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Changes in the brown seaweed *Ascophyllum nodosum* (L.) Le Jol. plant morphology and biomass produced by cutter rake harvests in southern New Brunswick, Canada

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Abstract

Shoots and clumps of shoots of the commercial brown seaweed *Ascophyllum nodosum* ("rockweed") add to the benthic complexity of the intertidal environment, providing an important habitat for invertebrates and vertebrates. To protect the structure of this habitat, management plans for the rockweed harvest of southern New Brunswick include restrictions on gear type and exploitation rates limited to 17% of the harvestable biomass. However, owing to physical and environmental factors, the harvest is not homogeneous, creating patches of exploitation ranging from 15 to 50%.

A direct relationship existed between clump vulnerability, weight and length in a controlled harvest at 50% exploitation within 8 m by 8 m plots. At this exploitation rate, the gear rarely impacted clumps below 50 g or 60 cm in length. Clumps larger than 300 g and 130 cm were reduced by up to 55% of their length and 78% of their biomass. The overall impacts of the harvest on intertidal habitat is however of short duration as biomass recovers after a year of the experimental harvest. The rapid recovery is mostly due to a stimulation of growth and branching of the suppressed shoots of the clumps. Some harvested plots showed biomass even higher than initial levels, suggesting an increase in productivity at least during the first year after the harvest.

Introduction

The brown seaweed *Ascophyllum nodosum* (L.) Le Jol. ("rockweed") dominates the rocky intertidal of the Atlantic shores of Nova Scotia and New Brunswick, Canada. The rockweed plant is an assemblage (clump) of dichotomously branching dominant shoots and basal or suppressed shoots arising from a common holdfast and floated by vesicles (Cousens, 1984; Sharp, 1986). The buoyant biomass creates a dense canopy as the tide rises. The high density of branching and suppressed shoots in a clump and the distribution and biomass of clumps in the intertidal create also a complex habitat for invertebrates and fishes during the tidal cycle (Rangeley & Kramer, 1998).

Ascophyllum nodosum's economic value as a raw material for fertilizer, animal fodder and alginate led to its commercial harvest in the Maritimes in 1959 (Sharp, 1986). Harvesting techniques have ranged from simple knives to sophisticated and expensive vessels with hydraulically driven suction cutters (Sharp et al., 1995). Although over the past 15 years the rockweed harvest of the Maritimes has expanded in quantity and extent, the harvesting technique has evolved from harvesting machines to manual cutter rakes (Ugarte & Sharp, 2001).

The cutter rake is attached to a 3 m pole and is equipped with sharp tooth-shaped blades held in a rake-head protected by three guides (Figure 1A). The shoots are cut by the blades and the tines of the rake gather the cut shoots while the guides prevent the blade from contacting the substratum. Harvesters work during the falling and rising tides, with vessel having a 4 to 6 t capacity (Figure 1B). The rake is drawn through the

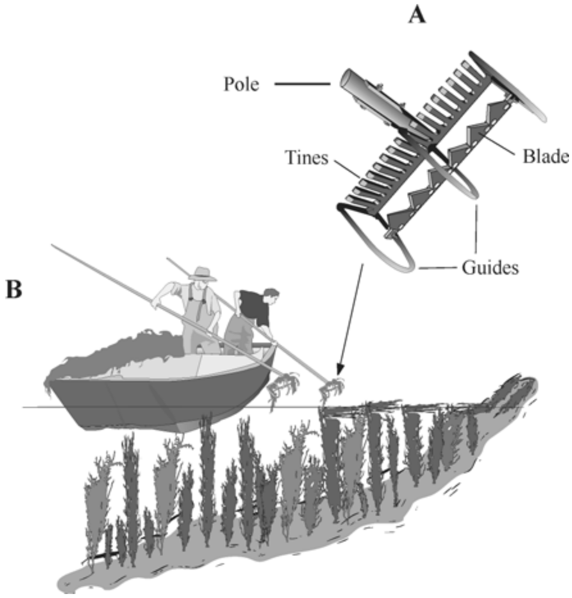

Figure 1. Harvest method of *Ascophyllum nodosum* in southern New Brunswick, Canada. (A) The manual cutter rake (B) Harvesting *Ascophyllum nodosum* from a 6 to 7 m vessel with 4 to 6 ton capacity on the falling and rising tide.

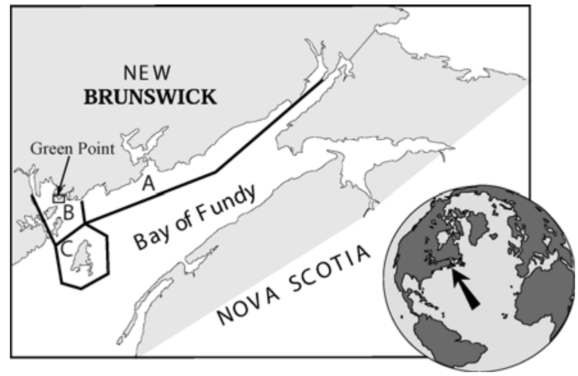

Figure 2. *Ascophyllum nodosum* harvesting areas and study site location in southern New Brunswick, Canada.

floating canopy at a 45 to 60 degree angle. Once the harvester reaches the rockweed bed, the vessel moves up and down the intertidal zone with the tide and along the bed with the wind and current. The harvester can choose areas of the bed to harvest but cannot directly control the cutting height of the clumps.

In southern New Brunswick regulations restrict gear type and the exploitation rate is limited to 17% of the harvestable biomass in order to protect the structure of this habitat (Ugarte and Sharp, 2001). However, owing to physical and environmental factors, the harvest is not homogeneous, resulting in patches of exploitation ranging from 15 to 50% (DFO, 1999).

The present paper examines the length and biomass structure of *Ascophyllum. nodosum* clumps immediately before and after a harvest and recovery in experimentally harvested plots. To date experimental harvests using various gear types have only examined shoots, and clump length and density (Ang et al., 1993; Lazo & Chapman, 1996).

Methods

The study area was located in Harvesting Area B, which produces the highest landing of the three harvesting areas in the northern shore of the Bay of Fundy in southern New Brunswick, Canada (Figure 2). A closed site (previously non-harvested) located at Green Point, inside Area B, was the location of the experimental harvest (Figure 2). This site was semi-exposed, with a boulder substratum, 15°–30° slope and 100% rockweed cover.

During the summer of 2001 the population structure of rockweed in Harvesting Area B was determined by sampling 16 sites within this area. All clumps were removed from fifteen 0.25 m^2 randomly-placed quadrats without evidence of harvest, along a 30 m transect set in the middle of the rockweed zone at each site. Clumps were bagged and immediately refrigerated (5 °C) and analyzed within two days. The total length, wet weight and number of shoots were measured in 1,196 clumps. From these, 482 clumps were randomly selected, dissected into 10 cm segments from base to tip and the wet weight of each segment measured to 0.1 g.

To measure the impact of the harvest on the population structure, five plots (8 m × 8 m) were permanently marked with rock anchors in the middle of the rockweed zone located at the Green Point study site (Figure 2). Thirty quadrats (each 0.125 m^2) were evenly spaced along five parallel transects in each plot. All clumps in a quadrat were tagged using permanent tags (Sharp and Tremblay, 1985). A total of 1,256 clumps was tagged at the start of the experiment but only 1,137 (90.5%) provided reliable data throughout the experiment. Three plots were randomly selected as treatments and two as controls. Each tagged clump was measured for length to 0.1 cm using a flexible tape. The wet weight (accurate to 0.1 g) for each clump was measured using a low-profile base electronic scale (Acculab VI-600). The clump was carefully piled inside a tared