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Ascophyllum Harvesting and Use of the Intertidal by Finfish

By

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ABSTRACT

Annual harvest of the intertidal seaweed, Ascophyllum nodosum, may soon increase from 6,000 t to 15,000 t. This study investigated the possible impact on intertidal finfish abundance and gut contents. Absolute fish abundance in areas with Ascophyllum removed and intact was determined with "pop-up seines." Fish were collected for gut contents with the seines and with trammel nets. Number and weight of fish were not significantly different between cleared and intact areas. Sedentary species (e.g. winter flounder and sculpins) had more food in their guts when leaving than when entering the intertidal, although there was no difference between fish leaving cleared and intact areas. Most fish captured in the intertidal were small (<15 cm) and of no commercial value, and the commercial species were of low value. Fish biomass in the intertidal was significantly lower than in the shallow subtidal. This study provided no evidence for adverse effects of Ascophyllum harvesting on finfish.

RESUME

La récolte annuelle d'algues en zone intertidale Ascophyllum nodosum, pourrait sous peu passer de 6 000 t à 15 000 t. Cette étude examine les répercussions possibles sur l'abondance des poissons osseux intertidaux et sur leur régime alimentaire. On s'est servi de seines "avec ralingue pneumatique" pour déterminer l'abondance absolue de poissons dans des secteurs où l'Ascophyllum avait été enlevé ainsi que dans des secteurs intacts. On a utilisé des seines et des trémails pour recueillir du poisson afin de déterminer la composition de leur alimentation. La quantité et le poids des poissons n'ont pas différé appréciablement entre les secteurs récoltés et les secteurs intacts. Les espèces sédentaires (p. ex. plie rouge et chaboisseau) avaient plus de nourriture dans l'estomac à leur départ de la zone intertidale bien qu'on n'ait constaté aucune différence entre les poissons quittant les secteurs récoltés par opposition aux secteurs intacts. La plupart du poisson capturé dans la zone intertidale était petit (< 15 cm) et n'avait aucune valeur commerciale; les espèces commerciales capturées n'avaient que très peu de valeur. La biomasse halieutique dans la zone intertidale était sensiblement moins élevée que dans la zone subtidale. L'étude ne présente aucune preuve permettant d'établir que la récolte de l'Ascophyllum a des effets néfastes sur le poisson osseux.

INTRODUCTION

New owners of Scotia Marine Products Limited of Yarmouth County, Nova Scotia, plan to increase the annual harvest of Ascophyllum from 6,000 t to 15,000 t (Sharp 1981; Sharp, pers. comm.). In 1981 a study was conducted within their harvest area on utilization of the intertidal by finfish. This report summarizes the results most relevant for judging harvest impact on finfish.

Ascophyllum was entirely removed manually from a 30 m length of intertidal shore in two locations. This was intended to simulate an extreme example of harvesting as well as ice scour or plant destruction by pollution. Fish and fish guts were subsequently sampled during six periods from June through October. Questions addressed were:

1. What fish species occur intertidally?

2. Does absolute fish density differ in intertidal areas with and without Ascophyllum?

3. Does relative fish density differ between the intertidal and shallow subtidal?

4. Do fish from areas with and without Ascophyllum differ in the amount of food in their guts?

The two areas selected for seaweed cleared-seaweed intact comparisons were in Lower Argyle, Yarmouth County (Sites 1 and 2, Fig. 1). Both areas contained virtually pure stands of Ascophyllum nodosum occupying about 20 m of the about 26 m wide intertidal. Tidal amplitude was 3-4 m. Plants averaged 95 cm long and biomass was about 10 kg/m^2. The substratum was loose cobble at Site 2 and cobble set in sand and gravel at the more sheltered Site 1. Low water was bordered by Irish moss at Site 2 and eelgrass at Site 1.

METHODS

Pop-Up Seines

These stationary seines were used to obtain densities and gut contents of fish that occupied the intertidal at high tide. They were made of black nylon with mesh of 25 mm stretch measure. They were set with a 20 m long section parallel to shore just above the low-tide mark and with 30 m wings running perpendicular up the beach past the high-tide mark. A plastic hose attached to the headrope was filled with water to keep a seine on the bottom and was inflated with air to raise the seine and enclose an area of the intertidal. They were deployed in adjacent cleared and intact areas in the early afternoon at low tide and were raised just before high tide about 17 h later. After the tide receded fish were gathered from the enclosed area, enumerated by species, and the guts removed and preserved. This procedure was repeated on two successive days in both Sites 1 and 2 in the six sampling periods.

Trammel Nets

These nets captured fish for gut analysis as they were entering the intertidal on the rising tide. Six sets were made for each set of two seines: three on the rising tide in the afternoon of the day before raising the seines, and three on the rising tide of the morning the seines were raised. These 25 m by 1 m high nets were set on bottom parallel to shore near the low-tide mark to either side of the seines. The minimum sized fish captured in both gears ranged from about 7 cm for winter flounder and grubby (a sculpin) to 12 cm for pollock. Positions of seines and trammel nets are illustrated in Figure 2.

To test for effect of time of day and location on fish catches, three trammel net sets were made at each of three times (rising tide in morning, falling tide in afternoon, and rising tide in evening) at each of four supplementary sites (Sites 3-6, Fig. 1). Results of a nested ANOVA on number of fish caught per net are as follows.

Source	d.f.	msq.	F	% of variance
Among times	2	9.5	2.0 n.s.	2
Among sites within times	9	7.9	1.7 n.s.	19
Within sites (error)	24	4.7		79

Because both time of day and location made only minor contributions to total variance, it was presumed that the sampling schedule at Sites 1 and 2 was representative of sites and times other than those chosen.

Subtidal-intertidal comparisons of trammel net catches were also made at Sites 3-6.

RESULTS

A summary of the total fish catch in both seines and trammel nets shows that the only commercial species among the six most important were pollock and winter flounder (Table 1). All but sculpins had a model length ≤15 cm (Table 6). Other commercial species caught in much lower numbers were American smelt, American eel, Atlantic mackerel, and white hake.

The mean catch per seine set was 12.0 fish, or 0.6 fish/m of shore after correction for escapement. The efficiency of retention by seines was tested by placing 197 fin-clipped fish including nine species into the seines after they were raised, and retrieving them after the tide had receded. Pollock retention was lowest; they probably escaped between the flotation hose and the headrope; sculpin and flounder were highest (Table 1).

A three-way ANOVA, two sites, two Ascophyllum treatments (cleared and intact), two successive days at each site, and six replicates (months), carried out on a number of fish per seine shows that the biggest effect is contributed by days (Table 2a), although none of the F tests are significant. The tendency for the second day's catch to be smaller than the first may have been due to fishing up of sedentary species. The other two main effects, *Ascophyllum* treatment and site, made only minor contributions to total variance. Applying the same ANOVA to fish weight per seine gives exactly the same results (Table 2b). The overall mean biomass was 21 g/m of shore and about (the intertidal area varies with tidal amplitude) 1 g/m^2.

The above ANOVA combines all species; a non-parametric sign test was also used on each of seven abundant species to test the hypothesis that the same number of fish were associated with intact and cleared areas. There was no evidence to reject this hypothesis for any species (Table 3). Note also in Table 3 the high co-occurrence of zeros in cleared and intact areas.

Because the number of fish captured in the intertidal was suprisingly low, trammel net pairs were fished in the low intertidal and about 2 m deeper in the shallow subtidal at the four supplementary study sites. The mean catch was nearly twice as high for the subtidal, and the difference was statistically significant (Table 4). However, the same species were abundant at both depths: pollock, 24 vs 47; white hake, 9 vs 17; and Atlantic tomcod, 7 vs 16 for intertidal and subtidal respectively.

Fish stomach contents from rising and falling tides were compared using trammel net catches from rising tides, which were assumed to be fish entering the intertidal, and seine catches from falling tides, which were assumed to be fish which spent several hours in the intertidal, in *Ascophyllum* cleared and *Ascophyllum* intact areas. By weight, the most important prey was green crab and small fish eaten by large sculpins. Sculpin prey was 81% of the total weight. Prey of other species were principally amphipods, isopods, and small gastropods.

Mummichog, grubby, and winter flounder had a higher portion of empty stomachs on rising tides than on falling tides as did all sedentary species taken together. There were no differences for the more mobile pollock and tomcod (Table 5). There were no differences in the portion of empty stomachs between cleared and intact areas (Table 5).

Visual inspection of data on the weight of food in guts gives the same results as above - no differences between cleared and intact areas and considerably more food in guts of sedentary species that spent time in the intertidal than those that were just entering the intertidal (Table 6).

The small size of the cleared treatments, about 20 x 30 m, may cause concern about extrapolating to a large area the lack of differences between cleared and intact treatments. However, this treatment area would seem to be large enough to be chosen or avoided by the small and sedentary fish most abundant in the intertidal. Also, fish were captive in seines in cleared and intact areas for over 5 h, probably long enough to reflect differences in prey availability in gut contents.

DISCUSSION

The most comparable study on fish utilization of the intertidal was conducted by Tyler (1971) in the western Bay of Fundy. Near the low-tide mark he erected a fence which funneled fish from a 15 m length of shore through a narrow opening. Fish passing up shore and down shore were counted in daylight with the aid of a television camera positioned over the opening. Erect seaweeds were sparse and the substratum was a mixture of cobble, sand, and gravel.

Tyler estimated that an average of 173 fish passed through the fence opening on the 12 h tidal cycle. If this is halved for fish entering on a flood tide, reduced a further 20% for fish which passed more than once on a flood tide, and divided by 15 m, the width of the fence, then 3.9 fish/m of shore entered the intertidal on a flood tide. This is much greater than the 0.6 fish/m of shore obtained from seine samples in Lower Argyle. However, dividing by the width of the intertidal, 184 m in the Bay of Fundy and 26 m in Lower Argyle, gives very similar results of 0.021 and 0.023 fish/m^2 respectively.

Tyler speculated that the intertidal was an important feeding area for winter flounder, and this was confirmed by Wells et al. (1973) working in the same area. Sixty-one percent by weight of gut contents of flounder collected in the intertidal was prey found only in the intertidal. For flounder collected in the subtidal 32% of gut contents were intertidal prey.

Of the six commercial fish species captured in Lower Argyle only pollock made up more than 1% of the value of southwestern Nova Scotia fish landings (Anon. 1985). Pollock was 12% of landed weight and 4% of value in 1984. Commercial species captured are low value per unit weight. Only one lobster was captured in 48 seine sets (and not considered in the above treatment), although Lower Argyle is a good lobster fishing area. Tyler (1971) counted only one lobster in 204 h of observation.

Fish biomass of 1 g/m^2 in this study was low compared to that from shallow, temperate, subtidal areas. Jansson et al. (1985) gave means for seven studies, most in <2 m depth, as 3.0-7.5 g live weight/m^2. In two California kelp beds 15 m deep biomass was 39 and 65 g/m^2; and on a similar area without kelp, biomass was 24 g/m^2 (Larson and DeMartini 1984). Also, trammel net catches in Lower Argyle were twice as high in the shallow subtidal as in the intertidal.

In summary, this study suggests no adverse effect of *Ascophyllum* harvest on finfish using the intertidal. Finfish were found in low abundance in the intertidal and fed there; most were non commercial, and the commercial species were of low value. Of the total weight of gut contents of fish captured in the intertidal, 81% was from large sculpins. There was no evidence for differences in fish density or feeding intensity between areas with and without *Ascophyllum*. The experimental removal of all *Ascophyllum* was a much more severe treatment than the usual harvest removal of 26-61% of biomass (Sharp 1981).

ACKNOWLEDGEMENTS

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Table 1. Summary of intertidal fish catches at Lower Argyle, Nova Scotia, May to October 1981.

Species	Total numbers		Mean numbers per 400 m^2 in seines	% efficiency	Corrected number/400 m^2
	135 Trammel nets	48 Seines			
Cunner	114	69	1.4	56	2.5
Grubby	82	61	1.3	53	2.5
Pollock	66	35	0.7	26	2.7
Winter flounder	66	85	1.8	75	2.4
Atlantic tomcod	49	11	0.2	71	0.3
Shorthorn sculpin	16	23	0.5	61	0.8
All others	104	20(6.5%)	0.4	50?	0.8
Total density			6.3		12.0
Mean number/ linear meter of shore	0.15		0.3		0.6

Table 2a. Total numbers of fish captured in fixed seines raised at or slightly before high tides in early mornings on two consecutive days each month at the two main study sites in intertidal areas with *Ascophyllum nodosum* removed (cleared) or left unaltered (intact). The areas of *A. nodosum* enclosed by the seines were 300 m^2 at Site 1 and 460 m^2 at Site 2 (catch uncorrected for escapes).

Treatment	Month	Site 1		Site 2	
		Day 1	Day 2	Day 1	Day 2
Cleared	Early June	7	1	34	4
	Late June	14	4	12	2
	July	4	2	7	0
	August	1	2	5	1
	September	0	0	9	6
	October	11	4	4	5
	Mean	6.2	2.2	11.8	3.0
Intact	Early June	12	15	16	9
	Late June	16	6	8	9
	July	5	2	4	1
	August	1	1	2	4
	September	1	6	8	12
	October	6	4	11	4
	Mean	7.0	5.7	8.3	6.5

Analysis of variance [2 sites (random) x 2 *Ascophyllum* treatments (fixed) x 2 d (fixed) x 6 mo (replicates)].

Source	df	MS	F	
Site	1	56.33	1.70	n.s
Ascophyllum	1	14.08	1.00	n.s
Day	1	192.00	2.74	n.s
A x D	1	70.09	2.12	n.s
S x A	1	14.09	0.42	n.s
S x D	1	21.34	0.65	n.s
S x D x A	1	14.07	0.43	n.s
Error	40	33.06		

Table 2b. Total biomass (1/10 kg) of fish captured in fixed seines raised at or slightly before high tides in early mornings on two consecutive days each month at the two main study sites in intertidal areas with *Ascophyllum nodosum* removed (cleared) of left unaltered (intact). The areas of *A. nodosum* enclosed by seines were 300 m^2 at Site 1 and 460 m^2 at Site 2 (catch uncorrected for escapes).

Treatment	Month	Site 1		Site 2	
		Day 1	Day 2	Day 1	Day 2
Cleared	Early June	4.78	0.06	10.11	4.11
	Late June	9.03	3.00	4.73	0.87
	July	5.05	0.00	0.72	7.10
	August	1.30	1.49	1.98	0.16
	September	0.00	0.00	2.67	1.10
	October	24.33	0.82	4.40	2.25
	Mean	7.42	0.90	4.10	2.60
Intact	Early June	11.73	7.18	14.82	14.54
	Late June	2.41	2.19	1.68	4.36
	July	8.01	0.09	1.94	0.65
	August	3.71	0.26	0.58	1.06
	September	2.05	1.84	5.93	11.90
	October	2.24	6.33	3.56	0.88
	Mean	5.03	2.98	4.75	5.57

Analysis of variance [2 sites (random) x 2 *Ascophyllum* treatments (fixed) x 2 d (fixed) x 6 mo (replicates)].

Source	df	MS	F	
Site	1	0.368	0.01	n.s.
Ascophyllum	1	8.234	0.71	n.s.
Day	1	64.218	1.86	n.s.
A x D	1	34.612	1.47	n.s.
S x A	1	11.525	0.49	n.s.
S x D	1	46.492	1.97	n.s.
S x D x A	1	3.499	0.15	n.s.
Error	40	23.555		

Table 3. Comparisons of number of fish caught in seines at the two main study sites. There were 26 matched pairs of catches in areas where Ascophyllum was left intact or cleared away.

	Number of pairs with catches				
	Greater in intact area	Greater in cleared area	Identical in both areas	Zero in both areas	Sign test p (I>C)
American eel	6	1	1	18	0.062
Mummichog	3	2	1	20	0.500
Pollock	4	4	0	18	0.637
Cunner	11	5	2	8	0.105
Grubby	7	7	5	7	0.605
Winter founder	7	7	3	9	0.605

Table 4. Total numbers of fish captured in 25 m trammel nets set in paired intertidal and adjacent subtidal locations at four supplementary study sites. Sets were made at high tide at dusk on different days at each site between 23-26 September 1981.

Site	Intertidal	Subtidal
3	10	18
	10	25
4	6	13
	4	4
5	6	9
	13	19
6	3	4
	1	6
M		
Sean	6.6	12.3
Standard error	1.44	2.76
Paired t, p	3.372, p = 0.005	

Table 5. Numbers of fish with empty stomachs compared with numbers of fish with stomachs containing some food. Probabilities are from x^2 or Fisher Exact tests for independence of stomach condition and tide treatment; combined probability test for sedentary species is $x^2 = 27.297$; 10df ($p<0.01$).

	Rising tide		Falling tide				P
	Intact		Cleared		Intact		
	Empty	Not empty	Empty	Not empty	Empty	Not empty	
Mobile:							
Pollock	2	66	1	13	0	20	0.4510
Tomcod	1	15			2[a]	3[a]	0.1278
Sedentary:							
Mummichog	8	12			0[a]	5[a]	0.007
Large sculpins	7	14			2[a]	11[a]	0.229
Cunner	34	84	6	23	13	37	0.671
Grubby	25	43	2	32	0	16	0.001
Winter flounder	10	52	4	31	1	51	0.095

[a]Cleared and intact combined.

Table 6. Summary of weights of stomach contents per fish for species with adequate sample sizes. Weights are for fish of modal length.

<table>
<tr><th></th><th></th><th colspan="3">Wet weight (g)</th></tr>
<tr><th></th><th></th><th></th><th colspan="2">Falling tide</th></tr>
<tr><th>Species</th><th>(modal length)</th><th>Rising tide (n)</th><th>Cleared (n)</th><th>Intact (n)</th></tr>
<tr><td>Mobile</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Pollock</td><td>(12 cm)</td><td>0.30 (68)</td><td>0.27 (14)</td><td>0.27 (20)</td></tr>
<tr><td>Tomcod</td><td>(15 cm)</td><td>0.26 (16)</td><td colspan="2">0.30 (4)[a]</td></tr>
<tr><td>Sedentary:</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mummichog</td><td>(10 cm)</td><td>0 (20)</td><td colspan="2">0.20 (5)[a]</td></tr>
<tr><td>Grubby</td><td>(10 cm)</td><td>0.12 (68)</td><td>0.20 (33)</td><td>0.34 (16)</td></tr>
<tr><td>Sculpins</td><td>(30 cm)</td><td>2.75 (21)</td><td colspan="2">13.52 (10)[a]</td></tr>
<tr><td>Cunner</td><td>(11 cm)</td><td>0.06 (118)</td><td>0.06 (29)</td><td>0.10 (49)</td></tr>
<tr><td>Winter Flounder</td><td>(8 cm)</td><td>0.01 (62)</td><td>0.12 (35)</td><td>0.13 (52)</td></tr>
</table>

[a]Cleared and intact combined.

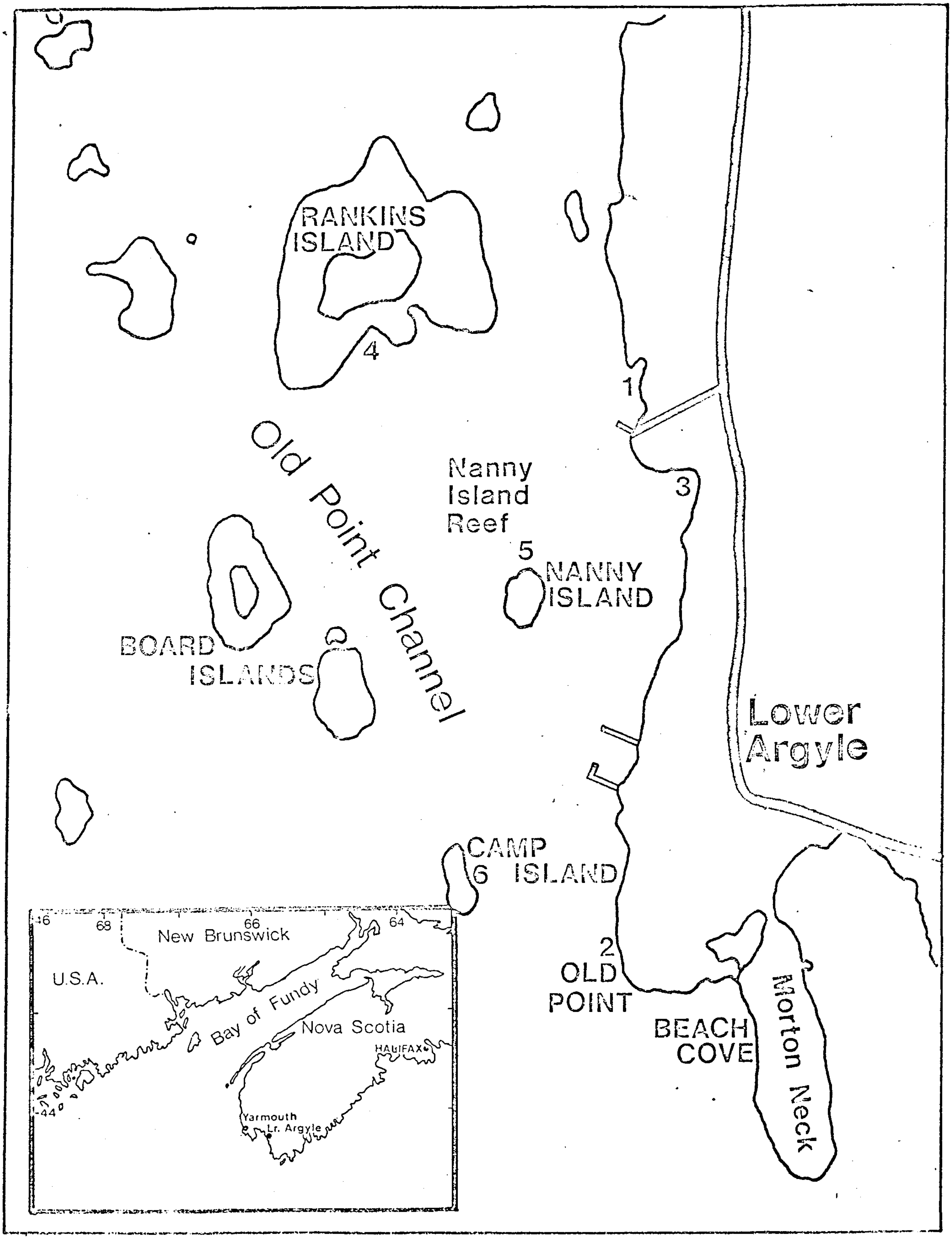

Fig. 1. Map of the area around the study site (43°44'N; 65°50'W) near Lower Argyle, Nova Scotia. The main study sites are Sites 1 and 2; the four supplementary sites are Sites 3, 4, 5, and 6. Sites 1, 3, 4, and 5 are adjacent to shallow sand and eelgrass subtidal areas. Sites 2 and 6 are adjacent to deeper water, without eelgrass, but close to stands of <u>Chondrus</u> and <u>Laminaria</u>.

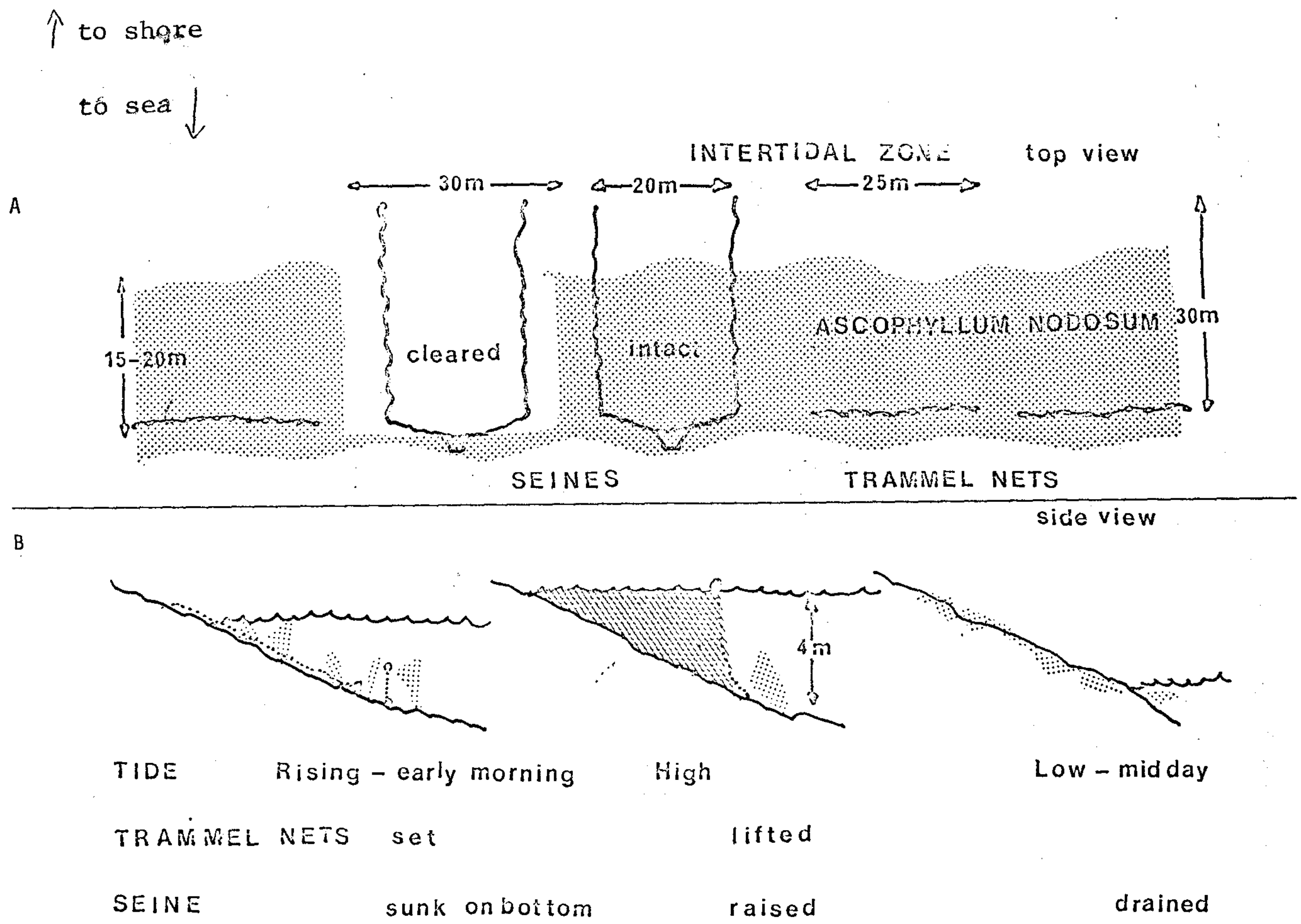

Fig. 2A. Top view of the intertidal zone, showing a schematic diagram of experimental design. Three trammel nets, 25 m long, are set at the lower edge of the Ascophyllum stand (stippled). Two seines, 20 m wide and 30 m long, have their bottom edges firmly and closely placed against the bottom. One seine is in an area where the Ascophyllum is left intact; the other seine is in the middle of a 30 m wide x 15-20 cm long area where Ascophyllum was removed.

2B. Side view of the intertidal zone, showing a schematic diagram of the experimental protocol. Trammel nets set on rising tides sample fish entering the intertidal zone. These nets are lifted at or before high tide in the morning. The pop-up fixed seine rests on the bottom during rising tides, but at high tide is raised quickly by inflating the hose attached to the headrope. The subsequent falling tide drains through the seine, leaving the fish enclosed by the seine when it was raised at high tide.