The Extent and Importance of Rockweed as a Habitat for Finfish, Shellfish, and Other Species

by

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Abstract

Intertidal rockweed beds in the Bay of Fundy area are habitat for snails (*Littorina* spp.) and small crustaceans such as amphipods and isopods. The snails and crustaceans feed mainly on the community living epiphytically on the algae, and on small algae on the rock surface, rather than directly on the *Ascophyllum*. The latter releases its productivity mainly as dissolved organic matter and particulate detritus. Several kinds of fish enter the *Ascophyllum* beds at high tide and feed on the invertebrates. Mussel beds which are mainly subtidal probably feed on the detritus. Diving ducks utilize the mussels as food in winter.

Résumé

Les gisements de goémon intertidaux de la baie de Fundy servent d'habitat pour les bigorneaux (littorines) et petits crustacés comme les amphipodes et isopodes. Ces espèces se nourrissent surtout des organismes épiphytiques vivant dans le goémon et des petites algues se trouvant à la surface des rochers, plutôt que de l'ascophylle elle-même. Celle-ci produit principalement des matières organiques dissoutes et des particules de détritus. Plusieurs sortes de poissons pénètrent dans les gisements d'ascophylle à marée haute et se nourrissent d'invertébrés. Les gisements de moules, essentiellement infratidaux, se nourrissent probablement des détritus. Les moules servent à leur tour de nourriture hivernale aux canards plongeurs.

The Resource

Ascophyllum nodosum occupies the middle intertidal zone, or mid-littoral, on rocky shores of the northwestern Atlantic. In studies in Nova Scotia and New England it has been found that *Ascophyllum* is most abundant in sheltered situations, while *Fucus* becomes more abundant with increasing exposure to wave action, and mussels take over from the algae in the most exposed situations. Thomas *et al.* (1983) showed that in the Bay of Fundy *Ascophyllum* dominates irrespective of exposure to waves. In the Passamaquoddy region *Fucus* may dominate in the upper part of the mid-littoral zone, but even there *Ascophyllum* normally comprises 90% of the biomass. The red alga *Polysiphonia lanosa*, among others, grows epiphytically on *Ascophyllum*.

Associated Animals

Barnacles (*Balanus* spp.) normally occur near the top of the mid-littoral zone. The smooth periwinkle (*Littorina obtusata*) is found throughout the zone, always on the macroalgae. The common or edible periwinkle *Littorina littorea* (an introduction, first recorded in the Bay of Fundy in 1861) is less constant in position, frequently abundant, and normally concentrated in the lower area of the zone. The amphipod *Gammarus oceanicus* is widespread. In dry conditions it remains in pools and under the shelter of the algae but in fog or high humidity is active on the surface of the rockweed. Other characteristic invertebrates are the tortoiseshell limpet *Acmaea testudinalis*, the dog whelk *Thais lapillus*, the hydroid *Sertularia pumila*, and the bryozoan *Flustrellida hispida*.

Mussels (*Mytilus edulis*) are a normal component of the mid-littoral zone in Atlantic Canada, although Thomas *et al.* (1983) stated for the Fundy area, "where blue mussels do occur they are tiny and are normally found considerably lower down the zone" (than barnacles). The literature on the diet of shore birds (see below) indicates that mussels are an important component of their diet, so we may infer that mussels are a significant component of the intertidal or subtidal fauna, at least in the Quoddy region.

A rich epifauna develops among the epiphytic algae in summer (Johnson and Scheibling 1987). At a site in Nova Scotia harpacicoid copepods, nematodes, and halacarid mites were the most abundant; but considerable numbers of young annelids and gastropods were also present.

Many species of fish enter the *Ascophyllum* zone when it is submerged. Black and Miller (1991), using seine nets and trammel nets, reported for a site in Nova Scotia (in order of abundance) cunner (*Tautoglabrus adspersus*), grubby (*Myxocephalus aenus*), pollock (*Pollachius virens*), winter flounder (*Pseudopleuronectes americanus*), Atlantic tomcod (*Microgadus tomcod*), and small numbers of other species. They obtained evidence that the fish were feeding in the intertidal zone. Tyler (1971), using a counting fence, reported at St. Andrews, N.B., a predominance of winter flounder entering the intertidal on a rising tide. Macdonald *et al.* (1984) gave beach seine catches for the lower intertidal of the lower Bay of Fundy and Passamaquoddy Bay. They found winter flounder, pollock, and Atlantic tomcod to be the most abundant. Rangeley (1991), after reviewing the literature, concluded that some 22 species of fish utilize rockweed habitat for at least some part of their life history.

Hogans and Trudeau (1988) reported on the wildfowl utilizing the intertidal of the Passamaquoddy and Grand Manan areas in the winter 1987-88. Most abundant were common eider (*Somateria mollissima*), followed by blackduck (*Anas rubripes*), scoters (*Melanitta* spp.), buffelheads (*Bucephala albeola*),

goldeneye (*Bucephala clangula*), and oldsquaw (*Clangula hymenalis*). Rangeley (1991) added loons, herons, and ospreys to the list of birds relying on the intertidal zone for food.

Feeding Relationships

a) Invertebrates

Lubchenco (1978) showed that *Littorina littorea* feeds little on macroalgae such as *Ascophyllum* and *Fucus* but has a strong preference for microscopic plants, sporelings, and small ephemeral algae. Lowell *et al.* (1991) showed that when *Ascophyllum* is damaged by invertebrate grazing it responds by increasing the toughness of its tissues. *Fucus*, on the other hand, responds to grazing damage by increasing its polyphenol content (Van Alstyn 1988). In general it seems that rockweeds make little direct contribution to invertebrate or vertebrate food webs. Instead, they contribute to the pool of dissolved and particulate detritus in nearshore waters (Sieburth 1969).

The question then arises as to whether seaweed detritus is an important part of the diet of animals in nearshore waters. A review by Mann (1988) showed that particulate detritus derived from vascular plants contains a great deal of refractory, indigestible material which must be conditioned by bacteria and fungi before it is nutritious for most animals. In the process of this conditioning much of the carbon and energy is lost to microbial respiration, so that vascular plant detritus is used very inefficiently in the food web. By contrast, algal detritus has much less refractory tissue and is used readily by animals that ingest it. It is believed that particulate algal detritus is used extensively by filter feeders. One of the clearest demonstrations is the use of kelp detritus by mussels in the nearshore system of the Cape Peninsula in South Africa (Siederer *et al.* 1982; Stuart 1982). In addition to the pathway through particulate detritus, it is believed that there is an important pathway through dissolved organic matter secreted by rockweeds which is incorporated into bacterial biomass and also condenses on solid surfaces to form amorphous organic aggregates (for references, see Mann 1988). This pathway has been conclusively demonstrated in freshwater systems and almost certainly exists in marine systems, though its magnitude is less clear.

From this we may conclude that *Ascophyllum* tissue *per se* is very little used by intertidal invertebrates. However, the rockweed is a substrate which supports a growth of epiphytic algae. Dissolved organic matter given off by the *Ascophyllum* condenses in this community to form amorphous particles which are intermingled with small macrophytes and microscopic algae. In this epiphytic turf develops a rich fauna of harpacticoid copepods, mites, etc. The total epiphytic community is browsed by amphipods, gastropods, etc. In addition, pieces of the *Ascophyllum* which break away are colonized by microorganisms, reduced in size by water movement, and serve as a detrital food resource for filter feeders such as mussels and clams.

b) Fish

The analysis of Black and Miller (1991) showed that the fish caught in the intertidal zone had in their stomachs fresh, intact animals corresponding with those occurring in the *Ascophyllum* beds. The most common were amphipods, isopods, and small young *Littorina* spp. The large sculpins ate green crabs (*Carcinus maenas*) and young fish. Sedentary fish were shown to have more food in their stomachs when leaving the intertidal zone than when entering. Comparing these results with analyses of gut contents of intertidal fishes

from other sites, the authors showed that small crustaceans (amphipods, isopods, shrimps) were the dominant animal component of the diet of intertidal fish worldwide.

c) Birds

Hogans and Trudeau (MS) examined (4-14) stomachs of each species of the wintering waterfowl that they studied. Mussels were the most important component of the diet of all species, except for blackduck which contained more littorinid snails than mussels. Amphipods and soft-shelled clams were also common in the stomachs. It appears that in most cases the mussels were taken from below the low-tide mark by diving. The birds were not therefore feeding directly in the *Ascophyllum* zone; but as we have seen, the shellfish may well have derived nutriment from that zone.

Ascophyllum Beds as Habitat

Hruby and Norton (1979) showed experimentally at a site in Scotland that the species diversity and abundance of individuals settling on the substrate was greater under an *Ascophyllum* canopy than outside it. They attributed this effect to the higher humidity found under the *Ascophyllum* when the tide was out. One might also consider that organisms living under a canopy of *Ascophyllum* would be sheltered from the full force of turbulent water movement induced by wave action in rough weather, while those outside the canopy would be exposed to it. Those under the canopy would also be more protected from predation. In a related study, Johns and Mann (1987) showed that under aquarium conditions the mortality of Stage 4 lobsters exposed to predation by cunner was 69% per day when kelp was present, but 97% when it was absent.

Consequences of *Ascophyllum* Harvesting

At a site in Northern Ireland, Boaden and Dring (1980) compared an undisturbed area with an area where *Ascophyllum* had been harvested (to within 10-15 cm of the base) 3 yr previously. In the area of harvest they found an increase of other algae (*Fucus*, *Enteromorpha*, and *Ulva*) and an increase in *Cirratulus* worms. On the sides of boulders there was a significant decrease in barnacles and sponges. On the habitable undersides of boulders the total animal cover had been reduced by nearly two-thirds and the number of species per boulder by one-third. The animals involved were mainly barnacles, mussels, and bryozoans.

Black and Miller (1991) experimented with total clearing of 30 m-wide strips of shoreline dominated by *Ascophyllum*. It should be noted that this is far more severe treatment than commercial harvesting practice, where stumps 15-25 cm high are normally left. The clearing was done in January 1981, and the main observations were made between May and September of the same year. They had two sites. At Site 1 the mean number of animals on the rocks showed no significant difference between the cleared and intact areas, but at Site 2 the number of animals on the rocks in the cleared area was approximately one-third of the number in the intact area. The differences were mainly in amphipods, nemerteans, and *Littorina obtusata*. They made nighttime tows with a plankton net close to the bottom and found that at both sites there were far more invertebrates at the intact sites. Particularly noticeable were the great abundances of gastropods at the intact sites. When crustaceans alone

were considered, there was no significant difference between cleared and intact areas at Site 2; but at Site 1 there were more crustaceans in the intact area.

In addition to the differences described above, we should note that the average *Ascophyllum* plant in an intact area has 95-200 animals per plant, of which the majority were *Littorina*. These would have been lost from the cleared sites when the plants were removed.

The main purpose of the clearing experiments conducted by Black and Miller (1991) was to investigate the fish species present and their abundances and feeding habits in cleared and intact areas. They found that the numbers and weight of fish present in intact and cleared areas were not significantly different. It is difficult to extrapolate these results to a harvested area because the treatment was more severe than normal harvesting practice and because the cleared and intact sites were relatively close to one another, offering the possibility for fish to move freely between them. Also, there may have been greater differences between cleared and uncleared sites if more time had elapsed between clearing and sampling.

Summary

Dominant invertebrates in the *Ascophyllum* zone of New Brunswick are *Littorina* spp. and small crustaceans such as amphipods and isopods. These derive their food primarily from the community living epiphytically on the blades and from algae growing on the rock surface. Nevertheless, removal of the *Ascophyllum* leads to a reduction in number of these invertebrates. This is because the *Ascophyllum* provides protection from desiccation when the tide is out, protection from excessive wave action, protection from predators, and because the blades of the rockweed are a platform for the growth of a rich epiphytic community.

Mussels are a normal component of the *Ascophyllum* zone in Atlantic Canada, although the literature indicates that the Fundy shores may be an exception. Here, the mussels may live primarily below the *Ascophyllum* zone. Although the evidence is incomplete, there is good reason to believe that particulate detritus derived directly from the rockweed, and by condensation of dissolved organic mater exuding from it, is a significant source of nourishment to the mussels.

A total of 10-20 species of fish enter the *Ascophyllum* zone at high tide to feed on the invertebrates. Of these, the ones of most commercial significance are pollock and winter flounder.

Six species of duck winter on or near the *Ascophyllum* zone of the Quoddy area of New Brunswick. Mussels are the dominant item of diet, but littorinid snails and amphipods are also taken.

The consequences of removal of *Ascophyllum* are:

i) a reduction in the amount of blade surface area available for development of an epiphytic community, which in turn means a reduction in food available for snails and amphipods;

ii) a reduction in the small algae and invertebrates on the rock surface consequent on reduced protection from desiccation, heavy wave action, and predation;

iii) a reduction in the flux of particulate and dissolved organic matter from the rockweed, with a consequent reduction in food supply for mussels and clams in neighbouring waters;

iv) a reduction in the amount of invertebrate food available to fish which enter the intertidal zone at high tide; and

v) if the mussels are food limited, a reduction in the amount of particulate and dissolved organic matter could mean a reduction in mussel production and food available to shore birds.

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