

1.1 The CIMAR Program in the austral Chilean channels and fjords

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The austral Chilean channel and fjord region is one of the vastest estuarine expanses on our planet. Although only slightly more than 1,000 km in a straight line, it has around 84,000 km of coastline when considering all the contours of its multiple islands and peninsulas. In other words, the coast of the Chilean fjord and channel region is more than 20 times the length of the country's continental coastline. In spite of the size of this region, until 1993, oceanographic information on the area was very scarce, with less than 20 scientific works for the entire area.

Intense use of this area began in the 1980s with activities related to aquaculture, fisheries, tourism, and human settlements. At the same time, harmful algal blooms were becoming ever more frequent and were recorded progressively northward from the Strait of Magellan, where they were first observed in 1972. Moreover, industrial, mining, and forestry projects were undertaken that involved the hydrographic micro-basins in the area. Thus, multidisciplinary oceanographic studies covering a wide geographic area needed to be carried out rapidly.

Studies of the pristine conditions in most of the austral Chilean channels and fjords do not exist, resulting in an urgent need for baseline information and the identification of the oceanographic and biogeochemical processes that affect the area. Such data would provide the corresponding authorities and industries with an integrated perspective on the local environmental elements, thereby allowing their inclusion in future management measures to be taken in the estuarine area. These clearly have implications for socioeconomic development.

Although the pertinent governmental authorities required prior environmental impact studies for granting marine aquaculture concessions, those studies were too localized and specific, and did not allow a global vision of the impact that the proposed activities could generate in the extensive area of interior waters.

The scant information published for this vast region, until 1993, came mainly from foreign and some national oceanographic expeditions. Expeditions in the northern channel and fjord zone (Fig. 1), from Puerto Montt to Laguna San Rafael, included: a) the Lund University-Chile cruise (September 1948 to July 1949) by Swedish researchers (Brattström & Dahl, 1951), b) the R/V Itzumi (March 1982) by Japanese and Chilean researchers (Vargas, 1983), and c) the Aysén I and II (September-October 1991, January 1992) by researchers from Universidad de Valparaíso (Sievers & Prado, 1994).

In the central channel and fjord zone, from Golfo de Penas to Estrecho de Magallanes, researchers from the Universidad de Concepción participated in the R/V Hero 72-4 expedition in September 1972 (Chuecas & Ahumada, 1980).

Cruises in the southern channel and fjord zone, from Strait of Magellan to Cape Horn, were also made, including: a) OGS Explora (October-November 1989) (Brambati, 1991), b) R/V Cariboo (February-March 1991) (Faranda & Guglielmo, 1991), and c) R/V Itálica (summer 1995) (Faranda *et al.*, 1996), all three by Italian researchers; d) R/V Víctor Hensen (November 1994) by German researchers (Arntz & Gorny, 1996); and e) R/V Polar Duke (July and August 1993) by North American researchers (Rojas, 1993).

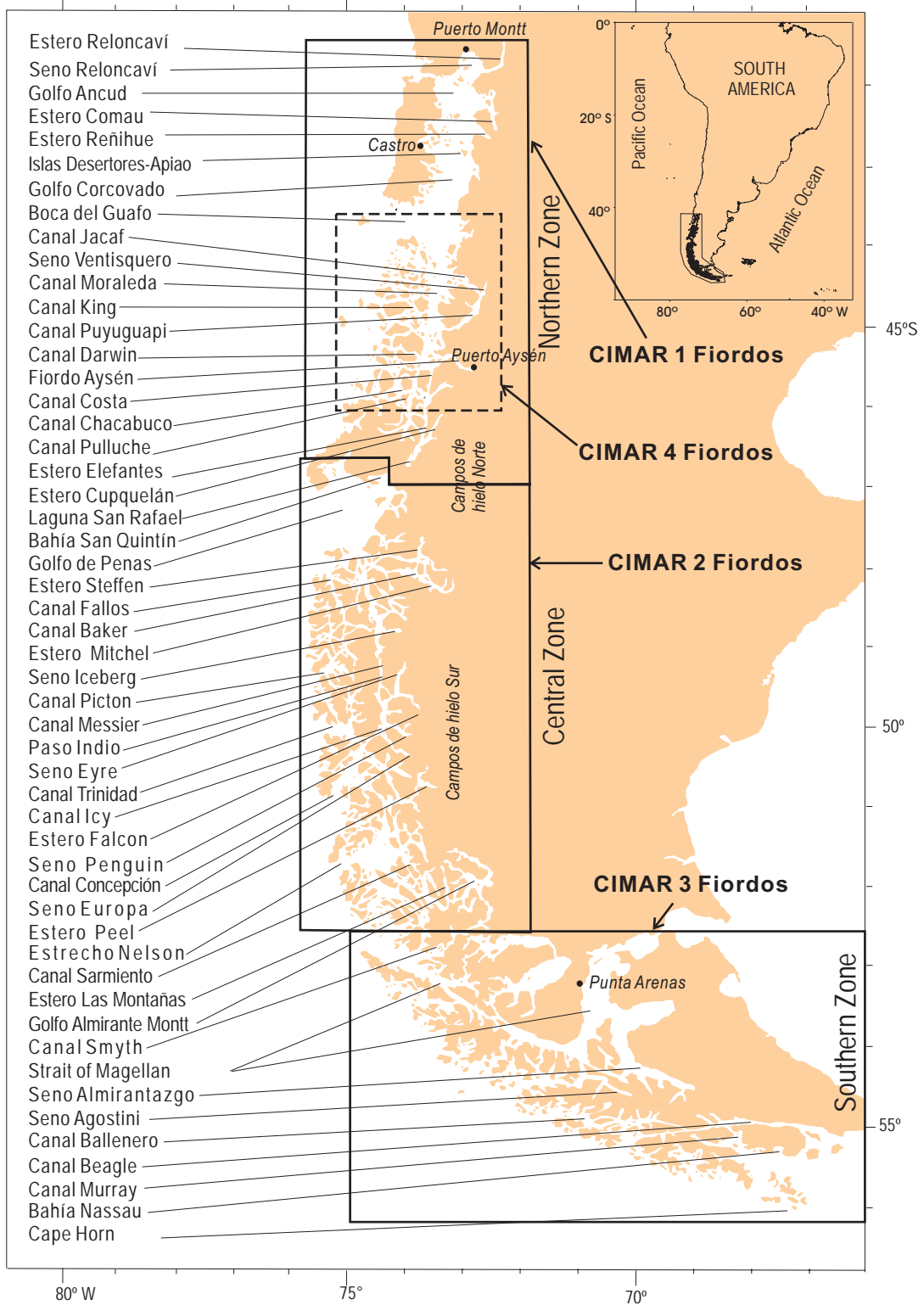


Figure 1: Geographic location of the oceanographic zones sampled during the CIMAR Program cruises 1 to 4, in the austral Chilean channels and fjords (adapted from Silva & Prego, 2000).

Two other major expeditions were also carried out: a) Hudson-Chile 70 (February-March 1970) by Canadian researchers and with the participation of Chilean scientists, covering the northern, central, and southern channel and fjord zones (Pickard, 1971) and b) R/V Itzumi (1993) by the Instituto de Fomento Pesquero de Chile (Chilean Institute for Fisheries Development), covering the central and southern zones.

In 1994, the scarcity of oceanographic information led the Comité Oceanográfico Nacional (CONA; National Oceanographic Committee) to prepare a Research Program for the oceanographic study of the austral channels and fjords located in Chile from Puerto Montt (42°S) to Cabo de Hornos (56°S).

The objective of this Program is “to perform a multidisciplinary study of the oceanography, meteorology, marine biodiversity, and underwater morphology in remote geographic areas, where information on the marine environment has a strong influence on the sustainable socio-economic development of the local communities and the country”. This Program was named CIMAR (Cruceros de Investigación Marina en Áreas Remotas; Marine Research Cruises in Remote Areas).

Due to the area's extension, the program began its studies with three exploratory cruises in the different oceanographic zones (CIMAR 1 to 3 Fjordos) (Fig. 1). Later, this information was used to plan seven more cruises (CIMAR 4 and CIMAR 7 to 12 Fjordos), that would study the relevant oceanographic processes, verify possible environmental changes, and continue to obtain information to fill the data base.

The CIMAR 1 Fjordos Cruise was carried out between 18 October and 15 November 1995, covering a total of 100 oceanographic stations in the northern zone (Fig. 2). The Cruise CIMAR 2 Fjordos took place between 14 October and 9 November 1996, covering 95 oceanographic stations in the central zone (Fig. 2). The Cruise CIMAR 3 Fjordos was done in two phases: 6 to 18 October 1997 and 9 to 23 October 1998. This cruise covered the southern zone, with a total of 104 oceanographic stations including both the two phases (Fig. 2).

During these cruises, samples were taken and records made of: a) the physical characteristics of the water column (temperature, salinity, light penetration, currents, tides), b) the physical characteristics of the sediments (grain size, porosity), c) the bathymetry of the sea floor, d) the chemical characteristics of the water column (dissolved oxygen, pH, alkalinity, nutrients, heavy metals), e) the chemical characteristics of the sediments (carbon, nitrogen, phosphorus, trace metals), f) the chemical pollutants (pesticides, chlorinated hydrocarbons), g) plankton (phytoplankton, chlorophyll-a, zooplankton, red tide, fish and crustacean eggs and larvae), h) coastal fish, and i) benthic organisms (foraminifera, crustaceans, mollusks).

With the execution of the CIMAR 1 to 3 Fjordos cruises, the first exploratory phase of the study was considered to be completed. During this phase, the first comprehensive data base of the main fjords, channels, estuaries, straits, gulfs, passages, and sounds in Chile's austral sector was compiled. Moreover, geographic areas of scientific interest and economic projection were identified along with the areas that are more vulnerable to the effects of anthropic activities.

The information acquired through the above exploratory cruises was processed and a new cruise, CIMAR 4 Fjordos, was proposed. This expedition focused on the study of the currents, water residence times, and budgets for salt, carbon, and nutrients in Fiordo Aysén and some adjacent channels (Figs. 1 and 2), while also continuing to gather information that would complement the oceanographic data base for the area. During this cruise, records were made and samples taken for: a) the physical characteristics of the water column (temperature, salinity, light penetration, currents, tides), b) the physical characteristics of the sediments (grain size, porosity), c) the chemical characteristics of the water column (dissolved oxygen, nutrients), d) the chemical characteristics of the sediments (carbon, nitrogen, trace metal, reduced metals, stable isotopes, organic components), and e) plankton (phytoplankton, chlorophyll-a, zooplankton, red tide). Furthermore, radioactive isotopes (^{210}Pb) were measured and used to estimate sedimentation rates.

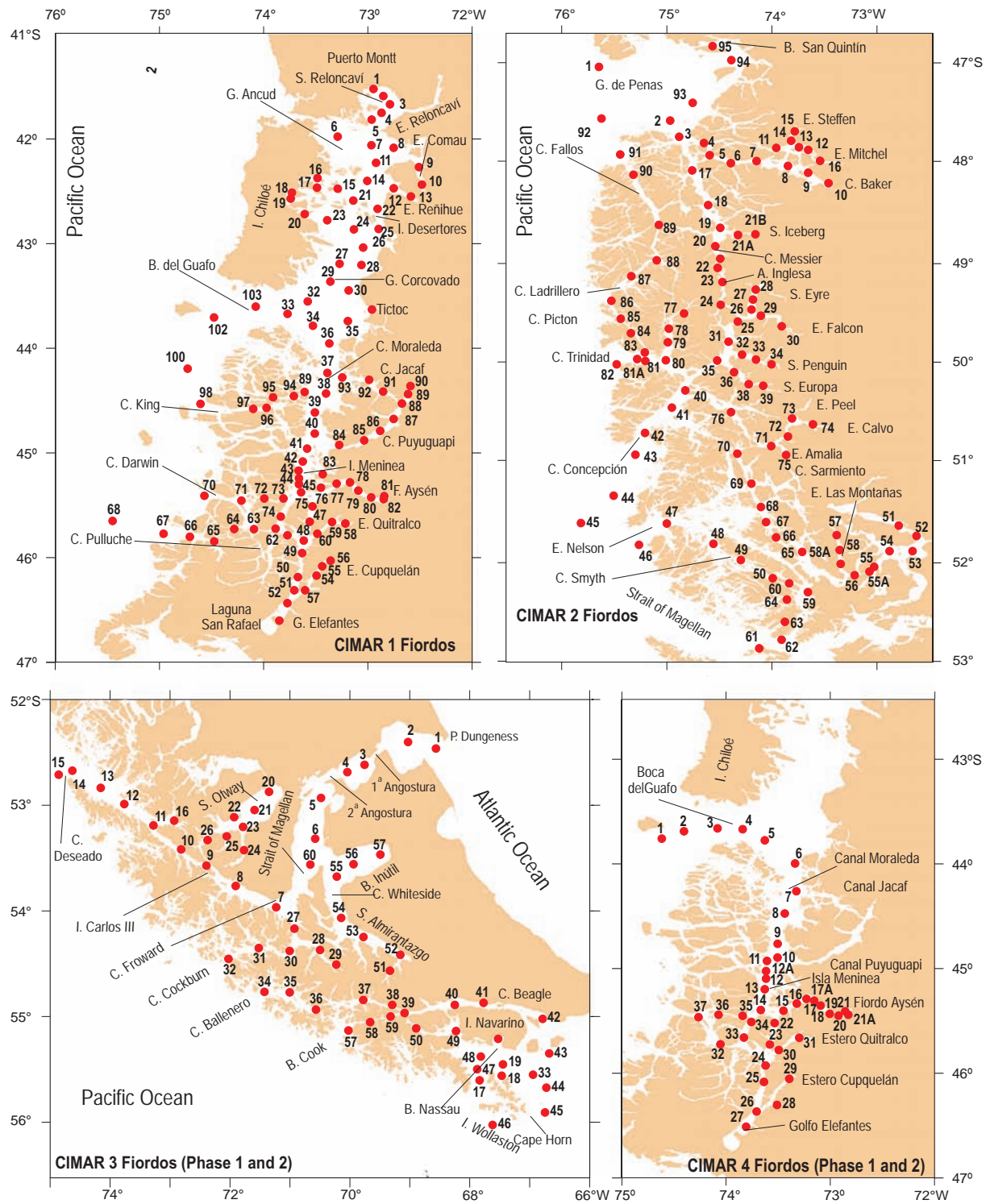


Figure 2: Geographic position of the oceanographic stations sampled during CIMAR 1 to 4 Fjordos cruises.

Given the need to broaden the data base with information from different seasons of the year, the CIMAR 4 Fiordos Cruise was carried out in two phases: spring (26 September to 8 October 1998), with 38 oceanographic stations, and summer (25 February to 8 March 1999), with 37 oceanographic stations (Fig. 2).

The scientific production generated for the austral fjord and channel region with the results of the first four cruises was prodigious, practically tripling the information available by 1993. These results, including information from the different projects carried out during all four cruises, were made available in the form of publications, presentations at congresses and workshops, as well as undergraduate and graduate theses. All told, these include:

- 74 publications in national journals.
- 8 publications in international journals.
- 90 presentations at national congresses.
- 13 presentations at international congresses
- 78 presentations CIMAR workshops.
- 17 undergraduate theses.
- 4 graduate theses.

Chapter 9 of this book includes the bibliographic references for the scientific production generated with the information from CIMAR 1 to 4 Fiordos expeditions. Moreover, four compact discs were prepared with the respective Data Reports from these cruises, constituting the first oceanographic data base for the austral Chilean channel and fjord region. This information and the bibliographic index of all the publications generated are available on the web page <http://www.shoa.cl/cendhoc/index.htm>, which is constantly updated.

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