

Food of winter flounder *Pseudopleuronectes americanus* in a sea urchin dominated community in eastern Newfoundland

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ABSTRACT: Gut contents were analysed from 63 winter flounder collected off eastern Newfoundland from rocky bottoms dominated by green sea urchins *Strongylocentrotus droebachiensis*. Availability of prey items consumed was determined in the field. After removal from the analysis of items too large for the flounder to eat, and of those from cryptic microhabitats, it is evident that winter flounder are not selecting their food species. They do, however, select those prey items which are near the maximum size which they can consume, rather than the most abundant size. Predation by winter flounder may be large enough to influence the abundance of 2 important prey taxa, *Metridium senile* and *Acmaea testudinalis*. Comparison of gut contents of winter flounder from smooth and rough bottoms suggests that winter flounder predation on the green sea urchins themselves is unlikely to be important except on smooth bottom lacking cryptic microhabitat.

INTRODUCTION

The winter flounder is one of the most abundant demersal fish in shallow water in the Northwest Atlantic (Klein-MacPhee 1978). It has a very broad diet, which includes most small invertebrates, demersal fish eggs, and plant material (Pearcy 1962, Richards 1963, Mulkana 1966, Klein-MacPhee 1969, 1978, Kennedy & Steele 1971, Frame 1972).

Dexter (1944) suggested that predation by winter flounder might influence the structure of the benthic community (which he termed 'the *Strongylocentrotus* – *Buccinum* biome') in Ipswich Bay, Massachusetts, USA. Winter flounder are abundant in shallow water off eastern Newfoundland (unpubl. obs.), where a *Strongylocentrotus*-dominated community predominates (Himmelman 1985). This community is characterized by a high biomass of green sea urchins, *Strongylocentrotus droebachiensis*, and a low biomass of fleshy algae. Coralline algae are well developed, often several centimeters thick and heavily undercut. Horse mussels *Modiolus modiolus* are very abundant, and form large patches, or beds, up to several meters across. The undercut and branched coralline algae, and the horse mussel beds, provide cryptic microhabitat for a number of invertebrate species (Keats et al. 1985, Witman 1985).

It is not known whether winter flounder predation has any influence on the abundance of benthic invertebrates, particularly the dominant herbivore, the green sea urchin. The main purpose of this study was to determine the diet of winter flounder in the urchin dominated sublittoral zone, by analysis of gut contents, with special attention given to predation on green sea urchins.

The high degree of variation, from area to area, in the composition of the diet (Klein-MacPhee 1978), and a high dietary preponderance of a few prey types within habitats (Tyler 1972), suggests that the importance of a food species is related to its availability, and that winter flounder show little or no selective feeding. To evaluate this suggestion requires detailed comparisons of gut contents of winter flounder with food species that are actually available within a habitat (Berg 1979). To determine availability requires knowledge of the abundance, size structure, microhabitat use, and behaviour of potential prey species, as well as the feeding behaviour of the flounder. Prey which are too large to be consumed, or species which are hidden during the day when flounder feed, should be removed from raw biomass data before such data are used to determine availability and to evaluate selection. A second purpose of this research was to evaluate the possi-

bility of selective predation by comparing the diet of winter flounder in the urchin dominated sublittoral zone with the food that is actually available in that habitat.

This work is part of a program to examine predation by the most abundant demersal macrophagous fishes in the sea urchin dominated community typical of eastern Newfoundland (Keats et al. 1986, 1987).

MATERIAL AND METHODS

Sixty-three winter flounder were collected during daytime (10:00 to 16:00 h) from Conception Bay, Newfoundland, Canada (Fig. 1) between 19 June and 17 August 1983 at 5 to 15 m depth using SCUBA diving. The bottom within this depth range consists of the urchin dominated hard substratum typical of the open Atlantic coast of Newfoundland. Specimens were either dissected fresh, or frozen for later dissection. Each fish was weighed (to the nearest 1 g), and the contents of the gastrointestinal tract were identified and weighed to the nearest 0.1 g. Fullness was estimated as:

$$\frac{\text{weight of gut contents}}{\text{weight of fish}} \times 100 \%$$

The mean length for the flounder sampled was $36.3 \text{ cm} \pm 0.78 \text{ SE}$ (Fig. 2).

The most abundant invertebrate prey, sea anemone *Metridium senile*, was not measured because of the difficulty of handling the partially digested anemones. Three other prey taxa, chitons *Tonicella* spp., green sea urchins, and limpet *Acmaea testudinalis* were measured from flounder guts. All potentially available prey were measured to the nearest 0.1 mm from habitat samples.

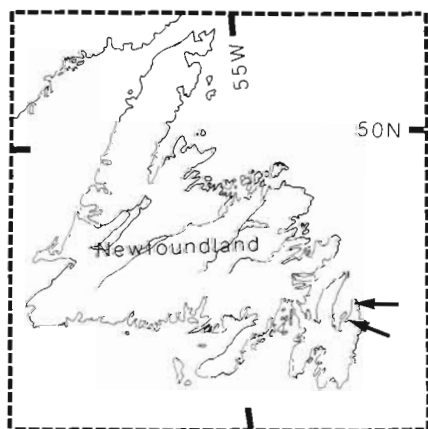


Fig. 1 Location of study sites in Conception Bay, Newfoundland. All collections and bottom samples were made in the area between the 2 arrows

Prey abundance was assessed by sampling in the main collecting area in Conception Bay ($46^{\circ} 40' \text{ N}$, $52^{\circ} 50.2' \text{ W}$; Fig. 1). Sampling was conducted in the middle of the urchin dominated zone (6 to 9 m), using a 0.1 m^2 quadrat. Ten quadrats were placed by blind casting during July 1983. Material which could be harvested by hand was placed into 0.5 mm (mesh size) collecting bags. The remaining material was then scraped from the rock surface using a combination of paint scrapers, diving knives and hard-bristle tooth brushes, and collected using an air dredge with a 0.5 mm (mesh size) collecting tube. Notes were kept on the microhabitat used by the invertebrate species, since many potentially available prey may not be actually available because they occupy cryptic microhabitats.

At all except two of the flounder collection sites there was an abundance of branched and undercut coralline algae, crevices, and horse mussels, all of which provide microhabitat from which winter flounder can probably not remove juvenile urchins (Keats et al. 1985, Whitman 1985). At 2 sites the substratum consisted of smooth bedrock, with very little such microhabitat. I therefore compared the abundance of urchins and the 3 other main food species in winter flounder guts on the basis of this microhabitat availability (i.e. the gut contents of 9 flounder from 'smooth' bottom was compared with that of the remaining 54 from 'rough' bottom).

RESULTS

Diet

The mean fullness index for the flounder sampled was 3.1% ($\pm 0.24 \text{ SE}$), and only 2 individuals had empty gastrointestinal tracts.

As a result of using the entire gastrointestinal tract, rather than just the stomach, a significant fraction

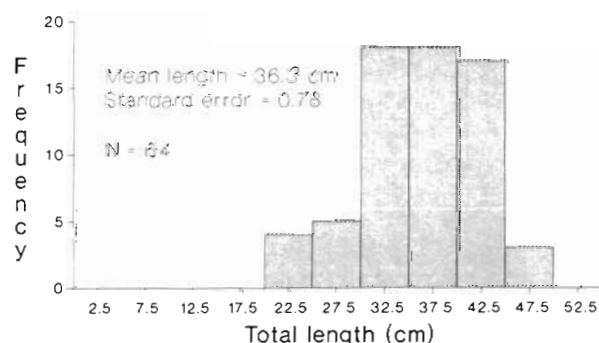


Fig. 2. *Pseudopleuronectes americanus*. Length frequency distribution for winter flounder sampled from Conception Bay

(40 % by weight) of the gut contents consisted of unidentifiable material (Table 1). This unidentifiable fraction represents digestive juices in combination with digested material from all prey items. Fleshy algae and the sea anemone *Metridium senile* were the only significant soft prey, and they were identifiable, even in

the mid-lower portion of the intestine. It is therefore unlikely that major prey were missed because of digestion, but the percent of identifiable material probably provides a better index of the importance of a particular prey species in the diet of winter flounder than does the percentage of diet by weight that includes the uniden-

Table 1. *Pseudopleuronectes americanus*. Gastrointestinal tract contents of all 63 winter flounder collected during 1983–84

Taxon	Mean weight \pm SE (g)	% of diet by weight	% of identifiable material	Frequency (N)	% occurrence in guts which contained food
Hydrozoa					
Unidentified	0.88 \pm 0.75	4.23	7.11	5	8.2
Anthozoa					
<i>Metridium senile</i> ^a	2.13 \pm 0.61	10.2	17.2	24	39.3
<i>Gersemia rubriformis</i>	<0.05	—	—	1	1.6
Bryozoa					
Unidentified	<0.05	—	—	1	1.6
Crustacea					
Gammarid amphipods	<0.05	—	—	1	1.6
<i>Hyas araneus</i>	<0.05	—	—	2	3.3
<i>Pagurus</i> sp.	<0.05	—	—	2	3.3
Polyplacophora					
<i>Tonicella marmorea</i> ^a and <i>T. rubra</i>	1.09 \pm 0.46	5.24	8.81	22	36.1
Gastropoda					
<i>Acmaea testudinalis</i>	0.32 \pm 0.29	1.54	2.69	11	18.0
<i>Lacuna vincta</i>	<0.05	—	—	1	1.6
<i>Margarites groenlandicus</i>	0.16 \pm 0.11	0.77	1.29	2	3.3
<i>Nucella lappilus</i>	0.20 \pm 0.19	0.96	1.62	3	4.9
Bivalvia					
<i>Hiatella arctica</i>	<0.05	—	—	3	4.9
<i>Mytilus edulis</i>	<0.05	—	—	2	3.3
<i>Modiolus modiolus</i>	<0.05	—	—	2	3.3
Polychaeta					
Unidentified	<0.05	—	—	6	9.8
Asteroidea					
<i>Asterias vulgaris</i>	0.14 \pm 0.045	0.67	1.13	17	27.9
<i>Leptasterias polaris</i>	<0.05	—	—	1	1.6
Stelleroidea					
<i>Ophiopholus aculeata</i>	0.47 \pm 0.33	2.3	3.80	4	6.6
Echinoidea					
<i>Strongylocentrotus droebachiensis</i> ^a	1.4 \pm 0.57	6.7	11.3	15	24.6
Ascidacea					
<i>Halicynthia pyriformis</i>	<0.05	—	—	1	1.6
Pisces					
<i>Mallotus villosus</i> (Eggs)	1.45 \pm 1.31	6.97	11.7	2	3.3
Other					
Unidentifiable material	8.4 \pm 1.42	40.4	—	37	60.7
Coralline algae	0.53 \pm 0.41	2.5	3.28	7	11.5
Fleshy algae	3.6 \pm 0.93	17.3	29.1	26	42.6
Inorganic material	0.48 \pm 0.37	—	—	3	4.9
Total ^b	20.8				
Empty GI tracts				2	

^a Prey taxa contributing more than 5 % to the diet and present in more than 10 % of the winter flounder examined

^b Inorganic material not included

tifiable fraction. The importance of *M. senile* will probably be slightly underestimated by this method, but this does not affect the conclusions reached in this paper.

Fleshy algae, more than 95 % of which was *Desmarestia aculeata* and *D. viridis*, made up the largest fraction (29 %) of the identifiable food material and occurred in 43 % of the guts which contained food (Table 1). The next most prominent food item was *Metridium senile* (17 %). Hydroids (mainly *Obelis* sp.), chitons (*Tonicella marmorea* and *T. rubra*), green sea urchins, and capelin (*Mallotus villosus*) eggs comprised from 7 to 12 % of the diet. Hydroids and capelin eggs occurred in few fish (5 and 2 respectively). *Acmaea testidinalis* contributed 2.6 % and brittle stars *Ophiopholus aculeata* contributed 3.8 % of the diet. The remaining food items were present at low weights and in only a few fish.

Predation on sea urchins

Much of the urchin fraction was accounted for by the 9 flounder collected from the 2 sites lacking cryptic microhabitat (Table 2). Sea urchins were a smaller fraction of the diet at the sites where such microhabitat was abundant.

Evaluation of selection

Winter flounder have a small gape (< 16 mm in the fish used in the present study). Much of the prey biomass was unavailable to winter flounder because the prey items were too large to be consumed (> 16 mm in smallest cross-sectional diameter). The fraction of biomass in this category was removed, and percentage of biomass was recalculated on this basis (Table 3, columns 4 and 5). Some of the species which form a large fraction of the 'available' biomass are actually unavailable because they occupy cryptic mi-

crohabitat. Winter flounder are visual predators (Olla et al. 1969), and lack the ability to find hidden prey in hard substrates. Additionally, much of the cryptic microhabitat is branched and undercut coralline algae (*Lithothamnion glaciale* and *Clathromorphum circumscriptum*), which presents a physical barrier to flounder predation. The bivalve *Hiatella arctica* is unavailable because it is found mainly underneath the thick coralline crusts, among the tightly matted branches of *Corallina officinalis*, and among byssal threads of *Modiolus modiolus*. Small individuals of both mussels *Mytilus edulis* and *M. modiolus* are found in the matted branches of *C. officinalis*, and among the larger *M. modiolus*, so they are probably unavailable to winter flounder. Polychaetes (mainly *Nerius* sp. and *Myxicola* sp.) and brittle stars *Ophiopholus aculeata* are almost entirely restricted to the undercut coralline algae and the *Modiolus* beds, so they are largely unavailable to winter flounder.

The chitons *Ischnochiton alba*, *Tonicella marmorea* and *T. rubra* and small green sea urchins also occur primarily in cryptic microhabitat. The chitons are found primarily among the thick uprights of *Lithothamnion glaciale*, beneath the undercut corallines, and in the *Modiolus* beds during the daytime. They emerge at night to graze. Juvenile urchins are also found in these microhabitats (Keats et al. 1985), and are probably also nocturnal during the summer (Bernstein et al. 1981). Nevertheless, some chitons and small urchins are always observed out in the open during the day. Therefore, using the actual biomass of chitons and urchins present will overestimate availability, but there is no alternative, given the available information. Prey items from 'cryptic microhabitat' were removed and the percentage of biomass was recalculated on this basis (Table 3, columns 6 and 7).

Food species were ranked according to this corrected availability, and compared with their ranking in the diet of winter flounder (Table 4). The assignment of a rank to macroalgae is based on observation, rather than quantitative data. *Desmarestia* spp., the main algae

Table 2. *Pseudopleuronectes americanus*. Comparison of the contribution of the 4 most important food items of winter flounder collected from smooth, coralline encrusted bedrock (smooth), and from bedrock with abundant cryptic microhabitat (rough) in the form of crevices, branched and undercut coralline algae, and horse mussels

Taxon	Smooth (N = 9 fish)		Rough (N = 54 fish)	
	Mean weight (g) (\pm SE)	% of identifiable material	Mean weight (g) (\pm SE)	% of identifiable material
Fleshy algae	1.97 \pm 1.24	17.4	3.90	31.4
<i>Metridium senile</i>	0.73 \pm 0.55	6.4	2.36 \pm 0.71	19.0
<i>Strongylocentrotus droebachiensis</i>	4.61 \pm 2.41	40.6	0.87 \pm 0.51	7.0
<i>Tonicella marmorea</i> and <i>T. rubra</i>	1.70 \pm 1.42	15.0	0.99 \pm 0.48	8.0

Table 3. Biomass and density of invertebrates, in urchin barrens, for comparison with prey species of winter flounder collected from barren habitat. + indicates present, but < 0.05 g m⁻²; 0+ indicates absent from samples, but occasionally observed near the sample site; 0++ indicates absence from samples, but abundant in patches near the sample site

Taxon	(1) Biomass (g) (± SE)	(2) Density (No. m ⁻²)	(3) % of invertebrate biomass	(4) Biomass at consumable size	(5) % of biomass at consumable size	(6) Biomass of non-cryptic species	(7) % of biomass of non-cryptic species	(8) Biomass in corrected flounder diet ^a	(9) Corrected % of flounder diet ^a
Hydrozoa									
Unidentified	0++	-	-	-	-	-	-	1.08 ± 0.92	10.3
Anthozoa									
<i>Metridium senile</i>	16.7 ± 7.3	112.0 ± 32.8	0.36	16.7 ± 7.3	4.93	16.7 ± 7.3	16.9	2.50 ± 0.75	23.9
<i>Gersemia rubrifloris</i>	0+	-	-	-	-	-	-	+	+
Bryozoa									
Unidentified	0++	-	-	-	-	-	-	+	+
Crustacea									
Gammarid amphipods	0.16 ± 0.11	59.0 ± 40.0	0.003	0.16 ± 0.11	0.05	0.16 ± 0.11	0.16	+	+
<i>Hyas araneus</i>	10.6 ± 9.8	9.0 ± 6.4	0.23	0.94 ± 0.79	0.28	0.94 ± 0.79	0.96	+	+
<i>Pagurus</i> sp.	0++	-	-	-	-	-	-	+	+
Polychaeta									
<i>Ischnochiton alba</i>	0.14 ± 0.14	4.0 ± 4.0	0.003	0.14 ± 0.14	0.04	-	-	0	0
<i>Tonicella marmorea</i>	5.71 ± 2.57	42.0 ± 23.8	0.12	-	-	-	-	-	-
<i>Tonicella rubra</i>	32.5 ± 7.68	632 ± 147	0.70	38.2	11.3	38.2	38.9	1.05 ± 0.51	10.0
Gastropoda									
<i>Acmaea testudinalis</i>	0.74 ± 0.34	31.3 ± 9.7	0.016	0.74 ± 0.34	0.22	0.74 ± 0.34	0.75	0.39 ± 0.36	3.7
<i>Lacuna vineta</i>	+	8.0 ± 5.93	-	-	-	-	-	0	0
<i>Margarites groenlandicus</i>	0+	-	-	-	-	-	-	0.19 ± 0.14	1.8
<i>Nucella lapillus</i>	2.6 ± 1.5	11.0 ± 5.5	0.056	2.6 ± 1.5	0.77	2.6 ± 1.5	2.6	+	+
Bivalvia									
<i>Hiatella arctica</i>	83.8 ± 21.0	326.0 ± 118.0	1.80	83.8 ± 21.0	24.7	-	-	0	0
<i>Mytilus edulis</i>	4.66 ± 4.60	17.0 ± 16.0	0.10	4.66 ± 4.60	1.37	-	-	+	+
<i>Modiolus modiolus</i>	3886 ± 2416	125 ± 61.3	83.4	6.20 ± 5.10	1.83	-	-	+	+
Polychaeta									
Unidentified	62.9 ± 29.8	N.D.	1.35	62.9 ± 29.8	18.6	-	-	+	+
Asteroida									
<i>Asterias vulgaris</i>	56.0 ± 45.0	72.0 ± 24.7	1.20	1.8 ± 0.73	0.54	1.8 ± 0.73	1.8	0.17 ± 0.05	1.6
<i>Lepasterias polaris</i>	0+	-	-	-	-	-	-	+	+
Stellerioidea									
<i>Ophiopholus aculeata</i>	129.4 ± 44.1	203.0 ± 56.5	2.78	83.0 ± 25.4	24.5	-	-	0.54 ± 0.41	5.2
Echinoidea									
<i>Strongylocentrotus droebachiensis</i>	367.3 ± 129.7	see Fig. 3	7.88	37.1 ± 10.0	11.0	37.1 ± 10.0	37.8	0.9 ± 0.5	8.6
Ascidacea									
<i>Halocynthia pyramidalis</i>	0+	-	-	-	-	-	-	+	+

^a Flounder from sites lacking cryptic microhabitat, and those whose guts contained capelin eggs, were removed from the calculations

consumed, were abundant in the vicinity of the study area, but were under-represented in samples because of their highly patchy distribution. My observations indicate that this was probably the most abundant and available of the taxa consumed by winter flounder. I have therefore assigned it the highest availability rank. Hydroids were also abundant in the study area, but they were also under-represented in samples for the above reasons. In view of their low frequency of occurrence in flounder guts, it is unlikely that winter flounder show any selectivity toward hydroids. Since I have no data on the abundance of hydroids, and since they occur at low frequency, they could not be included in the rank analysis. Species recorded only as present (+) in the winter flounder diet, or in habitat samples, were assigned the tied rank of '1'. Other species are ranked on the basis of biomass available, after determination of size limitations and occupancy of cryptic microhabitat.

The data show no evidence of strong selectivity for any particular prey taxa by winter flounders (Table 4). The 4 most highly ranked food taxa were also those most highly ranked in abundance. Differences in the position of a given taxon within this group are probably related to the inability to account for the use of cryptic microhabitat by chitons and urchins. The remaining taxa are essentially incidental in occurrence, and no value should be ascribed to differences in ranking within the latter group.

Table 4. Comparison of the ranks of each food item with its availability rank after the removal from analysis of biomass contributed by individuals too large for winter flounder to consume, or which occupy cryptic microhabitat

Food item	Rank in flounder guts	Availability rank
Fleshy algae	9	9
<i>Metridium senile</i>	8	6
<i>Tonicella</i> spp.	7	7
<i>Strongylocentrotus droebachiensis</i>	6	8
<i>Ophiopholus aculeata</i>	5	1
<i>Acmaea testudinalis</i>	4	2
<i>Margarites groenlandicus</i>	3	1
<i>Asterias vulgaris</i>	2	4
<i>Gersemia rubrififormis</i>	1	1
Gammarid amphipods	1	1
<i>Hyas araneus</i>	1	3
<i>Pagurus</i> sp.	1	1
<i>Nucella lapillus</i>	1	5
<i>Mytilus edulis</i>	1	1
<i>Modiolus modiolus</i>	1	1
Polychaetes	1	1
<i>Laptasterias polaris</i>	1	1
<i>Halicythis pyriformis</i>	1	1

It is evident that flounder did show some size selection, in that they seemed to avoid the smallest individuals, concentrating on the larger prey within the size range which they could consume (Figs. 3 and 4).

Winter flounder as predators

The minimum area of urchin-grazed habitat required to supply the average winter flounder with the contents of its gastrointestinal tract is 0.15 m² for *Metridium senile*, less than 0.03 m² for *Tonicella* spp. and *Strongylocentrotus droebachiensis*, and 0.54 m² for *Acmaea testudinalis* [these calculations are based on the corrected biomass in gastrointestinal tracts (Table 3, column 9); i.e. those flounder from sites lacking cryptic microhabitat and those containing capelin eggs were removed from the analysis] (Table 5). Assuming that the contents of the gastrointestinal tract represent 2 d of feeding (MacDonald et al. 1982, Worobec 1984), it is calculated that 1 winter flounder could clear 1 m² of habitat of all *M. senile* in 13 d, and all *A. testudinalis* in

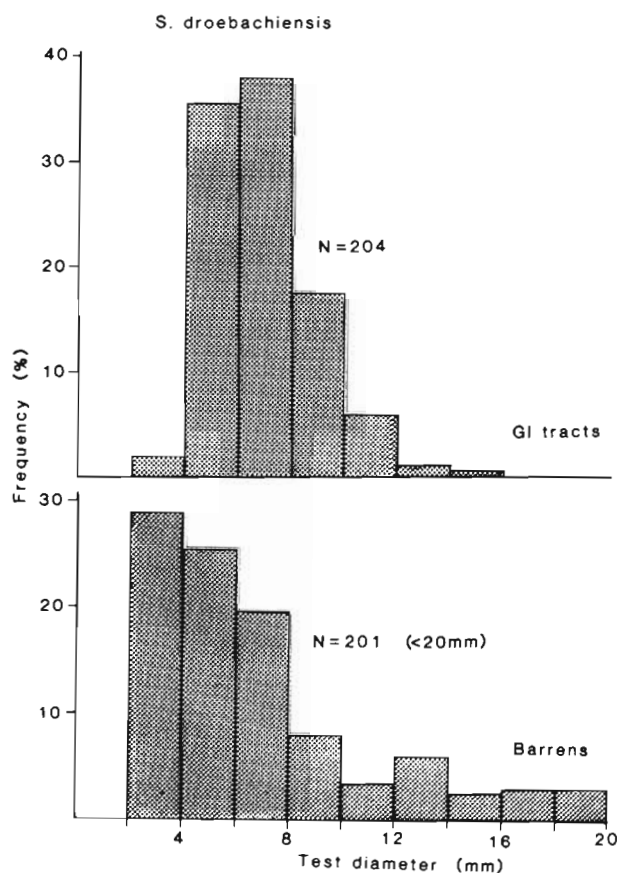


Fig. 3. *Strongylocentrotus droebachiensis*. A comparison of the size frequency for urchins from winter flounder gastrointestinal tracts (GI tracts) with a size frequency of those from urchin dominated habitat ('barrens')

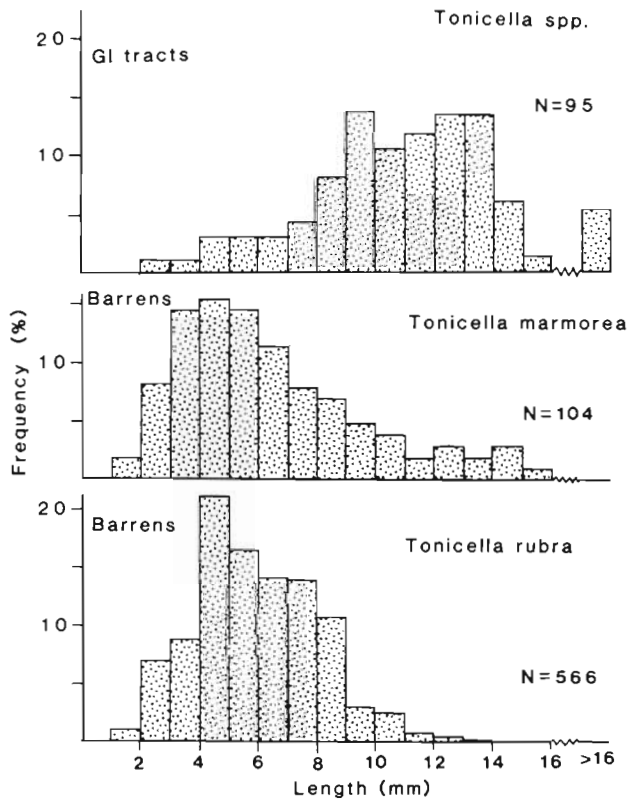


Fig. 4. *Tonicella* spp. A comparison of the size frequency for chitons from winter flounder gastrointestinal tracts (GI tracts) with size frequencies for *T. rubra* and *T. marmorea* from urchin dominated habitat ('barrens')

4 d (Table 5). A much longer time would be required to clear all *Tonicella* spp. and *S. droebachiensis*. If the correction factor recommended by MacDonald et al. (1982) is applied to *M. senile* this becomes 4 d for that species. Using this as the range, at a density of 1 ind. 10 m^{-2} winter flounder could consume all *M. senile* in 40 to 130 d, and all *A. testudinalis* within 40 d. This of course assumes no recruitment of prey taxa, but the true potential consumption probably lies within this range.

The size frequency distributions for *Tonicella* spp.

and *Metridium* show that there were very few individuals above a small size (Figs. 4 and 5). Even though *Metridium senile* can become quite large, few individuals above the size which could be consumed by winter flounder were found in the samples.

DISCUSSION

Results indicate that winter flounder are unlikely to be important predators of green sea urchins in most urchin dominated habitat in Newfoundland. Urchin grazing has dominated in Newfoundland for at least 25 yr, and probably much longer (Hooper 1980, Keats et al. 1986). Most urchin grazed areas have a thick crust of branched and undercut coralline algae, and beds of horse mussels (Fig. 6), which provide microhabitat within which juvenile urchins have a refuge from predation (Keats et al. 1985, Witman 1985). In areas without such cryptic microhabitat, predation by winter flounder is more likely to be an important source of mortality to juvenile sea urchins. Such areas occur mainly at sites with relatively unstable shale and sandstone substrata, and they are much less common off Newfoundland than areas with abundant cryptic microhabitat.

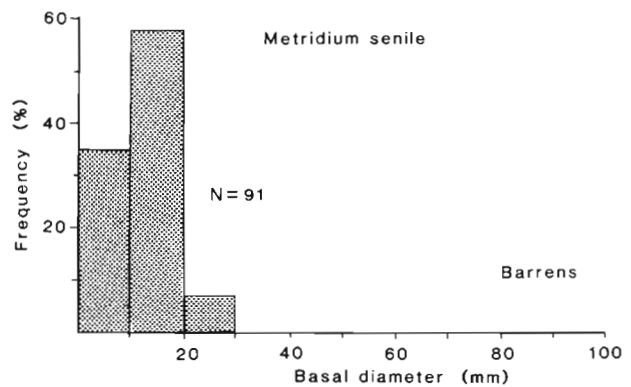


Fig. 5. *Metridium senile*. Size frequency for sea anemones from urchin dominated habitat

Table 5. Estimates of the minimum area from which an average winter flounder could have obtained the mean biomass of the 4 main invertebrates present in its digestive tract, and the time required for 1 flounder to clear 1 m^2

Taxon	Biomass available (g m^{-2})	Mean corrected biomass in flounder ^a	Equivalent area (m^{-2})	Time required to clear 1 m^2 (d) ^b
<i>Metridium senile</i>	16.7	2.5	0.15	13
<i>Tonicella</i> spp.	38.2	1.1	0.029	69
<i>Strongylocentrotus droebachiensis</i>	37.1	0.9	0.024	83
<i>Acmaea testudinalis</i>	0.30	0.74	0.53	4

^a From column 8, Table 3
^b Assuming the contents of the gastrointestinal tract represent 2 d of feeding.

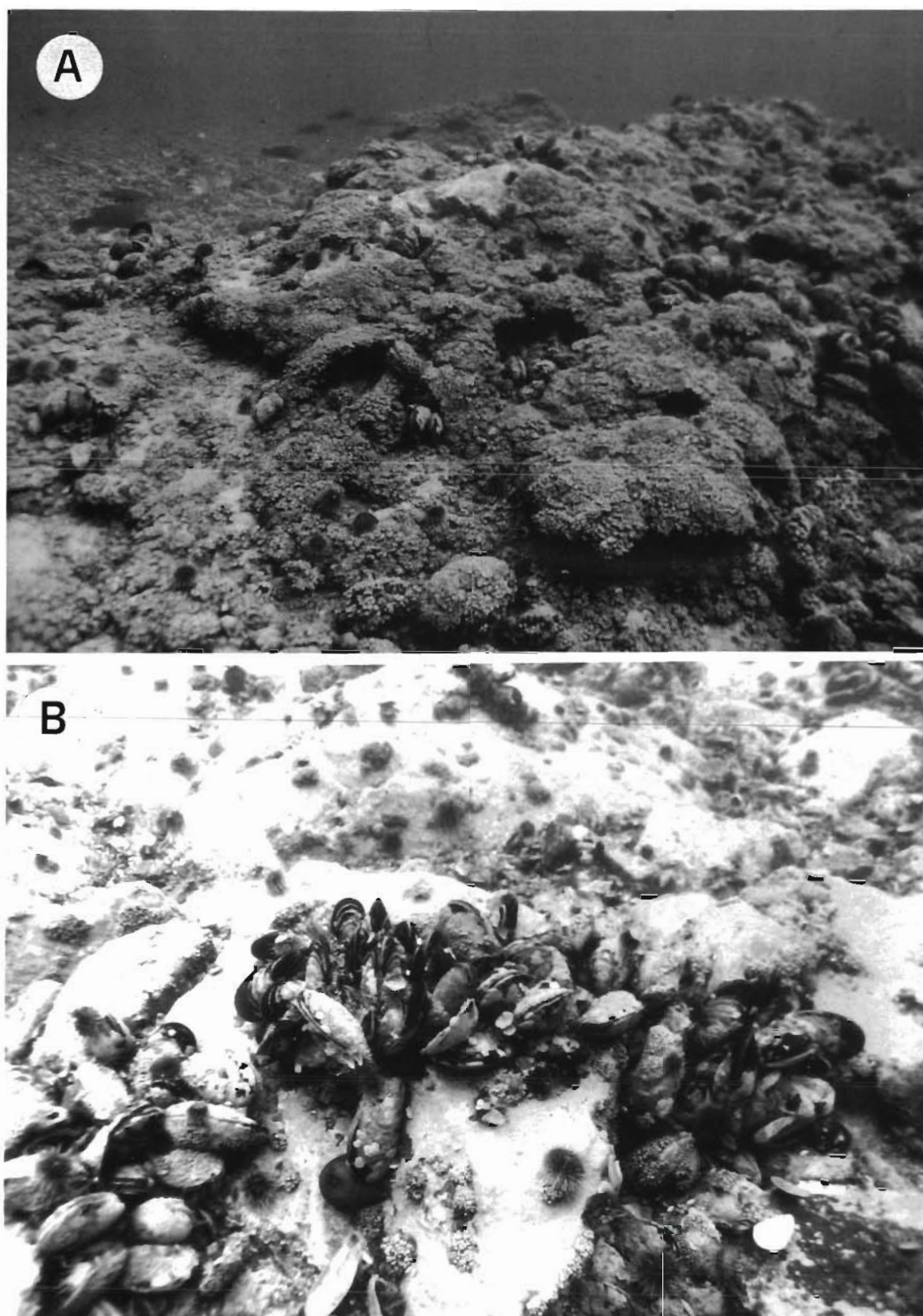


Fig. 6. (A) A thick crust of branched and undercut coralline algae (mainly *Lithothamnion glaciale* and *Clathromorphum circumscriptum*) and (B) beds of horse mussels provide refuge for many small invertebrates, making them unavailable to winter flounder

Several other taxa, potentially consumed by winter flounder, are also protected because they occupy cryptic microhabitat, and this indicates the importance to community structure of cryptic microhabitat as a refuge from predators. This cryptic microhabitat is important to *Hiattella arctica*, the chitons (*Ischnochiton alba*, *Tonicella marmorea* and *T. rubra*), *Ophiopholus aculeata*, and especially to polychaetes. Polychaetes are an important component of winter flounder diets in soft sediment areas, where, except for deeply buried infaunal species, such cryptic microhabitat is unavailable (Klein-MacPhee 1978).

The 2 species that are probably influenced most by winter flounder predation are *Metridium senile* and *Acmaea testudinalis* (Table 5). The size frequency histogram for *M. senile* suggests that there is very little survival beyond a small size. The time-frame within which it is calculated that a density of 1 winter flounder per 10 m² could consume all the biomass of *M. senile* and *A. testudinalis* in the study site is well within the period during which winter flounder are abundant and feeding inshore (pers. obs.). I have observed densities as high as this in the study area in Conception Bay, but the mean density of winter flounder in urchin-dominated habitat remains to be determined. Cunnners *Tautogolabrus adspersus* are also abundant off eastern Newfoundland (Keats et al. 1985), and they include these prey species in their diet (Martin 1979, Martel 1983). This suggests the experimentally testable hypothesis that the lack of larger *A. testudinalis* and *M. senile* is due to the combined effects of predation by winter flounders and cunnners.

Several studies of winter flounder diet have reported a high incidence of macrophyte food (Thomas 1970, Kennedy & Steele 1971, Wells et al. 1973). Wells et al. suggested that winter flounder probably derive nutrition from plant material. Alternatively, they may ingest algae for animal epiphytes, but this is unlikely since I observed very few epiphytic animals on the *Desmarestia* spp. from flounder guts. The possibility that winter flounder can derive significant nutrition from algae should be investigated in the laboratory.

This study supports the suggestion that winter flounder are largely unselective predators, and that they feed on whatever prey of a suitable size that is most abundant and actually available (Klein-MacPhee 1978). They do, however, seem to select prey by size, taking mainly the larger prey items within the size range which they can consume. These data also serve to emphasize the importance of using natural history observations, particularly knowledge of the behaviour of both predator and prey, as well as fractionation by size, in determining prey availability (Chess 1978).

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