

## A harvesting strategy for *Iridaea laminarioides* in central Chile

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### Introduction

About 5000 t of dry *Iridaea* are exported annually from Chile for carrageenan extraction (Lopehandía, 1986), but inadequate biological knowledge prevents rational management of these species. As in the case of other economically important algal species in Chile, studies have been oriented either to understand the morphology and taxonomy of the species (Etcheverry *et al.*, 1981) or to characterize chemically the nature of the gels produced (Matsushiro & Zanlungo, 1976a, b). Some of these species, such as *Iridaea laminarioides* Bory, are ecologically important in rocky intertidal communities (Santelices *et al.*, 1981) and careless harvesting might result in ecological damage and decreased production. Because of specific differences, ecological studies with species of *Iridaea* at other latitudes (Hansen & Doyle, 1976; Hansen, 1977, 1981; Adams & Austin, 1979) have limited application to the Chilean beds. Methods for field propagation or tank cultivation of species of *Iridaea* elsewhere (Waaland, 1973, 1976, 1982; Mumford, 1979; Mumford & Waaland, 1980) cannot be used in Chile, mainly owing to limited knowledge on the production ecology of the local species.

This study was designed to gather basic biological information on *Iridaea laminarioides* in central Chile for formulation of an optimum harvesting strategy for the species. This is considered a first step for a more comprehensive management program of this native resource. We first analyzed the temporal variations in standing stocks, reproductive pattern and gel content of intertidal popula-

tions in central Chile. Aided by field experiments, we then measured regeneration capacity of these populations to monthly harvesting and the recruitment capacity of juvenile fronds. All these data are integrated in a harvesting model for populations in central Chile.

### Materials and methods

#### *Study site*

Field studies were done at Matanza (35°56'S, 71°53'W). This is a sandy beach with frequent rocky outcrops projecting seaward. Periodic sand invasion of the lowermost intertidal and shallow subtidal levels prevents high grazer densities in these habitats and favors algal communities with sand-resistant perennial phases. *Iridaea laminarioides* reaches high representation values in this type of habitat, forming a conspicuous belt extending from 0.4 m to 2.2 m above zero level (mean tide chart datum). In Chile, this type of habitat is frequently found in the stretch of coastline between 33 and 42°S (Santelices, 1980) and constitutes one of the preferred harvesting areas for intertidal crops of *Iridaea laminarioides*.

Temporal variations in standing stocks, gel contents and reproduction patterns of these populations were measured by removing all individuals within eight 0.25-m<sup>2</sup> quadrats haphazardly placed within the *I. laminarioides* belt. Eight quadrats were the minimum sample size required to obtain a "good" representation of this population (Mueller-

Dombois & Ellenberg, 1974). Sampling was repeated monthly from January 1984 to March 1985. The fronds collected were transported to the laboratory, washed in clean seawater to remove sand and epiphytes, separated by reproductive stages and wet and dry weights determined. Carrageenan content of the dried thalli was measured as described by Craigie & Leigh (1978). The ploidy levels of 30 freshly collected sterile fronds were determined using the resorcinol-acetal reaction (Craigie & Leigh, 1978, p. 123), which assumes that tetrasporophytes produce  $\lambda$ -carrageenan whereas gametophytes contain  $\kappa$ -carrageenan.

In order to measure recruitment rates of juvenile thalli, 16 permanent 0.25-m<sup>2</sup> quadrats were established in the field within the *Iridaea laminarioides* belt. All thalli inside each quadrat were manually removed, and the remaining crustose bases were burned. All algal species which recruited before, together with or after recruitment of the juveniles of *I. laminarioides* were allowed to persist in eight experimental plots but were removed from the other eight quadrats. The observations began in May, 1984 and ended in February 1985.

Regeneration capacity of harvested thalli of *Iridaea laminarioides* was measured in another 16 0.25-m<sup>2</sup> permanent quadrats from January 1984 to March 1985. Each month all fronds within a quadrat were cut 2 cm above the holdfasts, placed in previously numbered plastic bags and transported to the laboratory for weight determinations and gel-content analysis.

## Results

### *Temporal stock variations and reproduction patterns*

These intertidal populations showed seasonal growth variously affected by abiotic factors and by the reproductive activities of the population itself (Fig. 1). Stocks started increasing during winter (May–June) owing to the growth and maturation of cystocarpic thalli. After spore release, many cystocarpic fronds became perforated or necrotic because of sorral losses and were eventually removed

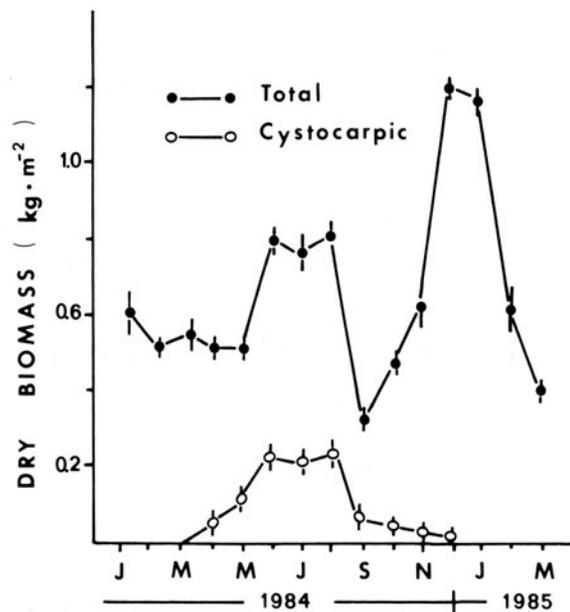


Fig. 1. Temporal variations of total and cystocarpic standing crops of the intertidal populations of *Iridaea laminarioides* in Matanza, central Chile.

by water movement, decreasing the stocks by late winter (August). Stocks, now composed almost entirely of vegetative thalli, increased thereafter, reaching maximum values (1–1.2 kg·m<sup>-2</sup>) by early summer (January). Desiccation during summer then reduced these stocks. Subsequent growth of new fronds during the next winter was achieved by regeneration from the holdfasts.

The abundance of tetrasporophytic thalli was low during most of the year and only occasionally were fertile tetrasporangial thalli measurable in stock assessments. Resorcinol-testing of the vegetative population confirmed that gametophytic thalli were the most abundantly represented in this population (Fig. 2).

### *Recruitment*

Recruitment of *Iridaea laminarioides* juveniles occurred if new substratum was made available, as in our removal experiments (Fig. 3). If the opportunistic algal species which first invaded the burned plots (e.g., *Porphyra columbina* Mont., *Ulva rigida*