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Time-space characterization of commercial seaweed species from the Gulf of California using a geographical information system

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Abstract

The Gulf of California, considered one of the most pristine areas of the world, hosts more than 50 seaweed species that have commercial applications. Only one species, however, is presently harvested commercially. In order to establish potential areas for seaweed use, a Geographical Information System (GIS) was used to determine areas for potential seaweed exploitation based on more than 9000 literature records. The system allows for the determination of sites, areas and times of the year when commercial species may be available. This information is being considered in a zoning program that would determine the areas of the Gulf sustainable for use or conservation. Temperature data were also included in order to determine potential areas for seaweed cultivation. GIS proves to be a powerful tool for large-scale management of seaweed resources.

Introduction

The Gulf of California, the youngest sea on Earth, is considered one of the most productive and pristine marine areas of the world (Alvarez-Borrego, 1983). It is responsible for 50% of the fisheries production in Mexico and 90% of the cultivated shrimp. It consists of a semi-enclosed basin of rectangular shape, approximately 1500 km long and 150 km wide, on average, with a mouth in the south connected to the Central Eastern Pacific. It covers an area of 260,000 km^2, comparable to the Red Sea, and encloses more than 900 islands and islets with many marine endemic species.

The Gulf of California is rich in all kinds of marine species including seaweeds. This has motivated many efforts by non-governmental organizations and government agencies to promote areas of the Gulf for conservation. At the same time, however, because it is one of the less developed areas in Mexico, the Gulf is currently being considered for many large-scale development projects including the construction of marinas, hotels and aquaculture farms.

The Gulf has also been recognized for its rich seaweed flora (Dawson, 1944; Norris, 1975). Of the 580 species mentioned by Espinoza-Avalos (1993) as reported for the Gulf, Pacheco-Ruíz and Zertuche-González (1996) have recognized at least 55 species that could have commercial applications, but only one is presently exploited (Pacheco Ruíz et al., 2003). Nevertheless, in the last decade, several of these species have been found to exist in sufficient amounts to be harvested commercially (Barilotti and Zertuche-González, 1990; Casas-Valdez et al., 1993; Hernández-Carmona et al., 1990; Pacheco-Ruíz & Zertuche-González, 1999; Pacheco-Ruíz et al., 1998, 2002).

The information currently available indicates that the Gulf of California may be an important source of commercial seaweed. This information, however, is not sufficient to define priority areas, their location and extent, which could be earmarked for seaweed harvesting or cultivation, nor the potential conflict with zones considered for conservation. A survey to determine the distribution of commercial species and the feasibility for exploitation in terms of abundance in space and

time would be costly and lengthy for an area the size of the Gulf of California.

In this study, we use a Geographical Information System (GIS) to characterize the Gulf of California in terms of the commercially valuable species reported in the literature. We test the possibility of defining areas of importance for commercial seaweeds by providing geographic references to all species reported in the literature and plotting the records on a map with the help of GIS. The records were superposed on a map of surface water temperature in order to define oceanographic regions of importance. Special attention was giving to those commercial species for which abundance data are reported in the literature.

With this study we expect to provide an inexpensive alternative for characterizing areas of importance for seaweed exploitation or cultivation, as well as to identify areas or species that require more studies, particularly in broad-scale regions. To our knowledge, this is the first study considering the use of GIS on the characterization of seaweed resources on broad areas.

Materials and methods

The extent of the Gulf of California varies depending on the criteria used to define its southern limit (Alvarez-Borrego, 1983). For the purpose of this work, the southern limit is established at 23°N latitude, which coincides with the southern end of the peninsula on the west coast and the southern limit of the state of Sonora on the east coast. Thus, four states border the Gulf of California: Baja California and Baja California Sur on the west coast, and Sonora and Sinaloa on the east coast (Figure1).

From a data base containing 9481 records of seaweeds reported for the Gulf of California from 1911 to 2003 (58 papers), the information relating to 55 species regarded as commercially valuable by Pacheco-Ruíz & Zertuche-González (1996), was displayed on a map to characterize their distribution within the Gulf in time and space. From these species, we selected those for which biomass studies were available to be analyzed in terms of the geographical and seasonal presence. The information was displayed and analyzed using Arcview 3.2a GIS. The data base considers only records published in refereed journals. Herbarium records, varieties, or species reported as doubtful were not included. Taxonomic and geographic attributes were considered. Seasonality was included

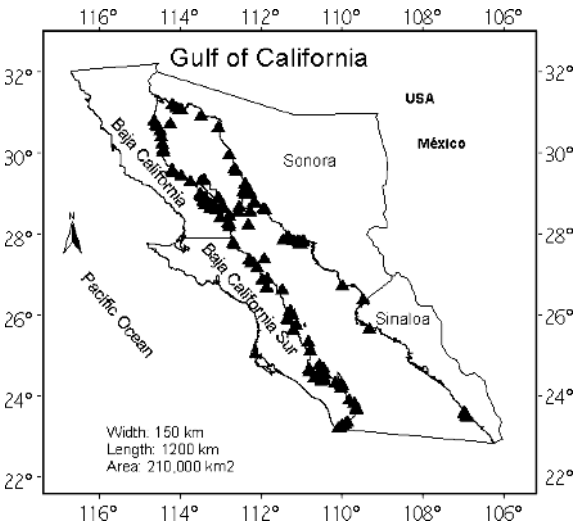

Figure 1. Sites with commercially valuable seaweed species reported from the Gulf of California.

when reported or when it was possible to deduce it from the manuscript. Most papers did not include geographic references. Therefore, based on the name of the localities, geographic coordinates were obtained from maps of the Mexican National Institute of Statistics, Geography and Informatics – INEGI – (Instituto Nacional de Estadística, Geografia e Informática). Records were grouped into "sites" when they were near an officially recognized map location. For instance, all records for a specific Bay or Point were grouped together.

Monthly mean surface temperatures were obtained from the PROMETEO data base (WWF, Program Mexico 2001). Seasonal temperature maps were derived from the average of three months. Data from January to March were used for winter, from April to June for spring, from July to September for summer and from October to December for fall. Site records for selected commercial species were superimposed on the temperature maps to determine their seasonal geographical distribution.

Results

Of the 160 sites recognized in the data base, 137 included commercially valuable seaweeds; commercial species occur throughout the Gulf of California, except for the southern east coast (state of Sinaloa), where the lack of studies was made evident by the low number of records (Figure 1).