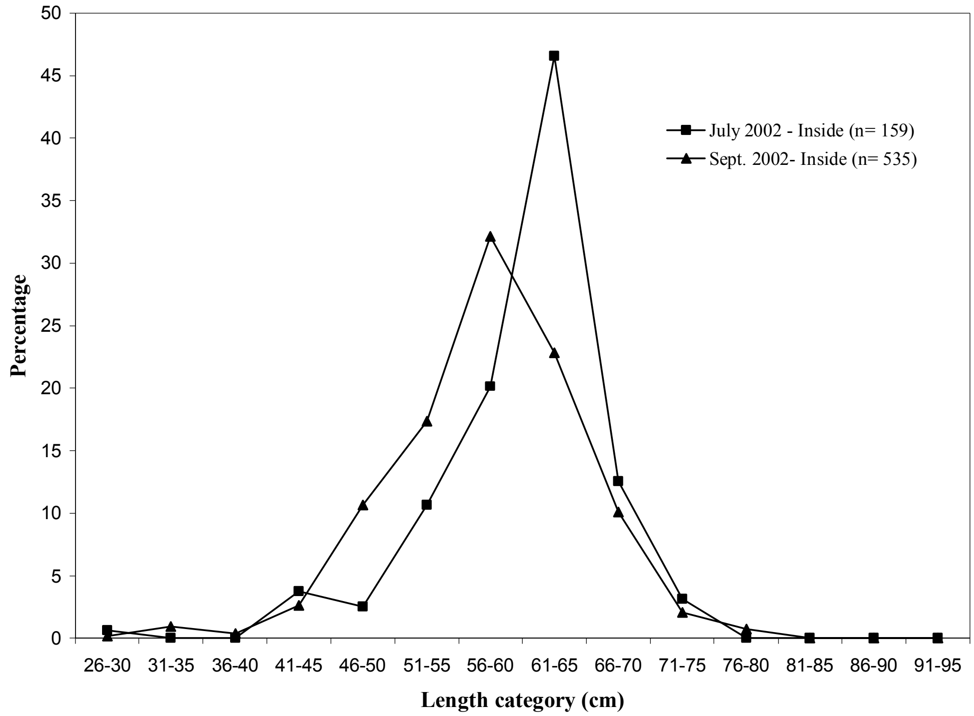

FIGURE 3. Length distribution of white hake from inside sites in St. Georges Bay during Phases 2 and 3 of sampling.

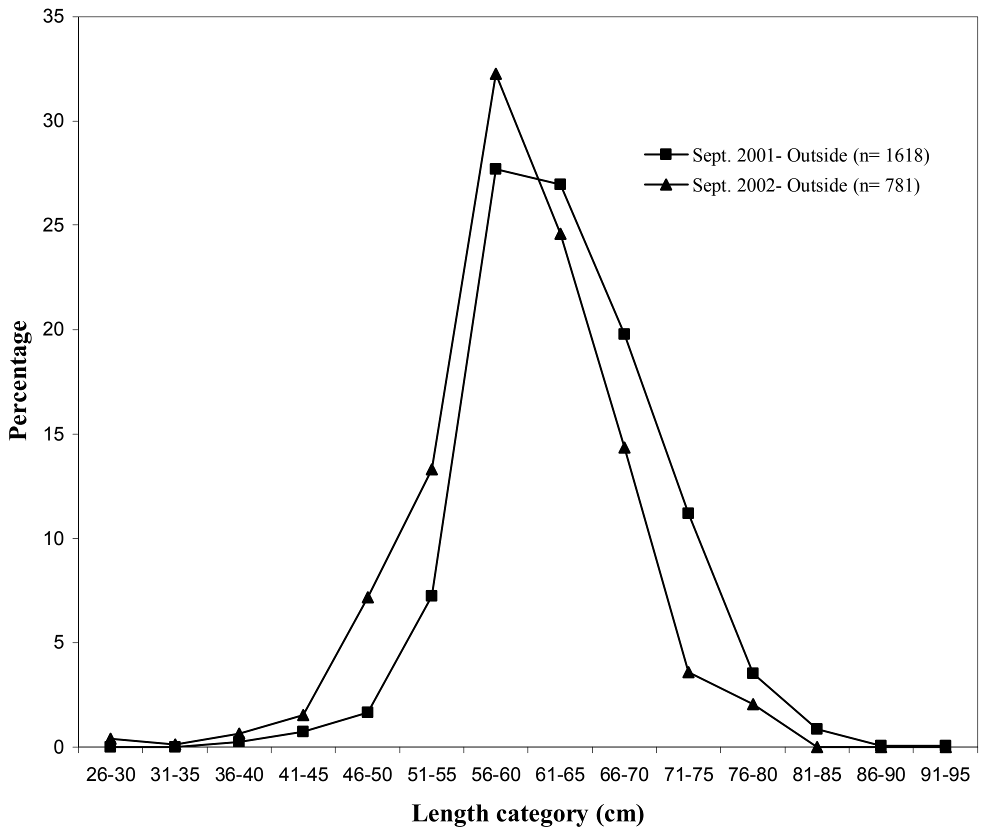

FIGURE 4. Length distribution of white hake from outside sites in St. Georges Bay during Phases 1 and 3 of sampling.

Differences in mean white hake lengths among inside and outside sites were detected using a t-test. These tests indicated significant statistical differences ($P<0.05$) in white hake lengths between the outside sites (1, 2, 3 – Figure 1) for the September 2001 (mean = 63.4 cm, n=1618) and September 2002 surveys (mean = 59.8 cm, n=781) (Figure 2). There was no difference in mean ($P>0.05$) white hake lengths between the outside sites (4, 5, 6 – Figure 1) for September 2002 (mean=59.8 cm, n=781) and inside sites for July 2002 (mean = 60.4 cm, n=159). There were significant differences ($P<0.05$) in white hake lengths between inside sites of September 2002 (mean = 58 cm, n= 535) and July 2002 (mean=60.4 cm, n= 159) (Figure 3). There were also significant differences ($P<0.05$) in white hake lengths between inside (mean = 58 cm, n=535) and outside (mean = 59.8 cm, n= 781) sites for the September 2002 survey. The above differences in mean white hake lengths in each phase and from each depth zone are very small, usually less than 2 cm. From a feeding study point of view these differences are minor. The vast majority of the fish sampled are longer than 45 cm and likely feeding on similar prey.

Notably, the white hake sampled in September 2001 included much longer fish than was the case for the July and September 2002 samples. For instance, 17.7% of the September 2001 sample were 70 cm or longer. But, only 5.7%, 4.3%, and 6.1% of the July 2002 (inside), September 2002 (inside), and September 2002 (outside), respectively, of the sampled white hake were 70 cm or longer. This notable difference may indicate nothing more than a sampling anomaly. It may also suggest a decline in either the occurrence or the availability of larger white hake. This latter prospect would be more troubling. Additional research is required to clarify the situation and its implications.

Diet Analyses

White hake diets

Mean prey biomass values were calculated for all sampling dates with two samples (inside vs. outside) for September 2002 (Figure 5). White hake smaller than 45 cm were excluded from the analysis to remove the influence of the smaller meshed gillnets used during September 2002. Atlantic herring (*Clupea harengus*) (mean 75.9% of prey biomass, range 68.0- 79.7%) was the most important prey identified (Figure 5). Mackerel (*Scomber scombrus*) was also eaten and represented an average of 18.0% of prey biomass (range 14.1- 24.8%) (Figure 5). Various roundfish represented an average of 3.7% of prey biomass (range 1.0- 7.4%) (Figure 5). These roundfish included snakeblenny (*Lumpenus lumpretaeformis*), cunner (*Tautogolabrus adspersus*), sculpin (*Myoxocephalus scorpius*), (*Triglops murrayi*), ocean pout (*Marcrozoarces americanus*), fourbeard rockling (*Enchelyopus cimbrius*), white hake (*Urophycis tenius*), Atlantic cod (*Gadus morhua*) and gaspareau (*Alosa pseudoharengus*). In all likelihood, the mean % values for herring and mackerel were even higher as they no doubt contributed to some of the unidentified roundfish remains.

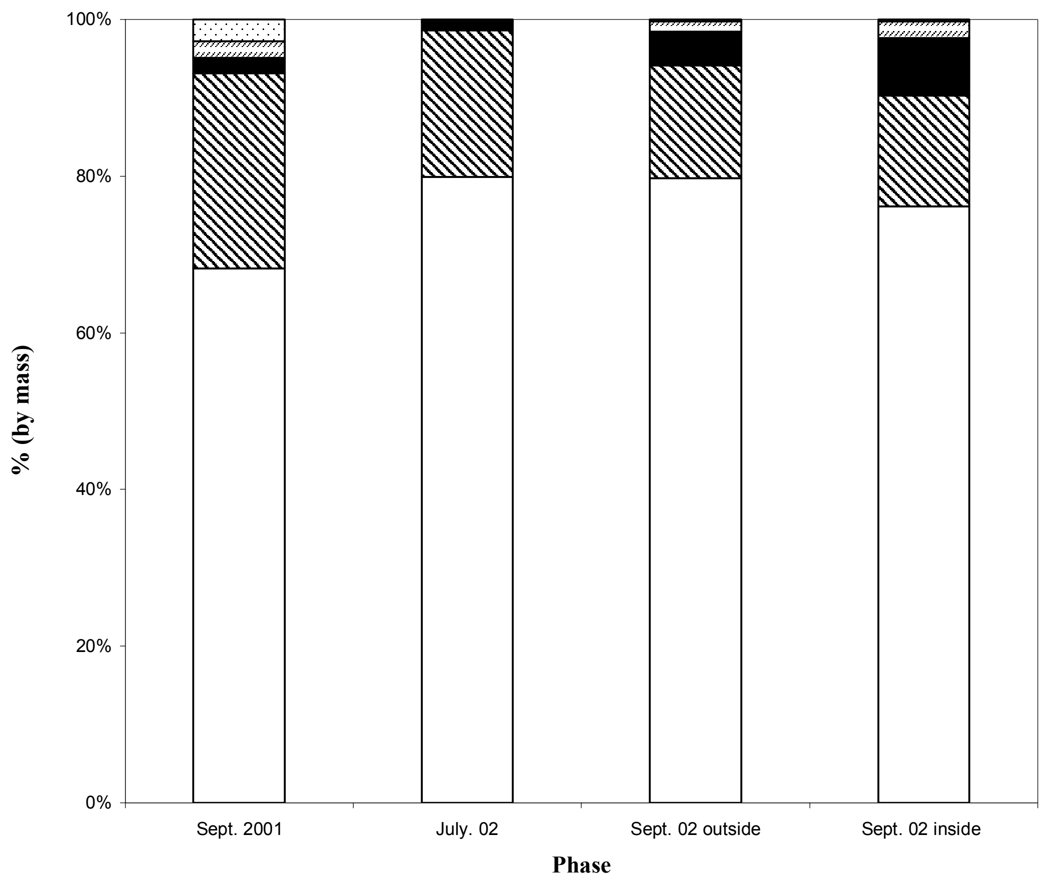

Figure 5. Contribution of various fish and invertebrates to the diet of St. Georges Bay white hake sampled in 2001 and 2002. White hake smaller than 45cm were excluded from the analysis.

In several cases, remains in the stomachs were clearly roundfish but so digested that species identification was impossible. Various flatfish also contributed to the diet of white hake (mean 1.4% of prey biomass, range 0.3- 2.1%) (Figure 5). American plaice (*Hippoglossoides platessoides*), yellowtail flounder (*Pleuronectes ferrugineus*) and winter flounder (*Pleuronectes americanus*) were the most common flatfish identified. As in roundfish, there were unidentifiable flatfish remains. The "other" category includes various invertebrates and represented an average of 0.8% of prey biomass in the white hake diet (range 0.1- 2.7%) (Figure 5). Invertebrates found in the stomachs of white hake included long-finned squid (*Loligo pealei*), short-finned squid (*Illex illecebrosus*), rock crab (*Cancer irrortatus*), toad crab (*Hyas araneus*), shrimp (*Pandalus montagui*, *Crangon septemspinosa*, *Axius serratus*, *Argis dentata*), sea stars (*Asterias vulgaris*), bivalves (*Macoma balthica*, *Mytilus edulis*), mysids (*Mysis mixta*) and various gammarid amphipods.

Pearson correlations were performed on all white hake size classes (bins = 1 cm, range 26-91 cm) to check for ontogenetic diet shifts. There was no relationship between white hake length and prey species. These results are not consistent with those reported in previous studies (Bowman & Micheals 1984; Garrison & Link 2000). However, as only 1.7% of the white hake we sampled were less than 45 cm in length, the number of juvenile fish may have been too small to detect shifts in prey preference.

The high mean % prey biomass values for herring and mackerel in the stomachs of adult white hake may be the result of their relative availability rather than their preference as white hake prey. Differences in mean % values for herring and mackerel may be explained by each species position in the water column. Mackerel tend to occur higher than herring in the water column; hence, herring are more available as prey for white hake – a demersal predator.

No American lobster was found in white hake stomachs during this study. These results are not unique. Hanson and Lanteigne (2000) sampled 2,287 white hake in the sGSL (eastern Northumberland Strait and St. Georges Bay). They found only three white hake had consumed an American lobster. These white hake were adults and the American lobster they consumed were very small juveniles (carapace length = 14 -15 mm).

Stomach analyses of white hake in other ecosystems show similar results. Bowman and Michaels (1984) sampled 535 white hake along the US continental shelf. They did not report any American lobster in those white hake stomachs. Garrison and Link (2000), analysed over 11,000 white hake stomachs sampled from the northeast US continental shelf ecosystem and the southwestern Nova Scotia shelf and did not mention American lobster as a prey item.

The occurrence of *Axius serratus* in the stomachs of four white hake may explain some of the reports by fish harvesters that white hake prey on juvenile American lobster. A benthic crustacean, *Axius* is very similar in appearance to juvenile American lobster, especially when partially digested. *Axius* have virtually identical exoskeletons as juvenile American lobster and are distinguishable only by the morphology of their claws and the shape of the abdomen. *Axius* have sharp protrusions on their chelipeds (claws). The claws of American lobster are smooth. *Axius* also have abdomens that are similar in width to the carapace. The abdomen of American lobster tends be more slender than the carapace. Thus, it is possible that some of the organisms in white hake that were identified as American lobster by fish harvesters were actually *Axius.*

Only 3% of the white hake that we sampled had vomited, demonstrating that the gill net sampling technique was very effective in retaining white hake stomach contents. Furthermore, since these results are not affected by regurgitation of stomach contents due to sampling technique, the stomach content data gathered may be considered representative of white hake predation.

Diets of other groundfish –

We collected 359 specimens of other groundfish (Table 2). Fish was the principal prey of Atlantic cod, sea raven, and spiny dogfish (Figure 6). In contrast, the diet of shorthorn sculpin consisted primarily of invertebrates such as American lobster, rock crab, shrimp and polycheates (Figure 6).

Table 2. Other groundfish sampled during the 3 Phases in St. Georges Bay, Nova Scotia.

Species	*Number sampled*
Atlantic Cod	175
Shorthorn sculpin	73
Sea Raven	73
Spiny dogfish	38

Only Atlantic cod and shorthorn sculpin stomachs contained American lobster remains (Figure 6). A small fragment (part of a uropod) of an American lobster (weight = 0.414 g) was found in one Atlantic cod stomach. That fish was 58 cm in length and was caught in 32 meters of water during the September 2001 survey. This low occurrence is consistent with published estimates of consumption of American lobster by Atlantic cod in the sGSL. In a field study, conducted between 1990 and 1996, over 12,000 Atlantic cod stomachs were sampled in the sGSL and only 6 of these had eaten an American lobster. Further, reviews of published diets of Atlantic cod collected in the sGSL between 1959 to 1980 (n = 22,625 cod stomachs) detected only one American lobster (Hanson and Lanteigne 2000; Hanson & Chouinard 2002).

Shorthorn sculpin was clearly the most important predator of American lobster in the St. Georges Bay study area. American lobster was found in the stomachs of thirteen shorthorn sculpins. The American lobster consumed were juveniles with carapace lengths ranging 30 to 50 mm carapace length. Similarly, another study examined 322 shorthorn sculpins from Chaleur Bay and Miramichi Estuary and found over 12% of these fish contained juvenile American lobster (Hanson and Lantiegne 2000).

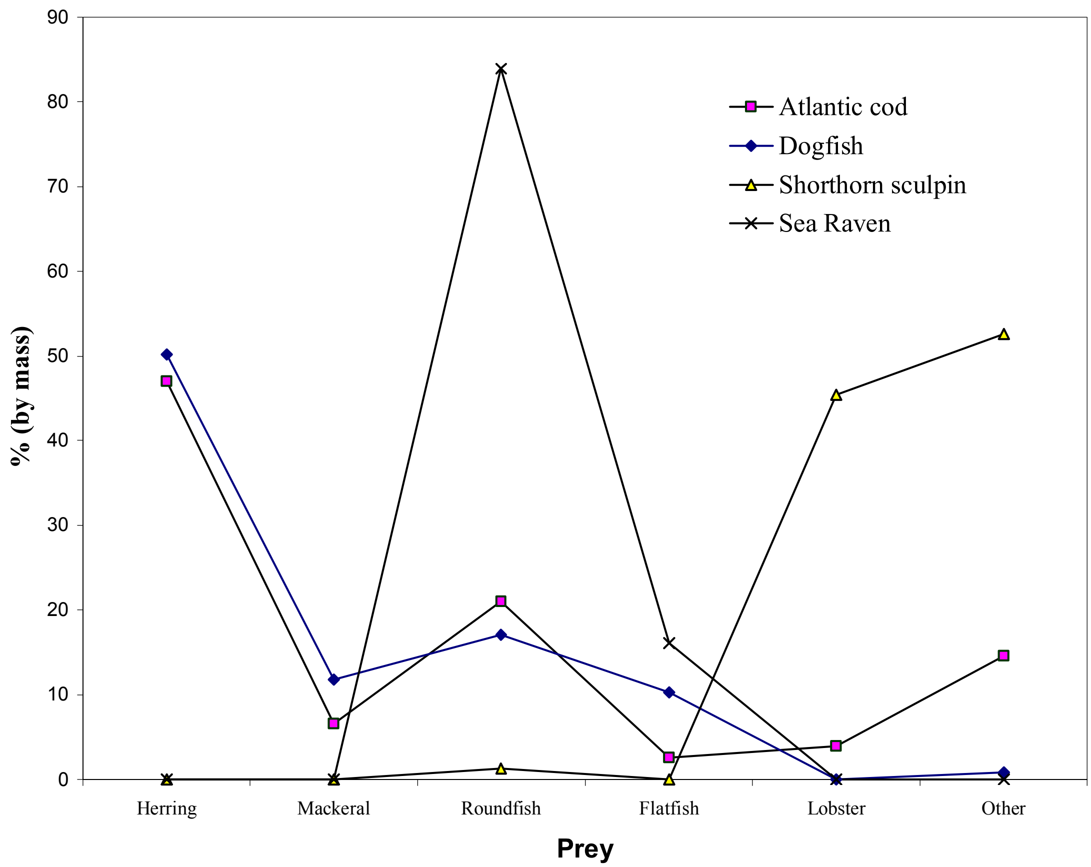

FIGURE 6. Contribution of various fish and invertebrates to the diet of other groundfish. Other includes shrimps, crabs, polycheates.

General Discussion

This study showed that, during the times of year and at locations specified by local fish harvesters (including peer-identified experts), white hake did not eat American lobster. Previous work in the adjacent waters of eastern Northumberland Strait and in St. Georges Bay itself, did find three lobsters in the 2,300 white hake stomachs examined (Hanson and Lanteigne 2000). Taken together, the present study and that of Hanson and Lanteigne (2000) have examined 5,380 stomachs of white hake from eastern Northumberland Strait and St. George's Bay. Only three lobsters were found in these stomachs. Clearly, consumption of American lobster by white hake is a rare event and, therefore would not have any measurable effect on the abundance of American lobster recruiting into the fishery.

However, we can not say that white hake will not eat American lobster. While other studies (Hanson and Lantiegne 2000) did not find white hake to be an important predator of American lobster, the white hake they sampled did indeed eat a small number of American lobster. That study sampled white hake in more northern waters of the sGSL than ours did. Our study was restricted to St. Georges Bay which is in more southern and warmer waters. North of our sampling area in colder deeper waters, Atlantic cod outnumber white hake and the few white hake present may find increased competition for food with the dominant Atlantic cod. In these circumstances, readily available pelagics like herring and mackeral may not be as accessible to the white hake, and alternate feeding strageties may be used. Where Atlantic cod outcompete white hake for herring and mackeral, the white hake may be forced to prey on organisms that it would normally overlook in a less competitive habitat. Here, a larger proportion of the diet may be made up benthic organisms like shrimps, crabs, polycheates and or American lobster. In essence, the diet of individuals in a high interspecific competition habitat, may be the result of the availabilty of certain prey items. And as such, white hake may prey more heavily on herring and mackeral in a low competion situation, and higher on invertebrates in a more competitive habitat.

Hanson and Chouinard (2002) have shown that variations have occured in the Atlantic cod diets in the sGSL. Similar changes may have also occured in the diets of white hake. While competition is no doubt an important factor involved in the feeding strategy of white hake, other mechanisms may also be involved. For example, changes in global thermal regimes. Slight temperature changes can have huge impacts on the primary production (i.e. phytoplankton, zooplankton) in the sGSL. As these primary producers are the driving force behind the ecosystem, any shift in production will be felt by the consumers of the ecosystem. A consequence of warmer waters in the sGSL, for example, is an increase in primary production resulting in more nutrients available to primary consumers such as shrimps. Increased populations of shrimps provide greater amounts of nutrients for pelagics (i.e. herring, mackeral). If the populations of these pelagics were to increase, their availabilty as prey for groundfish increases and predation on other prey species such as invertebrates decreases.

The moratorium on sGSL groundfish may also have had an influence on the diet of white hake. The advent of the closure itself created a new habitat for white hake – there was less gear in the water. The closure of the fishery also meant that discarded bycatch species (available as food for the white hake) were no longer present. Variations such as these serve to create unique habitat and one where variations in feeding strategy may be employed.

Based on Hanson & Lanteigne (2000), white hake will occasionally eat American lobster. It is certain that St. Georges Bay fish harvesters have indeed observed American lobster in the stomachs of white hake. However, opinion that white hake frequently eat American lobster may be explained by well studied social psychological phenomena. Here, established research in recall, memory, and frequency approximation demonstrates that what people recall seeing is influenced by the personal meaning attached to what is being observed. For example, seeing things that are potentially important to one's livelihood and its future will be remembered with much greater detail and sharpness than observations of the less important. Indeed, the personal meaning of what people observe has been shown to influence their sense of how often meaningful observations are made. That is, meaningful observations will seem to occur more often than is actually the case (Tversky and Kahneman 1973). In all likelihood, St. Georges Bay fish harvesters' concerns about white hake predation on juvenile American lobster have arisen from a very human experience such as this. In the past, fish harvesters reported they occasionally observed juvenile American lobster in white hake stomachs. The fact that their livelihood depends on the American lobster fishery, combined with the moratorium on commercial white hake fishing and declining lobster catches, has contributed to a concern that white hake are increasingly preying on juvenile American lobster. If the predation rate was high, it could depress recruitment into commercially exploitable populations. Recollections of white hake predation on juvenile American lobster, in this set of circumstances, become sharpened and remembered as more common than is the case. As a result, concern about the negative meaning of this for the commercial viability of American lobster populations heightens. Hopefully, the results from this research will provide fish harvesters with relief from concerns respecting the prospect and impact of white hake predation on American lobster.

This study has greatly improved our knowledge of white hake feeding habits in the sGSL. Prior to this study, little was known about white hake feeding habits in shallow, coastal waters. The few published studies were conducted in deep shelf waters, primarily in the Gulf of Maine. Nevertheless, one general conclusion is that adult white hake eat mostly fish and the species eaten seems to depend on which prey species are dominant in the specific ecosystem being studied – assuming the prey species occurred near the bottom.

In addition to documenting white hake stomach contents systematically within the St. Georges Bay setting, this research contributes to two other potentially important considerations. On the one hand, it demonstrates that consulting and incorporating fish harvesters' ecological knowledge will enhance the design and conduct of studies aimed at exploring groundfish ecology. While the content analyses of the white hake stomachs sampled do not support fish harvester's concerns about high levels of predation on juvenile American lobster, the fish harvesters' advice respecting the time of year for and location of sampling did produce successful catch results. Moreover, this research has also demonstrated the research design, research outcomes, and dissemination benefits of developing and working within fish harvester organisation, university and government science collaborations. As examples, the results of this collaboration have clarified the role of white hake predation within the sGSL ecosystem, have further demonstrated that shorthorn sculpin are the most important fish predator with respect to American lobster, and have shown the sensibility of incorporating fish harvester's local ecological knowledge in the research design and sample site selection process.

On the other hand, this research demonstrates that fish harvesters' observations and experiences have much to contribute to marine research, especially with respect to the design and conduct of research focused on examining local ecosystem concerns. While social science research methods may assure systematic documentation of experiences and observations, the fish harvesters' willingness to engage enthusiastically and to share their experiences and knowledge with this research illustrates the potentials of developing and working with an approach that is inclusive, sincere, and respectful.

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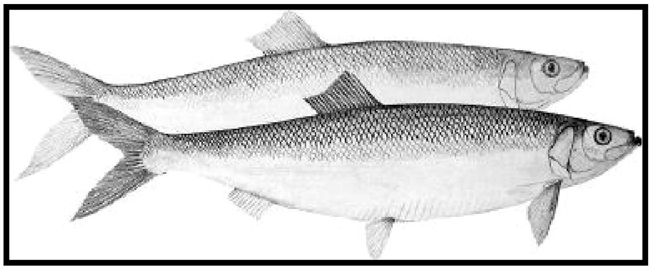
Watts, H.J., & MacPherson, H.C. 2002 (a). An Interdisciplinary Study of St. Georges Bay Fish Harvesters' Ecological Knowledge and White Hake (*Urophycis tenius*) Predation on Juvenile American Lobster (*Homarus americanus*). Phase II. Social Research for Sustainable Fisheries. Research Report 5. Saint Francis Xavier University. August 2002.

Watts, H.J., & MacPherson, H.C. 2002 (b). An Interdisciplinary Study of St. Georges Bay Fish Harvesters' Ecological Knowledge and White Hake (*Urophycis tenius*) Predation on Juvenile American Lobster (*Homarus americanus*). Phase III. Social Research for Sustainable Fisheries. Research Report 6. Saint Francis Xavier University. October 2002.

Appendix I

Species Identified in Groundfish Stomachs in the 3 Phases of Sampling, 2001-2002

Roundfish



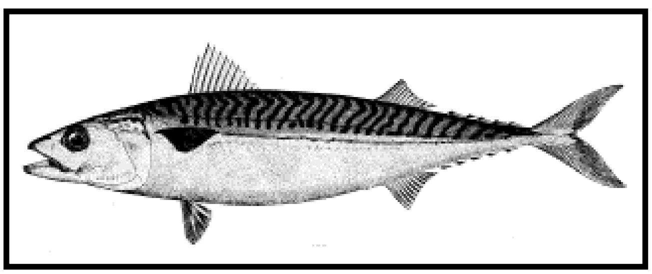
Source: http://collections.ic.gc.ca/peifisheries/species/herring/asp.

Herring – *Clupea harrengus*

Habitat: Herring are primarily pelagic fish occurring in schools from surface to depths of 200m. There are a number of separate stocks that have been identified. Each stock has different spawning grounds and migration patterns.

Reproduction & Growth: In Canadian waters, herring are most likely to spawn between April and May. The number of eggs deposited by a female depends on age and the stock a fish belongs to. The number of eggs increases with age up to a maximum age, and then the number decreases with age. Herring become sexually mature between 3 to 5 years of age. Growth rates for herring depend on a number of factors including temperature, population size, and food availability; but in general, after herring have reached 5 years, they grow an average of 1cm/year in the southern Gulf of St. Lawrence (sGSL).

Prey: Herring feed on euphasiid crustaceans, copepods, and small fish larvae (herring, silverside, capelin).



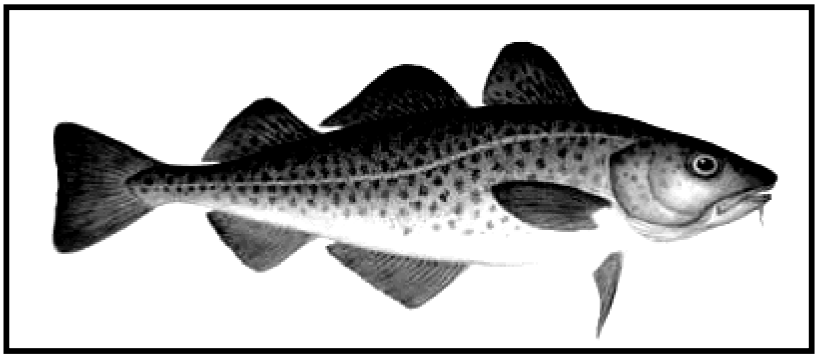
Source: http://photolib.noaa.gov/historic/nmfs/figb0351.htm

Mackerel – *Scomber scombrus*

Habitat: Mackerel are fast swimming pelagic fish which are usually found in large schools. They are found in the Northwest Atlantic from Labrador to North Carolina.

Reproduction & Growth: There are 2 major spawning components: the Southern group which spawns in the Mid-Atlantic Bight in April and May, and the Northern group which spawns in the southern Gulf of St. Lawrence in June and July. Both groups winter between Sable Island and Cape Hetteras in warm waters (around 7ºC). Maximum size for mackerel is around 47 cm in length and 1.3 kg in weight. Sexual maturity begins at around age 2 and ends at age 3. Mackerel can live to be 20 years of age.

Prey: Mackerel feed on small crustaceans (e.g. copepods, amphipods, mysid shrimp) and small molluscs. The diet of adult mackerel also consists of larger prey such as fish (herring and sculpins), shrimp and polychaetes.



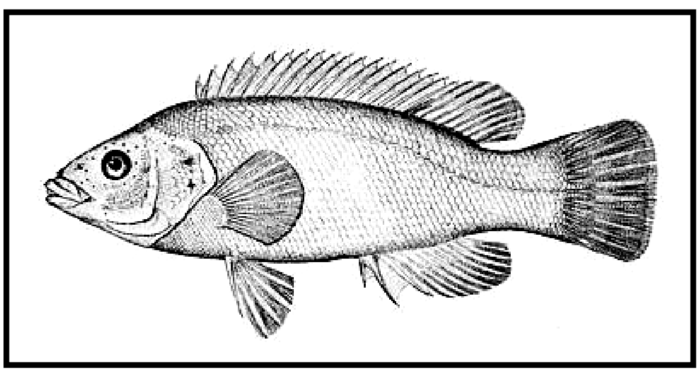
Source: www.chartingnature.com/AtlanticCod-2080.cfm

Atlantic Cod – *Gadus morhua*

Habitat: Atlantic cod inhabit waters with temperatures ranging from –0.5 to 10ºC and depths of surface to 457m. Distribution is from inshore regions to the edge of the continental shelf in the Canadian Atlantic area. There are different stocks in different areas and bottom type, temperature, and depth vary between stocks.

Reproduction & Growth: In the south western Gulf of St. Lawrence, spawning begins in May and ends in September, with peak spawning occurring in late June. Atlantic cod reach sexual maturity between 4 to 5 years (a length of 41 cm). The number of eggs produced by a female increases with age.

Prey: Prey includes herring, mackerel, fourbeard rockling, rock crab, flatfish, lobster, and other crustaceans and molluscs.



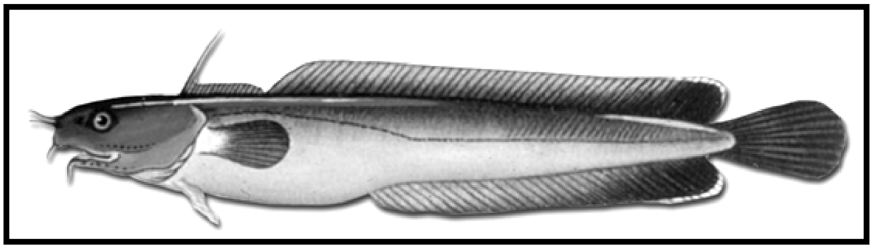
Source: www.nefsc.nmfs.gov.photos/lineart/Species_By_Name/cunner.jpg

Cunner/Perch – *Tautogolabrus adspersus*

Habitat: Perch are bottom dwellers that inhabit the shallow inshore waters. Perch cannot withstand cold temperatures easily and mass mortalities sometimes occur. Perch become inactive in winter months.

Reproduction & Growth: Spawning occurs from June to mid-August in the sGSL and a little later on the Nova Scotian coast. Sexual maturity is reached when fish are 8 to 11 cm long. In general, perch do not reach sizes over 30 cm long.

Prey: Perch are omnivorous, feeding primarily on molluscs and crustaceans but may also consume barnacles, sea urchins, marine worms, fish eggs and eelgrass.



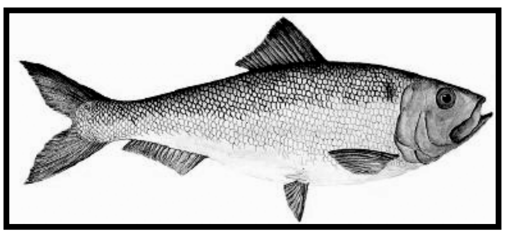
Source: www.seaangler.8m.com/fish%20id/r-w/pages/Rockling

Fourbeard rockling – *Enchelyopus cimbrius*

Habitat: Fourbeard rockling occur in soft mud, sand, and gravel bottoms at depths of 55 to 550m. They create depressions in the sediment surface to make partially concealed burrows, which provide shelter for fourbeard rocklings and expose potential prey.

Reproduction & Growth: Spawning occurs in May or June and can last anywhere from August to October, depending on water temperature. Adults reach an average size of 15 to 30cm in length.

Prey: Main prey of fourbeard rockling includes brown shrimp, prawn, isopods, polychaetes, and molluscs



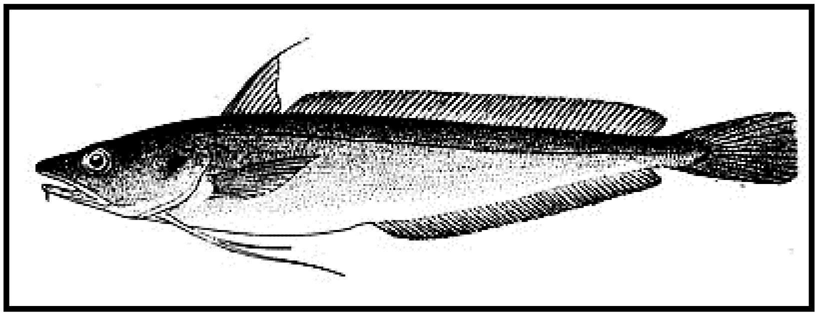
Source: www.chartingnature.com/Alewife-2010.cfm

Gaspereau – *Alosa pseudoharengus*

Habitat: Gaspereau are an anadromous species spending time in both fresh and salt water. Most of their adult lives are spent at sea, entering fresh water only to spawn. They are found most often in waters 56 to 110m deep at a temperature of 4ºC. Gaspereau are light sensitive and consequently are present in greater depths during daylight.

Reproduction & Growth: Spawning takes place in lakes, rivers, and streams above the head of tide. Spawning season occurs from late April or early May and lasts for a period of two months. The older fish spawn first with younger fish spawning later in the season. Average size of Gaspereau is 25 to 30 cm.

Prey: Main food includes amphipods, copepods, small fish, fish eggs, and mysids.



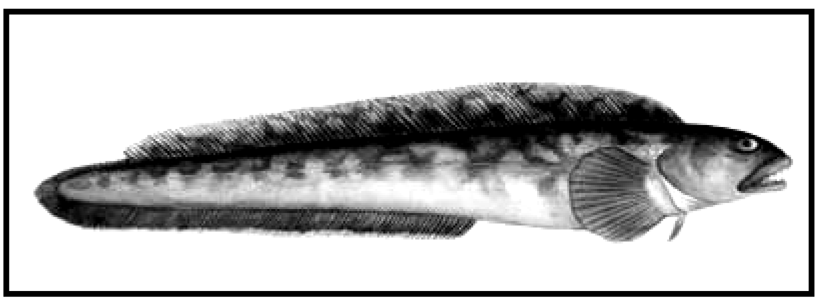
Source: www.portlandfishexchange.com/species/hk.htm.

White Hake – *Urophycis tenuis*

Habitat: White hake inhabit the continental waters of the western Atlantic Ocean on soft bottoms in waters 5 to 11ºC. They have seasonal migration in which they move from shallow waters to overwinter in the deeper warm waters of the Laurentian Channel.

Reproduction & Growth: This demersal species moves into shallow water in late June or early July to spawn. Males and females become sexually mature between 2 to 5 years of age and at lengths of around 40cm. White hake are considered by some to be the most fecund of the commercial groundfish species, producing several million eggs per individual. A fast growing species, white hake reach sizes up to 135cm.

Prey: As this appendix illustrates, white hake prey upon a variety of species. The most preyed upon species are herring and mackerel. Other prey items include various roundfish, flatfish, molluscs, crustaceans, shrimp species, mysids, and gammarids.



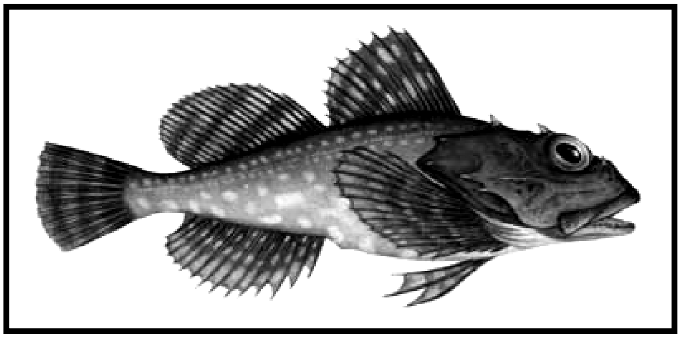
Source: www.chartingnature.com/OceanPout-2360.cfm

Ocean Pout/Rock Eel –*Marcrozoarces americanus*

Habitat: This fish is found from Labrador to North Carolina. Ocean pout are bottom dwelling fish occupying hard and semi-hard substrates although they will occupy other bottoms including muddy substrates. They can tolerate temperatures from sub-zero to 16 °C and have seasonal migration patterns where they move inshore in the spring and to deeper waters in autumn.

Reproduction & Growth: Ocean pout spawn in crevices and holes under boulders in shallow water in late August-late September, depending on the area. Females cease feeding prior to spawning and move into deeper water to feed after they spawn. Males guard the fertilised eggs until they hatch, 2 to 3 months after deposition. They can reach up to 100cm in length but generally average 30 to 60cm.

Prey: Ocean pout feed by scooping up mouthfuls of sediment from the bottom. Prey includes custaceans, molluscs, sea urchins, marine worms, and the occasional small fish.



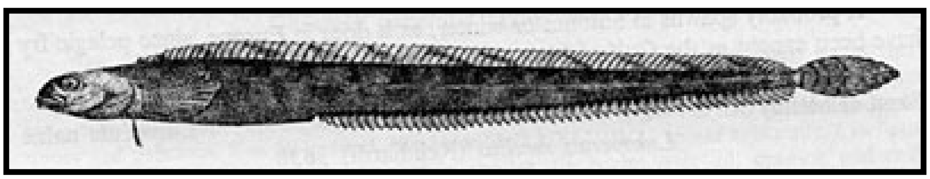
Source: www.chartingnature.com/ShorthornSculpin-2430.cfm

Shorthorn Sculpin – *Myoxocephalus scorpius*

Habitat: This benthic species is found in depths to 37m. They are often present around wharves where they are searching for food. They are slow moving fish, moving only short distances at a time using its large pectoral fins to propel it through the water.

Reproduction & Growth: Shorthorn sculpins spawn in late November or early December. There is one male and one female involved in this species' spawning. A female lays her eggs in V-shaped crevices and the male fertilizes the newly laid eggs. The male guards the eggs until hatching while the female moves to deeper water. Males reach sexual maturity at a younger age and smaller size beginning at age 5 (all are mature by age 6, 30cm in length). Females may become sexually mature at age 6 (all are mature by age 8, 34 to 35cm in length). Maximum size for males is 50.6cm and 42.2cm for females.

Food: Prey includes rock crab, American lobster, sea stars, sea cucumbers, and polychaetes.



Source: www.whoi.edu/marinecencus/doc/Reference/fishes_c11_22.htm

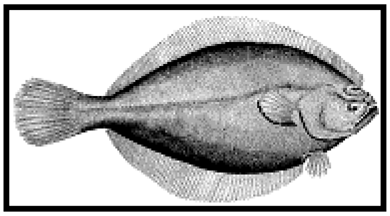
Snakeblenny – *Lumpenus lumpretaeformis*

Habitat: This benthic species inhabits muddy or hard substrates. They are usually found in water depths of 30 to 200m.

Reproduction & Growth: There is little information documented on this aspect of the snakeblenny. Spawning may occur in autumn or winter. Maximum size for the sGSL is 40.3cm total length.

Food: Main prey includes amphipods, copepods, small starfish, and molluscs.

Flatfish



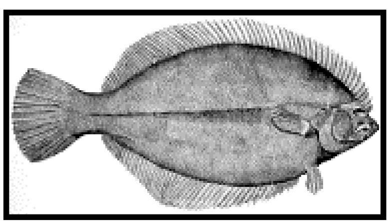
Source: http://collections.ic.gc.ca/peifisheries/species/americanplaice.asp

American Plaice – *Hippoglossoides platessoides*

Habitat: American plaice inhabit waters with fine sand or mud bottom. They usually occur in depths of 73 to 274m, but can also be found in depths of 36 to 713m. They are a cold water fish which prefer temperatures just below 0 to 1.5ºC.

Reproduction & Growth: Spawning occurs anywhere from April to June. Young hatch 11 to 14 days after being dispersed. American plaice are a long-lived, slow-growing species with females living longer and growing faster than males. Males mature at a younger age and smaller size.

Food: In the Gulf of St. Lawrence, young plaice (<30cm) eat mysids, amphipods, echinoderms, and polychaete worms. Larger plaice eat bivalve molluscs and echinoderms (brittle stars, sand dollars, and sea urchins)



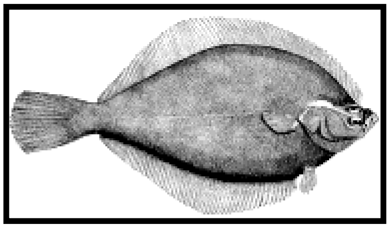
Source: http://collections.ic.gc.ca/peifisheries/species/winterflounder.asp

Winter Flounder – *Pleuronectes americanus*

Habitat: This inshore flatfish species lives in shallow water on soft, muddy to moderately hard bottoms. They are usually found in water depths of 1.8 to 36.6m, but can be found in deeper water. They live onshore in the summer and migrate offshore in winter months.

Reproduction & Growth: Spawning occurs in shallow water over sand and mud bottoms in late winter to early spring. Males and females mature at around 3 years, with males being 20cm in length and females being 25cm in length. Winter flounder seldom exceed 45 cm in length.

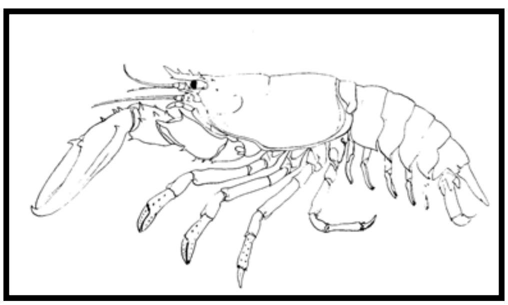
Food: Winter flounder are sight feeders and as a result, feed during the day. The most important food items in the GSL are polychaetes and crustaceans.



Source: http://collections.ic.gc.ca/peifisheries/species/yellowtailflounder.asp

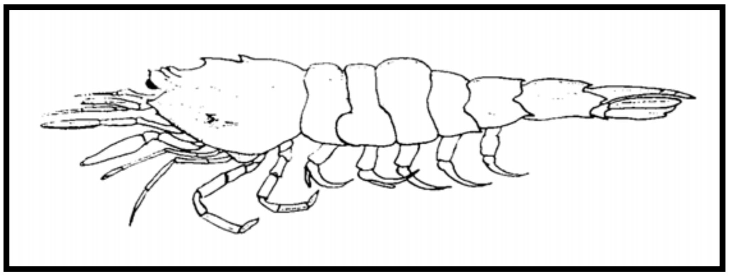
Yellowtail Flounder – *Pleuronectes ferruginea*
Habitat: Yellowtail flounder are an offshore species that live on sand or mud substrates. They inhabit shallow-water banks in waters ranging from 27 to 364m, but are usually found in depths from 37 to 91m.
Reproduction & Growth: Spawning occurs on the bottom in summer months in Canadian waters. Yellowtail flounder are a relatively fast-growing species. Females grow faster than males, especially after 6 years.
Food: The small mouth of the yellowtail flounder restricts food choice. Main prey consists of polychaete worms, amphipods, and shrimp. These flounders feed during the night.

Crustaceans



Source: (Squires 1990)

American Lobster – *Homarus americanus*
Habitat: This marine crustacean inhabits the Atlantic coast form North Carolina to Labrador. In the sGSL, most American lobsters are found in waters ranging from 1 to 40m in depth. They can be found on a variety of substrates including muddy, rocky, and sandy bottoms. Lobster are also found in burrows and among kelp forests which they use for protection against predators.
Reproduction & Growth: Lobsters generally mate after the female has molted. The male will flip the female onto her back while supporting her body to hold her up off the bottom. The male will then insert its modified first pair of pleopods into the female's seminal receptacle which is located at the base of the third pair of walking legs. Once he delivers the gelatinous spermatophore, he plugs the female's seminal receptacle so that the spermatophore will not be lost. The female does not extrude her fertilized eggs until 1 year after fertilization. She then carries the eggs on swimmerets on her abdomen for the next 9 to 12 months until the larvae hatch.
Prey: Lobsters eat crab, mussels, clams, sea stars, sea urchins, marine worms, small fish, amphipods, shrimp, and carrion. If there is a lack of available prey items, lobsters will eat marine plants and sponges to obtain the necessary energy.



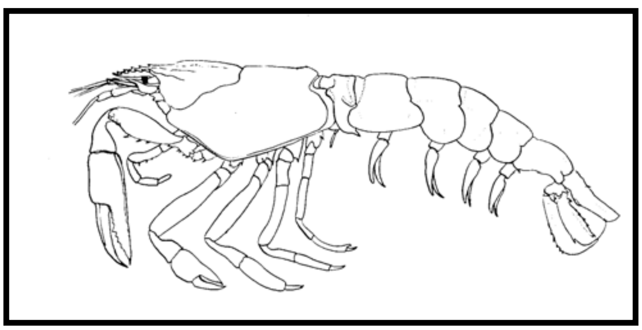
Source: (Squires 1990)

Arctic argid – *Argis dentata*

Habitat: *Argis* inhabits sandy and muddy bottoms from depths of intertidal water to 2000m. They are present in many areas of European and Canadian waters including Canadian Arctic Islands and northwest Greenland to Nova Scotia.

Reproduction and Growth: In some populations, there is a change of sex from male to female while others are primarily female. It is suggested that males live only 2 years while females live to 5 years of age. Mature males reach lengths of 10 to 17mm cl while mature females reach lengths of 10 to 27mm.

Prey: *Argis* feed on crustaceans, foraminiferans, small bivalves, gastropods, and polychaetes.



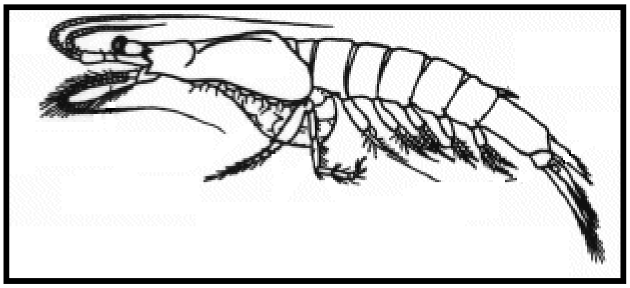
Source: (Squires 1990)

Mud Shrimp - *Axius serratus*

Habitat: There is very little information available on this species. It is a benthic organism inhabiting sandy, rocky, and muddy substrates.

Reproduction & Growth: General morphology is similar to the American lobster. However, in *Axius*, the abdomen is similar in width to the carapace, while in lobsters the abdomen is more slender than the carapace. In contrast to the smooth claw of American lobster, *Axius* has sharp protrusions on elongated claws. There has been little work done on the reproductive cycle of this crustacean, but it is known that they are similar to lobsters in that the female carries the fertilized eggs on her abdomen. Males can grow to lengths of 30mm carapace length (cl) while females grow to 33mm cl.

Prey: While not well documented, one can assume the mud shrimp have a diet similar to that of other shrimp species.



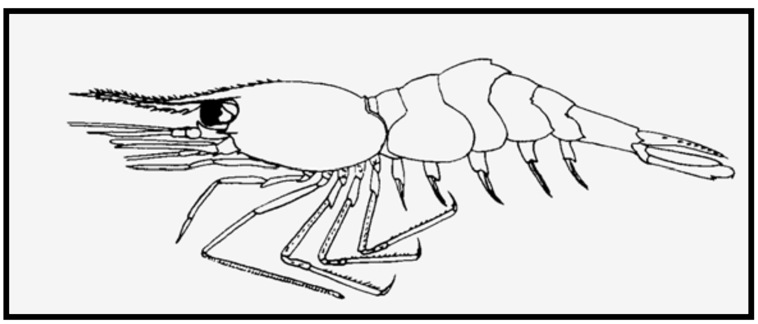
Source: http://tidepool.st.usm.edu/mysids/

Mysids – *Mysis mixta*

Habitat: *Mysis mixta* is found in the littoral, sublittoral, pelagic, and benthic habitats of the ocean. They have daily vertical migrations within the water column to find food.

Reproduction & Growth: *Mysis* is a marsupial animal whereby both embryonic and post-embryonic development takes place entirely inside the brood pouch of the female. This type of mysid is semelparous, meaning the female dies after producing one brood. They have a two-year life cycle in which they breed during their second autumn. Fully developed juveniles are released from the brood pouch in the spring of each year. Mysids grow to 23mm.

Prey: Mysids feed on phytoplankton and zooplankton such as diatoms, dinoflagellates, and copepods.



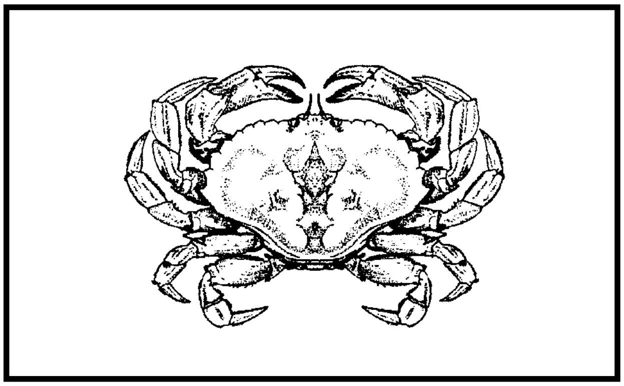
Source: (Squires 1990)

Pink shrimp - *Pandulas borealis*

Habitat: Pink shrimp are present throughout the north-temperate and subarctic regions of the sea. They are usually found on soft, muddy bottoms in depths of 150 to 600ft. They are present inshore in winter and migrate offshore in the spring.

Reproduction & Growth: All pink shrimp mature as males. At 2 and ½ years of age, the males fertilize older females and then develop into female pink shrimp. Adult female shrimp move inshore to spawn. Pink shrimp have a life span of 4 to 5 years and can grow to 5 inches in length. In order to grow, pink shrimp shed their exoskeleton (moult).

Prey: Pink shrimp feed on microscopic plankton while larvae, and feed on euphasid shrimp, amphipods, copepods, polychaetes, foraminiferans, and other benthic organisms as adults.



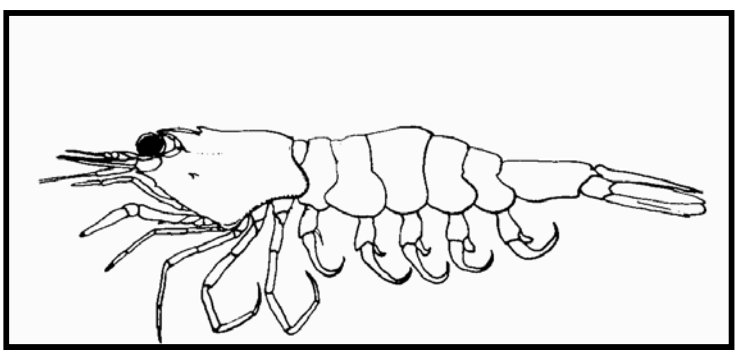
Source: www.mar.dfo-mpo.gc.ca/fisheries/ res/imp/98rkcrab38.html

Rock Crab –*Cancer irroratus*

Habitat: Rock crab live on rock, sand and gravel bottoms and inhabit water less than 20m. They are present in the open ocean and in estuaries.

Reproduction & Growth: Moulting occurs in April and May for rock crabs. Earliest maturity for females is 25mm carapace width (CW) and 40mm for males, but average maturity is between 50 to 57mm and 65 to 75mm for females and males respectively. Fertilization of the female occurs just after moulting and eggs are extruded onto the females abdomen in late October. Males have a maximum CW of 155mm while females have a maximum CW of 110mm. Commercial size is reached in approximately 6 years.

Prey: The diet of rock crab consists of detritus, small fish, and molluscs.



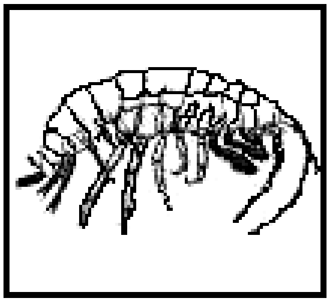
Source: (Squires 1990)

Sand Shrimp– *Crangon septemspinosa*

Habitat: Sand shrimp live on sandy bottoms and in eelgrass beds in the open shores, bays, and estuaries from the low-tide line to 91m deep water.

Reproduction & Growth: *Crangon* grow by shedding their exoskeleton. Male sand shrimp grow to be 47mm while females grow to 70mm total length.

Prey: Primarily, *Crangon* eat mysids but will also eat amphipods, small gastropods, and bivalves.



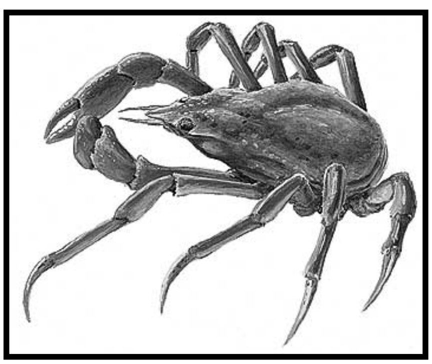
Source: www.georgiastrait.org/quadratspecies.html

Sideswimmers or Scuds - *Gammarus sp.*

Habitat: Gammarids are found throughout the intertidal zone. They are found under rocks, in wet algae, and swimming freely in the water column.

Reproduction and Growth: Reproduction involves mating patterns where a male will choose a female and carry her underneath his ventral surface for several days before copulation. Gammarids reach lengths over 2 cm.

Prey: Gammarids eat a variety of phytoplankton and zooplankton including copepods and diatoms.



Source: www.fauna.is/Pages/archves/ inverteb/trjonukrabbi.html

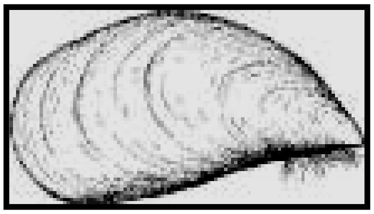
Toad Crab – *Hyas araneus*:

Habitat: Toad crabs are found in the shallow subtidal zone to depths of 510 m, with the bulk of the species found in deep water. They are most commonly found on gravel or mud substrates.

Reproduction & Growth: Males reach an average size of approximately 0.75kg in weight and 75mm carapace width. Females are smaller having a maximum carapace width of 65mm.

Prey: Prey includes amphipods, polycheates, sea urchins, small crabs and scavenged fish.

Other Invertebrates



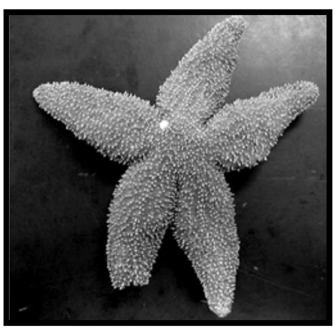
Source: http://boat.iac.wa.gov.shellfish.htm/

Blue mussel – *Mytilus edulis*

Habitat: Blue mussels inhabit rocky shores of open coasts on rock surfaces and crevices. They are also present in estuaries, sheltered harbours, and around piers. They form dense masses from the high intertidal to shallow subtidal zones.

Reproduction & Growth: Peak spawning occurs in spring and summer, lasting from May – October. Fertilization is external. Mussels become sexually mature at 1 to 2 years. They have a short life span of just 2 to 3 years.

Prey: Blue mussels filter water to obtain important nutrients like detritus and phytoplankton for survival and growth.



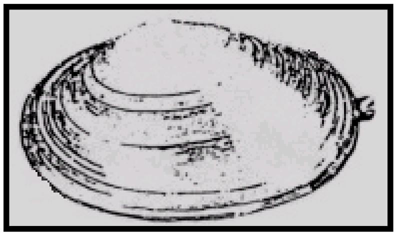
Source: http://www.dscc.edu/bwilliams/Biology2/bio2animal.htm

Boreal Sea Star – *Asterias vulgaris*

Habitat: Sea stars are common along the intertidal zone to deep water. They can withstand fairly long periods out of the water, which allows them to be present high in the intertidal zone. Sea stars can be found on a number of substrates including rocky, muddy, and sandy substrates.

Reproduction & Growth: Female sea stars release their eggs into the water column where they are fertilized externally. A female of 144mm in diameter can release up to 2.5 million eggs at one time. Maturity is reached at about 1 year. The life span of sea stars is usually 7 to 8 years but can be between 5 to 10 years depending on the area.

Prey: Sea stars feed on bivalves, polychaetes, small crustaceans, other echinoderms, and carrion.



Source: www.glf.dfo-mpo.gc.ca/.../ clam_clam_%202001_2006-e.html

Clam – *Mya arenaria*

Habitat: This clam lives on muddy, sandy, or gravely bottoms from the shore to shallow water. They burrow to depths of 50cm, extending only its siphon into the water.

Reproduction & Growth: In general, spawning occurs once annually in the spring. In some instances (warm water temperatures) spawning will occur twice annually. Males and females reach sexual maturity at <20mm. Spawning is external. Males spawn first, which then triggers the females to spawn. These clams can live for 10 to 20 years and reach sizes of 155mm in height and 60mm in width.

Prey: *Mya arenaria* feed on phytoplankton, small zooplankton, diatoms, suspended particulates, and dissolved organic matter.

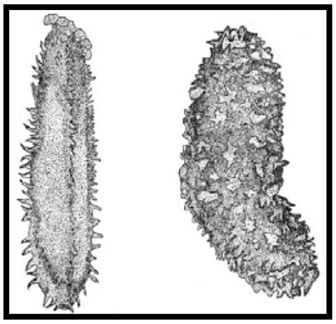
Source: http://www.marlin.ac.uk/index2.htm?demo/Macbal.htm

Macoma clam - *Macoma balthica*

Habitat: This clam lives a few centimetres beneath the surface of sand or mud. They occur in the upper region of the intertidal to sublittoral zone, particularly in estuaries and tidal flats.

Reproduction & Growth: Spawning occurs primarily in the spring. Fertilization is external, with the eggs being ejected from the exhalant siphon of the female. Males and females are usually less than 2.5cm in size. Maturity is reached at 3 to 6mm. There is a general growth rate of 3 mm/year.

Prey: Prey includes diatoms, deposited plankton, suspended phytoplankton, and detritus.



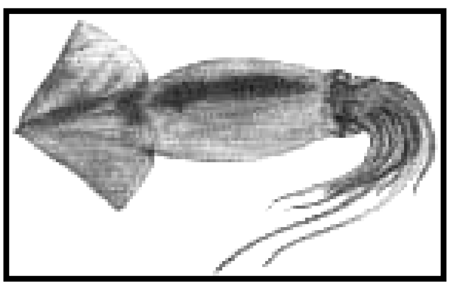
Source: www.itmonline.org/ arts/seacuke.htm

Sea Cucumber – *Class Holothuroidea*

Habitat: Sea cucumbers inhabit tropical, temperate, and cold deep-water areas. They are found on a variety of substrates.

Reproduction & Growth: Fertilization is external with females and males releasing eggs and sperm into the water column to be fertilized. The life span of sea cucumbers is 5 to 10 years. The largest species can grow to lengths of 2m, but most species are much smaller than this – only several centimetres in length.

Prey: Sea cucumbers feed on detritus found in the water column or on the substrate.



Source: www.gov.nf.ca/fishaq/Species/ Shellfish/squid.htm

Short-finned Squid – *Illex illecebrosus*

Habitat: Short-finned squid inhabit the Atlantic from Central Florida to southern Labrador. These squid migrate distances of more than 1000 miles. They spend daylight hours near the bottom where they prefer water temperatures of 6 to 7ºC, while at night, they move into the upper layers of the water column.

Reproduction & Growth: Spawning occurs over several months (December to June). Life span of short-finned squid is 12 to 18 months – they die after spawning. These squid reach lengths of 35cm, with an average size of 26cm.

Prey: Juvenile squid feed on a variety of crustaceans, while adults have a diet composed of fish and crustaceans.

References:

The majority of the textual information was taken from the following sources:

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Scott, W.B. & Scott, M.G. 1988. Atlantic Fishes of Canada. Can Bull. Fish. Aquat. Sci. **219**:731 p.

Squires, H. J. 1990. Decapod Crustacea of the Atlantic Coast of Canada. Can. Bull. Fsh. Aquat. Sci. **221**:532 p.