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A "BIOTOPE" APPROACH TO THE MARINE BENTHIC BIOLOGICAL ASSEMBLAGES OF THE LAGUNA SAN RAFAEL NATIONAL PARK, CHILE

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ABSTRACT

The biotope approach developed originally for use in Northern Europe has been used to describe and classify benthic marine assemblages in various parts of the world, including the Laguna San Rafael National Park (LSRNP) in southern Chile and nearby protected areas. Given is a brief description of how to identify, describe, classify and map marine biotopes. Some of the more widely distributed rocky shore biotopes in the LSRNP area are briefly described. Full biotope descriptions are given for the most distinctive biotope within the fjords (*Macrocystis pyrifera* biotope) and two on the very wave-exposed open Pacific coast (*Durvillaea antarctica, Lessonia nigrescens).* All the biotopes recognised are regarded as provisional and require further testing and refinement. Once refined biotopes can be taken into account when making management and conservation decisions on seashore and seabed habitats within the LSRNP and surrounding nature reserves.

Key words: Marine Biotope, Laguna San Rafael National Park, Aisén, Chile.

RESUMEN

Una aproximación de la metodología de "Biotopos", al estudio de las comunidades marinas bentónicas del Parque Nacional Laguna San Rafael, Chile. Una metodología basada en el estudio de los "Biotopos", desarrollada originalmente para su uso en Europa del Norte ha sido utilizada para describir y clasificar las comunidades marinas bentónicas en varias partes del mundo, incluido el Parque Nacional Laguna San Rafael (PNLSR) en el Sur de Chile y áreas vecinas protegidas. En el presente trabajo se entrega una descripción breve de cómo identificar, describir, clasificar y mapear biotopos marinos. Algunos de los más ampliamente representados biotopos presentes en las costas rocosas del PNLSR son brevemente descritos. Una descripción completa de los biotopos es entregada para la mayoría de los biotopos más distintivos presentes en los fiordos.(Ej. el Biotopo *Macrocystis pyrifera*) y los Biotopos *(Durvillaea antarctica y Lessonia nigrescens),* estos dos últimos presentes en áreas de gran exposición al oleaje, abiertas a la costa del Pacífico. Todos los biotopos reconocidos deben ser mirados como provisi~nales y requieren ser probados y estudiados a un nivel más fino.. Una vez que éstos sean descritos en forma más detallada, podrán ser considerados en la toma de decisiones respecto al manejo y conservación de las costas y habitats marinos dentro del PNLSR y de otras reservas naturales que rodean este Parque Nacional.

Palabras clave: Biotopos marinos, Parque Nacional Laguna San Rafael (PNLSR), Aisén, Chile.

INTRODUCTION

To the south of the island of Chiloé the coast of Chile consists of a series of offshore islands between which lie deep channels that sometimes lead into fjords and a glaciated mountainous hinterland. Associated with this largely unspoilt wilderness is a unique assemblage of ecosystems whose habitat diversification is greater than that to be found elsewhere in Chile. In this area lies the Laguna San Rafael National Park (LSRNP) and other protected areas that harbour a wide variety of aquatic ecosystems, including fully marine wave-exposed shores, brackish water estuaries, fjords, tidal lagoons, freshwater lakes and rivers. Until the launch in 1996 of the LSRNP Darwin Initiative-funded biodiversity research programme, the Corporación Nacional Forestal (CONAF) had a problem making meaningful and effective management decisions in the absence of scientifically sound knowledge. In response to the urgent need for baseline information on marine biodiversity and the conservation status of the coastal sector of the Park and neighbouring protected areas, several collaborative research projects were undertaken involving British and Chilean scientists. These projects were aimed primarily at the provision of information in a form that CONAF staff could use for monitoring or poses and on which to base future management decisions. Additionally, it was recognised that there was a priority to provide CONAF with tools necessary for identifying and mapping marine animal and plant assemblages.

An approach developed in northern Europe for describing and classifying the seashore and seabed habitats and their associated communities has been used in the LSRNP and its environs. It is designed to provide a sound scientific framework for setting conservation priorities by enabling an assessment to be made of the conservation value of sites and coastal sectors. The approach, termed biotope assessment, is discussed here in the context of Chile and briefly described are the methods used to identify, describe and to classifying benthic marine assemblages. Some preliminary findings concerning the more distinctive rocky shore biotopes within the boundary of the LSRNP and protected areas to the north are presented.

BIOTOPES IN THE COASTAL ZONE

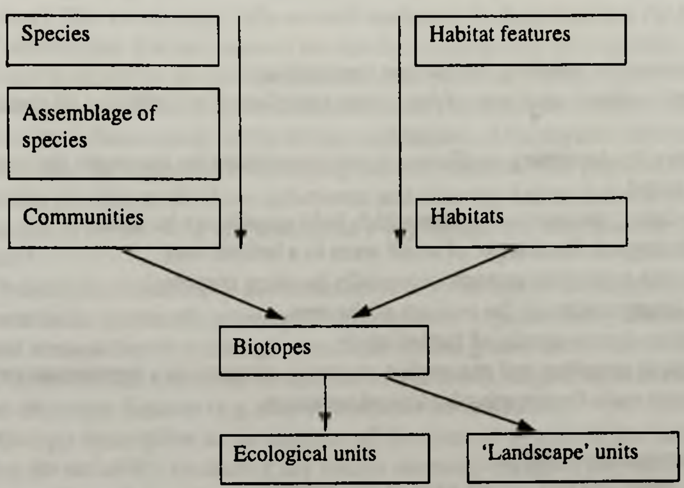
Until the advent of the biotope approach marine conservation management planning and the selection of protected areas in Europe was based largely on subjective criteria or focused on a few highly visible organism. The biotope approach was developed in order to provide more objective criteria and has proven very successful when applied to assemblages of marine macroalgae and sessile invertebrate fauna associated with rock and sediment shores. It was developed by the Joint Nature Conservation Committee of the UK as part of an assessment and classification of marine habitats in Europe and became known as 'The Marine Nature Conservation Review'. Later the approach was expanded as part of the European Union *Biomar* project co–funded by the European Commission Life Programme (Hiscock, 1996; Connors *et al.*, 1997). To date it has been used in Thailand in South-East Asia, Ghana in West Africa, Abu Dhabi (UAE) in the Arabian Gulf, Helgoland in the North Sea and in the Azores archipelago (Tittley & Neto, 2000); John *et al.* (1999) and Paterson *et al.* (2001) have reported on its application in southern Chile.

¿What are the biotopes?

A biotope is very broadly defined as 'the biota interacting with the physical habitat: plants and animals found at a location together with their immediate physical'. Defining a biotope is a convenient means of summarising field conditions for the purpose of describing general ecological patterns. A biotope should be compared to a 'habitat' which is defined as a physical entity (e.g. rock, sediment) together with particular conditions of wave exposure, salinity, etc. Biotopes are artificial constructs used simply for convenience with the boundary line between them often somewhat subjective. In drawing this imaginary boundary, it is necessary to ensure that biotopes are easily recognisable 'in the field' by having distinctive features and species and recur relatively frequently. They are best regarded as 'nodes' along an environmental continuum and if carefully selected provide a useful tool to assist in the identification of important ecological patterns and stimulate further ecological study.

The species assemblages used to define biotope are thought of as circumscribed units as opposed to physical environmental features which cover a range of gradients and scales. The biotopes integrate the species and abiotic components and can be used to described the larger landscape. The relationship of the different components one to another is shown in Table 1.

TABLE 1. Showing the position of biotopes in relation to broader landscape features.



Every effort should be made when defining biotopes to ensure that they are conspicuous and their characteristics are easily recognisable. They should be described in terms of the following: (a) the most conspicuous and predominant species; (b) if taxonomically difficult then life form is used, e.g. sponges, sea squirts; (c) groups of species which form a mixed-species life form with a list of some of the more important component species, e.g. turf forming algae, crustose coralline red algae; (d) key species in the ecosystem, e.g. grazers such as sea urchins and molluscs; (e) species or group of less common species unique to a biotope. Features of the physical habitat are used and include details of the substratum (amount of physical relief; rock, coral, sand, etc.), position on shore and wave exposure. Scale is important and for most shore work a biotope should cover an area of at least 5-10 square metres or more. Often this area takes the form of a long linear strip reflecting the fact that many shore biotopes form horizonatl bands or zones. Smaller scale variation within a biotope are often referred to as attributes of a larger biotope unit. Scale has to be used with caution since many biotopes are mixed or form a mosaic resulting from small differences in substratum type, wave-exposure, etc.

In summary, our biotopes should have the following features:-

- There should be a presumption to limit their number and not proliferate them.
- They should be based on conspicuous features.
- They should be identified readily (at least to a workable level in the hierarchy).
- They should be arranged into broader categories.
- Biotopes should be based on descriptions of areas ideally of about 25m x 25m for mapping.

What are advantages and disadvantages?

Apart from aiding rapid identification, the conspicuous species or life forms used to characterise biotopes, are likely to be biologically important since they structure the habitat for less conspicuous species, generally have a greater biomass and structure trophic interactions within the biotope (or larger ecosystem). The more important biotopes so defined can be mapped using remote sensing data from aerial photography and satellite imagery. However, small species (particularly grazers and carnivores) may also exert considerable influence on the composition and biology of a biotope and therefore need to be noted. For sediments, the use of the predominant species is especially problematic since these are often buried.

Some of the main reasons for adopting the biotope approach are:

- To provide a short-hand and rapid way of describing complicated assemblages of species and habitat features.
- To provide structure for describing small areas by predetermining the important attributes that should be observed and noted.
- To provide a 'yardstick' description against which field records can be assessed.
- To describe the biological 'landscape' of small areas in a holistic way.
- To detect broad scale ecological patterns (especially by using mapping).
- To help with the interpretation of the ecology of the area.
- To focus attention on issues worthy of further study.
- To stratify ecological sampling and ensure that an area is surveyed in a representative way.
- To provide the basic units for mapping biological resources.

Limitations to the biotope approach are:

- They are human constructs and do not exist as real entities.
- They should be used to help ecologists develop new insights and must not be used to restrict vision.
- In particular, they must be used flexibly to help description, not rigidly to constrain description.
- They should be used to describe small areas in the field based on observed attributes. In other words, they should not be the only information recorded in the field but be supported by other recorded observations.
- It is unlikely that they will be adequate in themselves (without recording their attributes) to describe fine scale diversity.
- They are not a complete description of the ecology of an area – just an introduction to the ecology.

How are biotopes defined?

In practise, biotopes are recognised based on prior knowledge of the major habitat types of a region and field recording. It is also likely that the framework for biotopes will be similar to that derived for other regions. Local knowledge might be useful in drawing up a basic framework for the biotope system and suggesting what might be some of the higher levels present. Examination of maps and charts, aerial photography as well as consulting local knowledge might assist in predicting what biotopes might be found in an area.

All sources of information should be consulted at the pre-planning stage in order to construct a list of habitat types that might be expected to support different biotopes. The next step is to carry out field survey at as many representative sites as possible. These field records are used to compile the biotope descriptions. Some survey site selection is need to ensure that well developed and typical examples of different biotope types are covered rather than focusing too much attention on a mosaics of biotopes. Such mixtures of biotopes are often difficult to interpret, at least initially, and often reflect substrate heterogeneity. Inevitably continua will be recognised and it will be necessary to decide where to draw the line between the 'nodes' or biotopes.

The format for recording data for deriving and refining biotope classifications is the same as that used for field recording for biotope mapping. Marine and coastal intertidal biotopes should be grouped into very coarse categories that form the basis for a very broad classification. For example, the broad categories found in the LSRNP include rocky marine shores, rocky brackish shores, sand/shingle shores and salt marsh.

How are biotopes described?

A formalise scheme has been adopted for laying out the description of biotopes and this is shown for the provisionally recognised *Macrocystis, Durvillaea* and *Lessonia* biotopes described in southern Chile (see below). The biotopes in Chile are still inadequately described and for that reason not all the categories of information that are required for standard descriptions are available.

All biotopes should be given a unique code letter based on biotope features some combination of key species, life form and physical habitat characteristics. The descriptive title is often long since included are the key biological characteristics of the biotope and features of the physical environment, with emphasis placed on those that distinguish it from closely related biotopes. The physical component in the title normally includes position on the shore, substratum and other key habitat features such as wave-exposure. To ensure the title is bot too long and clumsy only key habitat characteristics or characterizing species are mentioned.

The "habitat classification" is placed before or after the habitat description. The following are the habitat characteristics commonly considered: salinity, wave exposure (very sheltered to very/extremely exposed), tidal streams (weak to strong), substratum (sand, gravel, mud, bedrock, boulders, etc.), zone (supralittoral downward to sublittoral fringe; sublittoral zone), height/depth in relation to chart datum, and any other important features (e.g. also on sheltered vertical rock).

The biotope description is an account of the general nature of the habitat and community characteristics, its variability (including any known temporal changes), any microhabitat features (e.g., crevices, fissures, beneath boulders, shaded, *Macrocystis* stipes), and its relationship to other biotopes (i.e. along gradients of zonation on the shore, substrate type, wave exposure, salinity, etc.).

Distribution in the region is important and sometimes a map is included indicating its site or general distribution in a coastal sector. Where there is a considerable body of information in existence then it might be possible to indicate its likely frequency of occurrence.

Photographs to illustrate the main features of a biotope are important and should show it in broad view and/or close up. In some cases it might be necessary to photograph it at different times in the season if it changes in the course of time.

Other features are recommended for inclusion in biotope description. Unfortunately, unless a region has been thoroughly surveyed then it is not always possible to include information on regional variation in habitat or species characteristics compared to elsewhere. Similarly without having a large body of information available it is often difficult to comment on features of conservation interest. Often it is desirable to include a list of species that characterise the biotope and the typical abundance at which they occur. The list should include species listed in perhaps over 60% of the records of the biotope ("constant species") compared to those in less than 60% of the records ('faithful species'). In addition, normally listed would be those that occur in a high proportion of the records but which are not particularly indicative of the biotope.

How are biotopes classified?

The biotope types/categories can be placed in a classification system that ranges from a description of the environment in terms of a few broad categories to the identification of individual biotopes placed in a comprehensive and formally structured hierarchical classification system. There is a two-way flow of information since the biotope categories are based on field descriptions and these categories can assist in structuring further field survey.

Descriptive field data	Deriving categories Identifying categories	Biotope classification system

TABLE 2. The following is a lexicon of some of the codes used for biotopes including some of those described from southern Chile (see below).

How are biotopes coded?

Codes are defined for habitat complexes, biotopes and variants using the habitat complex code, a full stop and then the biotope code. Where a variant is recognised then a further full stop is added after the definition of the biotope. Biotope and subbiotope or variant codes are based wherever possible upon the most dominant and characteristic taxa. The species names derived using the first three letters of a genus or higher taxon name. Where a species is used then the code is derived using the first letter of the genus and the first three letters of the specific name. Where the biological composition is too complex to derive a simple code then features of the habitat have been use (increased salinity). Within the biotope code each new element begins with a capital. As far as possible the codes used follow those adopted by the MNCR for the British Isles (Table 2).

Shore position/wave exposure: littoral zone (L), sublittoral zone (SL), rock pool (RP), sheltered (SH), moderately exposed (M), exposed (E), unattached (UNAT).
Substrata: rock (R), sand (SND), sediment (SED), Mud (MUD), Mixed (MXD), Wood (WD).
Life forms: algal turf (ATRF), algal film (AFILM), kelp (KP).
Groups/functional groups: ascidians (AS), brown macroalgae (B), barnacles (BARN), bivalves (Biv), crustaceans (crus), cyanobacteria (cyan), gastropods (GAS), green macroalgae (G), lichens (LICH), polychaetes (POLY), red macroalgae (R) sea urchins (SURC), sponges (SP), tunicates (TUN).
Taxa: *Acrosiphonia pacifica* (Apac), *Ahnfeltia* (Ahn), *Austromegabalanus* (Aust), *Bostrychia harveyi* (Bhar), *Cladophoropsis brachyarcta* (Cbra), *Durvillaea antarctica* (Dant), *Elminius kingii* (Ekin), *Gelidium* (Gel), *Iridaea tuberculosa* (Itub), *Hildenbrandia lecanellieri* (Hlec), *Lessonia nigrescens* (Lnig), *Macrocystis pyrifera* (Mpyr), *Mazzaella* (Maz), *Mytilus edulis* (Medu), *Nothogenia* (Noth), *Prasiola tesselata* (Ptes), *Notochthamalus* (Noto), *Rivularia* (Rivu), *Rhizoclonium ambiguum* (Ramb), *Sarcothalia crispata* (Sarc).

How are biotopes mapped?

The mapping of robust, easily recognised and well defined biotopes provides information that can be combined with maps of land use, geology, climate and coastal morphology to study the dynamic patterns of landscape ecology and their underlying causes. These maps also provide valuable information for the identification of sites of conservation or heritage importance, sites which are sensitive to various types of disturbance (e.g. tourist impact, fish farming) and will also help identify areas for which the sustainable use of resources may be achievable. They can also be used by those involved with the scientific study and teaching of ecology as well as by planners and economists.

It is useful if biotopes are based on conspicuous and highly visible characteristics so that they may be used in conjunction with remote sensing. Traditional cartography and remote sensing impose size limits on biotopes. Often is difficult to map units less than about 25m x 25m and this size is probably also appropriate for use in the interpretation of remotely sensed data. Unfortunately, on the steep sided rocky shores of the fjord systems in Chile the biotopes frequently are in the form of narrow linear strips less than a metre in width. It is often impractical to have too many classes shown on a map and likewise it is difficult (if not impossible) to interpret a large number of classes from remotely sensed data. The upper limit imposed by these practical considerations means that the large number of maps might be needed to cover a large region. However, it would be reasonable to arrange the biotopes into some form of hierarchy of smaller numbers of higher levels and possibly even subdividing the basic mapping biotopes into smaller units as the location demands (or to be used for specific purposes).

The mapping of habitats and biotopes should be designed to give an overview of the broad but ecologically important properties of an ecosystem. It is possible from the observed biotope distribution patterns to formulate hypotheses about very broad ecological patterns (e.g. importance of salinity, sea urchin grazing), and to provide a context for the interpretation of more detailed data. The approach is not designed to provide a definitive description of the shore ecosystem, but rather to give a broad description intended to be the starting point for further investigations that might include monitoring the biological impact of future development including the impact of tourism in an area.

RESULTS

Description and classification of rocky shore biotopes

Only considered are those biotopes associated with intertidal and subtidal rocks since these are the most extensive habitats in the four marine regions recognised within the LSRNP and areas to the north and west of it (Fig. 1). The marine regions are distinct geographically and in terms of salinity and degree of exposure to wave and swell action: the Laguna San Rafael, a brackish-water lagoon at the head of a narrow strait (Río Témpanos) connecting it to fjords to the north; the Golfo Elefantes, fjord region immediately to north of the Laguna, characterised by increasing salinity (>15‰) and mostly

FIGURE 1. Map of region showing the main marine and geographical areas including those within and outside the boundary of the LSRNP.

moderate wave exposure; the wave-exposed Pacific coast along the Taitao Peninsula and covers the Golfo de Penas and the Golfo San Esteban in the southern part of the Park - the shores of the Taitao and Golfo de Penas are fully marine and subject to heavy oceanic swell compared to the Bahía San Quintín which is sheltered from the open sea by the Península Forelius; the fjords just to the north (including Estero Elefantes) and west of the Park (extending beyond the present boundaries), and another area of fjords in the south of the Park.

All the biotopes associated with these shores are characterised by a conspicuous biota and habitat features. Differences in the biotope at different shore levels clearly relate to a small number of key physical parameters, namely tidal exposure to air and exposure to wave action. The biological communities are structured by adaptations to stress and disturbance. However, there are a number of physical features which modify the biotopes in important ways including ice scour. At present the knowledge of the range of potential biotopes for rocky shores in southern Chile are not sufficient to justify fine divisions between biotopes. Some of the most distinctive intertidal and subtidal biotopes recognised outside the low salinity environment of the laguna area of the LSRNP are described below. The last three descriptions follow the format recommended by Connors *et al.* (1998) and used in the BioMar Biotope Viewer 2.0 (Environmental Sciences 1997).

Many of the rocky shore biotopes described below form bands and the position they occupy is described using the scheme and terminology proposed by Stephenson and Stephenson (1947, 1972) that was modified by Lewis (1964). According to Lewis, the shore can be divided into a littoral zone and an uppermost area he termed the *littoral fringe*. He defined the *littoral fringe* as that area of the shore only influenced by wave splash or spray. Sometimes this area is referred to as the 'supralittoral fringe' and the littoral fringe is confined to that part covered by spring high tides. The shore area usually influenced by all tides is the *eulittoral zone* and immediately below it lies the *sublittoral fringe*; the latter only exposed at spring low tides and often recognised by the upper limit of some convenient dominant organism(s). The *eulittoral zone* is divided into an upper subzone normally dominated by barnacles and a lower one dominated by bands of macro algae or animals. The sublittoral zone is normally subdivided into two subzones: a shallow zone usually dominated foliose macroalgae (*infralittoral subzone*) and a deeper one dominated by animals (*circalittoral* subzone).

Full biotopes descriptions

Sublittoral Zone: higher salinity (>20 °/$_{oo}$)

SLR.Mpyr Dense forests of *Macrocystis pyrifera* on moderately sheltered and largely sea urchin-free areas of infralittoral rock

Description

Dense 'forests' subtidal forests fringing the shoreline of fjords where attached on bedrock, boulders and small stones from about 0.5 down to a depth of 10 m below Chart Datum distribution pattern is governed by factors that include depth, availability of suitable substrata, water movement, salinity and grazing. In the fjords of the Chonos Archipelago and Estero Elefantes sea urchin grazing appears to be important contolling factor on steeply sloping sublittoral rocks in more wave-exposed areas. Wherever sea urchins are present in large numbers the kelp *Macrocystis* and other macroalgae (other than crustose coralline reds) are absent or sparce. Optimum development of *Macrocystis* is in tidal surge channels where its fronds frequently fouled by sea anemones. Often heavily encrusted by greyish colonies of *Membranipora*, possibly this bryozoan characterising its own biotope. Understory of poorly developed layer of crustose red coralline algae accompanied in deeper water by membranaceous algae that include *Pseudophycodrys phyllophora*, *Myriogramme livida*, *Schizymenia binderii*, and *Callophyllis* *atrosanguinea*; possibly these red algae grow on rocks outside the *Macrocystis* forest and form a 'membranaceous red algae deep water rock' biotope. Only at one site were two species of *Desmarestia* (*D. ligulata, D. patagonica*) dredged in the vicinity of the *Macrocystis* beds. In the shallow water small sporelings often accompanied by various red algae including *Sarcothalia crispata, Ahnfeltiopsis durvillaei* and *Gigartina skottsbergii. Macrocystis* provide a substratum for a diverse fauna including sea urchins, sea anemones, star fish, crabs, ophiurioids, blennies, sea squirts, isopods and the molluscs *Nacella mytilina* and *Flabellina falklandica.*

Habitat classification

Salinity: 20 ‰ to full seawater (salinities of 10 ‰ in beds of *Macrocystis* growing in tidal channel at one site).
Wave exposure: sheltered to exposed.
Zone/range: sublittoral zone/sublittoral fringe (to 10 m depth or more)
Other modifiers: type of substratum, wave exposure, sea urchin grazing (principally *Loxechinus*).

Distribution (Fig. 2)
Sites: Chonos Archipelago, Golfo and Estero Elefantes; few small shallow water plants found in Bahía San Quintín on the Pacific coast and not considered to be sufficiently developed to be regarded as forming a distinct biotope.

Sublittoral Fringe: full salinity, severe wave exposure

LR.Dant Zone of the kelp *Durvillaea antarctica* on severely exposed lower eulittoral subzone rock

Description

Large kelp (reaching 5-8 m) forming a distinctive zone on bedrocks in the lower eulittoral zone along the westerly facing shores of the Forelius Península where shores are exposed to the full impact of Pacific swells. Often associated with the base of the *Durvillaea* plants are animals also characteristic of wave-exposed shores (chitons, key-hole limpets), clumps or mats of bleached straw-coloured plants of the red algae *Gelidium lingulatum* and individual plants of *Sarcothalia crispata.* Often immediately above the *Durvillaea* is a poorly developed *Halopteris* biotope, possible the abundance of animal-grazers is responsible for the reduced cover of algae on such shores.

Habitat classification

Salinity: full seawater
Wave exposure: severe wave exposure.
Zone/range: lower eulittoral subzone
Other modifiers: slope, wave exposure, grazing pressure

Distribution (Fig. 2)

Site: single site on the Península Forelius, Pacific coast of LSRNP; probably widely distributed along the exposed side of the peninsula.

Sublittoral Fringe: full salinity, severe wave exposure

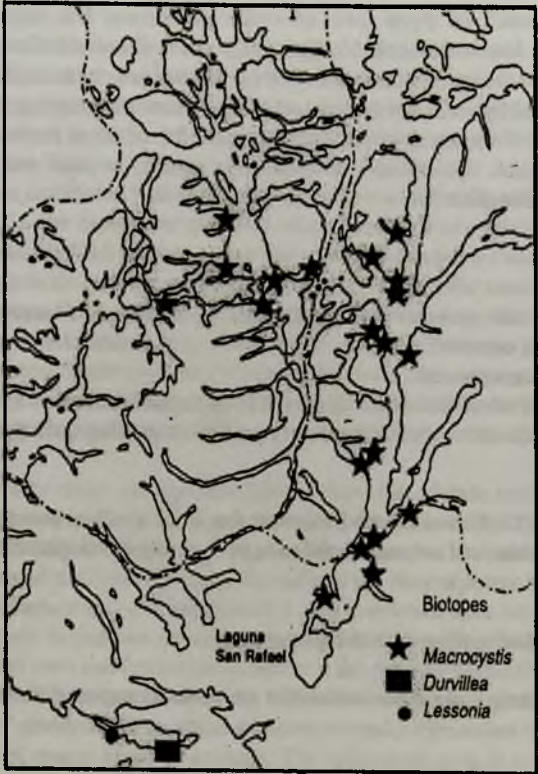


FIGURE 2. Map showing the distribution of the *Lessonia, Durvillaea* and *Macrocystis* biotopes.

LR.Lnig Patches or zone of *Lessonia nigrescens* on very wave exposed sublittoral fringe rocks

Description

Dense clumps on bedrocks on shores exposed to wave action. Often associated with the base of these clumps are many animals associated with wave-exposed shores (chitons, key-hole limpets) and pink crustose corallines are the only evident algal growths. Possibly the abundance of animal-grazers is a factor responsible for the absence of algae other than crustose corallines. Sometimes the stipe and fronds of *Lessonia* have a felty covering of an ectocarpoid brown alga.

Habitat classification

Salinity: full seawater.
Wave exposure: moderate wave exposure.
Zone/range: lower eulittoral subzone.
Other modifiers: slope, wave exposure.

Distribution (Fig. 2)

Sites: Bahía San Quintín, to date only on Alborada Island, Pacific Coast.

Summary of rocky shore biotopes

Littoral Fringe: unshaded

LR.Ptess Dark coloured patches of *Prasiola tesselata* patches on nutrient enriched littoral fringe rock

Forming dark green or blackish (especially when dry) patches consisting of the membranous thalli of the green alga *Prasiola tesselata* (=*P. stipitata*) on rocks often receiving nitrate-enrichment from sea birds or seals. Often grows in close association with black, yellow and grey lichens that form themselves a distinctive biotope often at the same position on rocky shores. Widely distributed throughout the region.

LR.LICH Crusts of grey, orange and black lichens on littoral fringe rocks

Unshaded rocks and boulders are typically encrusted with grey, orange and black lichens belonging to the genera *Caloplaca, Xanthoria, Physia* and *Verrucaria.* These lichens often extend above the littoral fringe into the supralittoral zone to disappear if the rocks are shaded or moss-dominated. Damp crevices are often occupied by amphipods, possibly these form another biotope with or separate from those associated with decaying drift algae. Widely distributed throughout the region.

Littoral Fringe: shaded

LR,WD.Riv Dark coloured patch or zone of hemispherical *Rivularia* on various shaded surfaces in the littoral fringe

Small hemispherical colonies (up to 10 mm across) of *Rivularia* sp. (a cyanobacterium) form a dense, dark blue-green or almost black zone or patches on bedrock, boulders, tree roots and stranded logs in the littoral fringe. A well defined biotope that is most extensive on damp surfaces shaded by trees and overhanging rock ledges. Sometimes present are small littorinid molluscs are confined to crevices and small fissures. Freshwater run-off results in the biotope becoming associated with the coarse, dark green mats of the *Cladophoropsis brachyarcta* biotope. Most evident along the steeply sloping rocky shores of the fjord systems and the Estero Elefantes.

LR.Cbra Dark spongy mats of *Cladophoropsis brachyarcta* on shaded littoral fringe rocks influenced by fresh-water seepage

Bedrock or boulders in the littoral fringe to about the mid eulittoral zone are sometimes covered by a dark green or almost black, coarse mats or cushions of *Cladophoropsis brachyarcta* if shaded and influenced by a steady seepage of freshwater. Absent from the Laguna San Rafael but likely to be present if local conditions are suitable.

Upper Eulittoral Zone

LR,WD.Bhar Yellowish or brownish mats of *Bostrychia harveyi* on various surfaces on upper eulittoral subzone rocks

Forming yellowish or brownish coloured mats or tufts on bedrock, stable boulders, tree roots and stranded logs at the uppermost limit of the tides. Often the band of *Bostrychia harveyi* is most conspicuous on the steeply sloping bedrock shores of the fjords. On almost vertical surfaces and/or where shaded, often accompanied by dark purplish to blackish clumps or mats of *Catenella fusiformis*. Develops over a wide range of wave-exposure, salinity and degree of shading. Widely distributed throughout the region.

LR,WD. Ramb Bright green mats cf *Rhizoclonium ambiguum* on various surfaces in the littoral fringe and upper eulittoral subzone

Bedrock, boulders, tree roots or stranded logs in the littoral fringe and upper eulittoral zone commonly have a bright green mat of the hair-like filaments of *Rhizoclonium ambiguum*. This bright green band is very evident on the roots and branches of trees overhanging the steeply sloping shores of the fjords. It is common on stranded logs and not so well developed on rocks where it is usually associated with the more dominant *Bostrychia harveyi*. Widely distributed throughout the region.

LR.Hlec *Hildenbrandia lecanellieri* on unshaded rocks in upper eulittoral subzone

Bedrock and stable boulders in the upper eulittoral sub zone are sometimes covered by a thick (often 5 mm thick), black, irregular and warty-surfaced encrustation of *Hildenbrandia lecanellieri*. Often the biotope is most evident on moderately wave-exposed bedrock lying immediately above the barnacle-dominated biotope. Often *Hildenbrandia* overlaps with the *Bostrychia* biotope lying immediately above it, or sometimes the *Iridaea tuberculosa* biotope immediately below. This biotope is normally absent rocks shaded by trees or overhangs.Widely distributed in the region but not known from the Laguna San Rafael.

LR.Apac Dark green mats of *Acrosiphonia pacifica* extending from the upper eulittoral subzone to the sublittoral zone on rocky shores in brackish water

Bedrock and stable boulders in the eulittoral zone (most common in mid to upper shore) are often covered by dark green mats of this filamentous green alga where salinity is 20 ‰ or below. Often it accompanies *Scytothamnus* and *Adenocystis*, brown macroalgae characteristic of the lower eulittoral subzone within the Laguna San Rafael. Most conspicuous where the cover of other algae is low, especially in the upper eulittoral subzone and the sublittoral zone (0-10 m). Golfo Elefantes and the Laguna San Rafael.

LR.Itub Brownish-red patches or band of *Iridaea tuberculosa* on mid to upper eulittoral subzone rocks

Brownish-red band or small patches of the red alga *Iridaea tuberculosa* on sheltered to moderately wave-exposed bedrocks and stable boulders, sometimes overlaps with the barnacle biotope below. Widely distributed throughout region except the Laguna San Rafael.

Mid Eulittoral Zone: full Salinity — moderate to severely exposure

LR.Noto Grey band of the barnacle *Notochthamalus* on moderately to severely exposed mid to upper eulittoral subzone rocks

Grey barnacle band in the mid to upper eulittoral zone of *Notochthamalus* on moderately to severely wave-exposed headlands and the open rocky shores. Frequently associated with the barnacle is *Nodilittorina araucana*. In the lowermost part of the biotope there are several other molluscs, including species of *Nacella magellanica* and *Acanthina monodon*. Replaced by a biotope dominated by the barnacle *Elminius kingii* in sheltered bays influenced by freshwater streams. Often the *Notochthamalus* is accompanied by the straw coloured or purplish membranes of *Porphyra*, a red algal biotope found at different shore levels (upper-lower eulittoral subzone). Widely distributed throughout region except the Laguna San Rafael.

Mid-Eulittoral Zone: reduced salinity — sheltered to moderately sheltered

LR. Ekin Grey band of the barnacle *Elminius kingii* on mid to upper eulittoral subzone rocks influenced by fresh-water

Distinctive grey band due to a dense cover of the barnacle *Elminius kingii* on bedrock and boulders in sheltered bays influenced by freshwater discharge, or in more wave-exposed habitats where salinity is below 20 °/$_{oo}$. Frequently associated with it are various molluscs including *Nodilittorina araucana, Siphonaria lessonii* and *Nacella magellanica.* Sometimes where streams flow onto the shore it is closely associated with green algal dominated biotopes, the *Enteromorpha-Ulva* biotope or the *Enteromorpha ramulosa* biotope.

Lower Eulittoral Zone: full salinity - sheltered

LR.Maz,Noth Brownish or straw-coloured patches or band of *Mazzaella* and *Nothogenia* on sheltered to moderately exposed mid to lower eulittoral subzone rocks

Somewhat brownish or straw coloured *Mazzaella laminarioides* and *Nothogenia fastigata* on bedrock and boulder shores in sheltered to moderately wave-exposed bays and inlets. These fleshy red algae are accompanied by several brown algae that include *Scytothamnus fasciculatus, Adenocystis utricularis, Scytosiphon lomentaria, Halopteris* sp., and other red algae (e.g. *Ahnfeltiopsis durvillaei, Ahnfeltiopsis furcellatus, Ahnfeltia plicata*). Commonly associated with these algae is a diverse assemblage of molluscs, including *Fissurella, Chiton, Tegula, Plaxiphora, Tonicia* and *Nacella.*

Lower Eulittoral Zone: full salinity - sheltered to moderate exposure

LR.Medu Black patches or band of the mussel *Mytilus edulis* on moderately wave-exposed mid to lower eulittoral subzone rock

Black band of the mussel *Notochthamalus* on sheltered to moderate wave-exposed bedrock shores outside the confines of bays and inlets and occupying the mid to lower part of the eulittoral zone. Les immediately below the although on rare occasions the barnacles extend to below the mussels. Sometimes another mussel *Perumytilus purpuratus* occurs in quantity in the upper part of the band. Other associated molluscs include the whelk *Argobuccinum pustulosum ranelliforme* and species of *Acanthina monodon, Nacella magellanica* and *Tegula atra.* Commonly growing on the mussels are the straw coloured or purplish membrane like fronds of *Porphyra,* a red alga. Not discovered in the Golfo Elefantes or the Laguna San Rafael.

Sublittoral Fringe

LR.Gel,Ahn Dark purplish or blackish turf dominated by *Gelidium* and *Ahnfeltia* on sheltered to moderately exposed lower eulittoral subzone and sublittoral fringe rocks

Dark purplish to blackish turf of red algae, principally dominated by *Ahnfeltia plicata* and *Gelidium chilensis,* develops on sheltered bedrock and boulders in the lower eulittoral zone and sublittoral fringe. Sometimes shows greatest development close to freshwater inflows and therefore tolerant of varying salinity regimes. Occasionally extending into the sublittoral fringe and gives way at about 0.5 m to encrusting coralline algae and small *Macrocystis pyrifera* plants. Other algae associated with the turf include *Griffithsia antarctica, Polysiphonia* sp., *Heterosiphonia berkeleyi, Corallina officinalis* var. *chilensis, Laurencia chilensis* and *Halopteris* sp. Only known from the Estero Elefantes and fjords to the north.

SL.Scri Dark red fleshy fronds of *Sarcothalia crispata* in the sublittoral fringe on sheltered and moderately exposed rocks

Flattened, somewhat fleshy fronds of *Sarcothalia crispata* grow in quantity on sheltered to moderately exposed bedrock and boulders within bays and inlets. In very sheltered bays these sometimes are associated with the algal turf dominated by *Gelidium* and *Ahnfeltia.* Often replaced by *Macrocystis pyrifera* representing the beginning of yet another distinctive biotope. Often associated with encrusting coralline algae ("lithothamnia") and other common lower eulittoral zone algae (e.g., *Nothogenia fastigiata, Ceramium* sp, *Polysiphonia* sp., *Adenocystis utricularis*). Yet other algae only occur subtidally, these include *Griffithsia antarctica, Callophyllis atrosanguinea* and *Gigartina skottsbergii*. Sometimes there present small sea urchins, crabs, and a range of other animals many of which many have a subtidal distribution. Absent in the Golfo Elefantes and the Laguna San Rafael.

LR.Aust Grey patches of the large barnacle *Austromegabalanus* on moderately to severely wave exposed lower eulittoral zone rocks

Small patches of the barnacle *Austromegabalanus* sp on severely wave-exposed bedrock in the lower eulittoral zone. Often on vertical cliff areas and lies immediately above the sea urchin and crustose red algal biotope. Immediately above lies a bare algal zone characterized by grazing animals (the *Nacella-Tegula-Chiton* biotope). Occasionally accompanied by clumps of *Aulacomya ater*, the latter possibly forming a separate biotope. Not detected in the more wave-sheltered confines of the Golfo Elefantes and Laguna San Rafael.

DISCUSSION

Setting conservation priorities

The still relatively pristine LSRNP and its environs covers a vast area with not all of its sites and marine sectors having the same conservation status. To effectively target resources requires setting priorities by using existing knowledge that includes species diversity patterns within the context of habitats and the biotopes contained therein. Species inventory data can be used to assess the conservation status of marine sites along with diversity and relative quality of the biotopes present. Species and biotope information can be used for assessing the nature conservation importance of large scale features including estuaries or sections of coast. The following criteria are commonly used for priority –setting and conservation appraisal of sites and coastal sectors: typicalness – how well it corresponds in having the main characteristic of habitats and biotopes; diversity – numbers of species (includes numbers of endemics), habitats and biotopes; rarity – uniqueness of species, habitat types and biotopes; naturalness – degree to which uninfluenced by human activities. Other criteria include fragility, size or extent, representativeness, recorded history, position in an ecology/geographical unit, potential value, intrinsic appeal.

CONCLUDING REMARKS

Any organization charged with preserving, managing and sustainably using the wildlife resource of an area needs to know the identity and geographical distribution of the fauna and flora present within its boundaries. Inventories or audits of the species are important not only in enabling scientifically sound options to be selected when managing the area, but are required for monitoring change and sometimes for providing sustainable economic use. It is our belief that conservation efforts should not be focused on a few highly visible species with emotive connotations, but rather the overriding concern should be to maintain ecosystem processes by safeguarding biodiversity based on the precautionary principle of "where there is doubt then protect". The biotope approach is one that focuses on assemblages rather than on its individual components. It has been implemented successfully in the LSRNP and its environs where a number of distinct biotopes have been recognised. These currently defined biotopes require testing before mapping and placed within a hierarchial classification. Nonetheless, sufficient biotope information exists for them to be considered when making management and conservation decisions concerning seashore and seabed habitats in the area of southern Chile surveyed.

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