Integrated Coastal Zone Management for the Gulf of Ancud & Corcovado and its adjacent Fjords

1. General Information

Project title	**Bio-Monitoring and Law Compliance in the Fjords of Puyuhuapi and Ventisquero, XI.Region, Chile - Phase I**
Partner	**Fundación Pumalin**
Reporting period	**January 2007 – December 2008**

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2. Background

This project formed the main emphasis of the Marine Conservation Program of the Pumalin Foundation and was dedicated to improve the knowledge on the marine ecology of selected Patagonian fjords on the one hand, and to monitor the ongoing processes of aquaculture installations and the compliance of the environmental regulations by fish farms on the other hand. The mayor goals of the Marine Conservation Program are protection, preservation, and conservation of the marine biodiversity and ecosystems of the coastal waters along the southern Pacific coast, including the promotion and establishment of MPAs (Marine Protected Areas) and restriction and reformation of the salmon industry, and finally supporting any activity of future sustainable coastal management. Main project areas of this project are located in the channels and fjords around Magdalena Island (XI. Region, Chile) as well as in the Comau and Reñihue Fjords adjacent to the Pumalin Park (X. Region). The waters of Magdalena Island are diversified by extended inlets, a labyrinth of channels and numerous small islands, forming a tremendous number of habitats, which result in high overall benthic species diversity. So far, only part of the land mass of Magdalena Island is assigned as a protected area, but excluding the entire marine environment of the coast line in front of it.

Industrial aquaculture and salmon farming in particular has been singled out as major threat and having the most important ecological impacts in the Puyuhuapi and Jacaf channels and the Ventisquero and Magdalena fjords, since about 200 concessions for fish farming have been assigned by the government around the island during the past two decades. Only one third of these concessions had been used for salmon farming until 2007, but with increasing problems of the salmon industry by diseases especially in the Xth Region, more and more farms were activated during the past year around Magdalena Island (with still increasing activities during the implementation of this project).

As in other regions, none of the governmental institutions manage a detailed public data base about the geographic locations of the concessions, the allowed production limits and actual numbers of operating fish farms. Against the background of poor ecological knowledge on the marine ecosystem and the lack of official information about the presence of fish farms, the major objectives of this project were to generate an accurate data base of all present salmon farms in the project area and to verify the production of the operating farms, measured as the existing number of fish cages. The most important part of the biomonitoring component was to improve the general knowledge on marine biodiversity (of the bottom living fauna, “benthos”) and to verify and document any impact of fish farming on the marine ecosystem, in particular the bottom fauna.

3. Project objectives

As part of the Marine Conservation Program and in order to contribute to the advances of an integrated coastal zone management of the Patagonian fjords, major goals of this project were a) environmental bio-monitoring, b) law compliance and c) environmental communication. The activities were focused on three different sectors (channels) surrounding Magdalena Island, the Puyuhuapi and Jacaf channels and the adjacent Magdalena and Ventisquero estuaries.

- Since the entire area comprises over hundred square kilometers, the biomonitoring was concentrated on selected sectors of intensive fish farming on the one hand and on possible hotspots of biodiversity and wildlife on the other hand. All field observations were collected into a data base and geo-referenced to allow a general characterization of the entire area, with simple classifications of the natural conditions and wildlife, human activities and environmental impacts within each sector.
- To round up the bio-monitoring, the control of law compliance was essential, preventing the area from incorrect appliance of environmental laws or illegal activities, such as illegal hunting, poisoning and waste dumping. Whether areas classified for aquaculture (AAA) were assigned correctly, never had been proved so far, and this may be a significant milestone in law compliance and finally to contribute to the protection of the marine ecosystems of the Patagonian fjords.
- Finally, the success of the project can´t be achieved without any participation and integration of the local community and by continuous contact and exchange of data and ideas with local stakeholders and partner organizations.

4. Activities

The XI. Region is a remote area, poorly populated, accessible directly from the north only by plane or by sea and unpredictable climate conditions restrict field activities generally to the spring – summer period. The execution of any biomonitoring in the Patagonian fjords requires an adequate infrastructure, especially a well equipped boat for all operations on sea, and good logistics to organize and execute the field trips on land. Logistic support was supplied by the Pumalin Foundation and ECOMAR Consultancy, which was contracted to carry out the biomonitoring and underwater robot operations. Puerto Cisnes was chosen as the most secure and centrally located port in the area to host the boat and to start the field trips.

First activities at the beginning of 2007 were dedicated to acquire the necessary infrastructure, as the boat and its accessories, software and the implementation of a GIS based data base of farm concessions and to elaborate maps, since no digital marine maps of the project area existed. Than intensive field work started during the second half of 2007, to verify the locations of operating fish farms and to get a first impression on the marine ecosystem, focusing on the distribution and presence of sea mammals and birds and also to evaluate the geomorphology of the coast line to prepare the biomonitoring of the bottom fauna (benthos). The field activities were significantly improved, when the Pumalin Foundation acquired a remotely operated vehicle (ROV) at the mid of 2007. This equipment and the boat were tested first on the Llanquihue Lake. After a period of additional technical improvements and necessary adaptations, the boat was shipped to Puerto Cisnes in the second half of 2007 and the ROV followed during January 2008.

Software for all GIS work, a GPS antenna device and also a GPS / Echo-sounder for the boat were acquired at the beginning of the project and completed by some software tools, paper maps and accessories for the work on sea throughout 2007. As mentioned before the adoption of the boat, which finally was baptized during a small celebration in Puerto Varas as “Melimoyu”, took several months, but finally the “Melimoyu” was equipped with wooden bunks and stores to keep the working tools, all obligatory live saving equipment and a desk was installed to allow a perfect operation of the ROV. Nowadays the “Melimoyu” is a fully equipment small scientific boat or cutter.

Occasional farm inspections (verification of positions and counting of cages) were initiated during March 2007, also monitoring of law compliance by fish farms in the project area. The first intensive period to check the exact geographic positions of fish farms and to count the cages lasted from August to December 2007, with trips of one to two weeks per each month. All biomonitoring by means of underwater video with the ROV was executed from January to June 2008.

Work on the GIS based data base of farm concessions and generating of maps started during March 2007 and is continued up to now, subsequently aggregating and actualizing the positions of fish farms, the results from field observations (including notes provided by fishermen and/or other NGOs) and any other information available on fish farming and illegal behaviors of fish farmers in the area. A detailed analysis of the benthos by means of underwater videos was started during May and is still ongoing; however a first revision and preliminary results of the videos were obtained after each field trip.

Some additional activities were carried out to support the Marine Conservation Program of the Pumalin Foundation. Technical assistance was given to the Huinay Foundation, first in December 2007 to provide the ROV for a review of the benthos and fish farm impact in the Comau Fjord (X. Region) and later providing the “Melimoyu” to the same NGO, to execute a diving trip around Magdalena Island (January 2008), which was helpful to complete the general observations on the marine ecosystem. Finally, at the end of April 2008 the project work was documented on location in Puerto Cisnes by journalists from the German TV (ARD), as part of a documental about the impact of salmon farming in Chile.

5. Results

5.1 Infrastructure

A detailed technical description of the cutter “Melimoyu” itself was already presented in the first half year report (2007). Additionally, a small rubber boat with it’s on out board engine was acquired at the end of 2007, as well as a trailer, to keep the cutter on land during winter time and to facilitate maintenance since the community administration of Puerto Cisnes provides their yard to keep the boat on a safe place. A special desk was mounted in the rear part of the cabin to allow an adequate operation of the ROV during hours and the installation of a small kitchen finally makes field trips much more comfortable.

The remotely operated vehicle (ROV) was used without any mayor technical problems. Maintenance of the equipment was made by the consultant each time the ROV was used and the ROV is kept in Puerto Cisnes in the office of Mr. Farias, the boat captain. Occasional necessary adjustments of the main electronic device were fixed on location by the consultant (since the electronic is based on digital signal processing, like a computer, the electronic sometimes has to be reseted, opening the device and realizing the reset in a certain procedure).

5.2 GIS Data base, digital mapping and video analyses

All GIS mapping and data base management was executed using the ARC GIS 9.2 software package. Additional software tools allowed online navigation using the generated digital maps, especially to make sure to stay outside the limits of farm concessions. Other software was used to adapt or transfer different datum formats of digital maps, which is important for exact geo-referencing. During the entire project period numerous digital marine maps were generated, first of all of the project main areas, but also of other locations, as part of the support for the Marine Conservation Program and other NGOs.

To operate the ROV and to allow online observation of the underwater video camera as well as to store the video sequences, professional video equipment (analog-digital converter) and software was used and video analyses and production of video clips was done with the SONY VEGAS software.

The data base of farm concessions, field observations and biomonitoring was designed with the AGILENT VEE programming software. This data base was subsequently completed and improved and contains actually data of about farm 450 concessions, comprising the project main areas, but also part of the adjacent counties of the XI. Region. Direct access from the data base to important photographs of the biomonitoring is possible as well as access to environmental declarations of fish farms and all geographic data can be transferred directly to the Google Earth server, which is a simple but efficient tool to visualize any information on a map.

5.3 Presence of the Salmon Industry in the project area

A total of 42 fish farms is actually operating in the main project areas (representing about 20% of the 232 farms operating in the entire XI.Region), but the total number of all assigned concessions around Magdalena Island is 128. Actually (2008) at least 5 of these concessions are under revision of the governmental institutions to start fish farming in the nearest future. On the other hand, most farms are claiming to raise their production from some several hundreds of tons per year to over 2000 tons. Mean surface size of most farms is 10 hectares, but the biggest dimension has a farm operated by the company “Aguas Claras” in the Estero Pangal (about 50 hectares). The fish farms around Magdalena Island belong to 17 different big companies, to some few private owners and to a few investment companies. “Los Fiordos“ and “Salmones Pacifico Sur” own most of the farms. According to the data obtained from the Chilean Fisheries Board SUBPESCA and other published documents, most of the concessions, which still are not used for farming, belong to private owners. As seen from the documents and confirmed by locals, these private persons act only officially as the owner, whereas later the farm is operated by one of the big enterprises of the salmon business.

Nearly all concessions reveal problems with their geographic positions. One may accept that many farm limits around Magdalena Island where fixed years ago, when global positioning was less accurate and referencing of geographic positions with differential GPS was a nearly unknown method in Chile. However, the authorities still tolerate these problems and accept differences of about 500 meters between the officially assigned

positions and the positions of the installations. Throughout the execution of the project it was noted that several supervising institutions such as the CONAMA (the Environmental Department of the Chilean Government) have no data base on fish farms and they do not even know the correct locations of the operating fish farms in their region.

Puerto Cisnes turned out to become one of the central ports in the region to supply the fish farms with feed and with services, especially for net changing and cleaning. About 10 vessels of diving companies and suppliers are operating permanently from this port and net washing for most of the farms is done a couple of kilometers outside of Puerto Cisnes (with all environmental problems and health problems for the workers involved in this business). Since most of all supply of the service companies and fish farms itself is done by ship from Chiloe or Puerto Montt, marine traffic increased also drastically and major water way is the Jacaf channel, since this channel allows passages even under worth climate conditions, compared to the Puyuhuapi channel.

Finally it went out that fish farming around Magdalena Island still is an increasing business, with all consequences for the marine ecosystem. Although diseases such as virus infections (ISA) already affect the region, the companies try to raise the production to recompense their financial losses, especially generated by the farms in the X. region. Increasing of production in the XI. Region is still favored by the weak governmental control. However, at the end of 2007 a special department of ecological crime investigation of the Chilean Police of Investigation started activities in Puerto Aisen. As outlined below (5.5) participants of the project were interviewed recently to confirm some of the results of the biomonitoring on illegal waste dumping in the Jacaf channel.

5.4 Biological Environmental Monitoring

According to the mayor goals and objectives, the environmental monitoring included to verify the positioning of fish farms and to count the number of installed fish cages. Apart from some few farms operated in the Moraleda channel (eastern part of Magdalena Island) nearly all existing farms were visited between 2007 and 2008. Accepting the “officially tolerated” differences of about 500 meters, all farms where found to be “inside” the assigned positions and the legal minimum distances between the farms are also respected (3 sea miles between each farm). On the other hand in some locations, fish farmers take advantage that the presence of a so called “geographic accident” (peninsula, cap or even a small land tip) allows to place legally one farm beside the other, although this from an

ecological point of view makes absolutely no sense and increases dramatically the ecological impact in a particular spot.

The number of fish cages varies between the farms. Most farms count with 12 to 20 rectangular cages, but some farms are already using the bigger modern circular cages. It turned out to be difficult to proof by means of counting the cages whether farmers comply with allowed production limits. Most of the concessions around Magdalena Island were assigned before 1995, and thus there is no obligation to publish the production data. The platform to verify data on production and compliance with environmental obligations is the system of “E-SEIA”, a governmental web page, where all environmental declarations and studies (DIA/EIA) can be accessed. However, farms assigned prior to 1995 are excluded to publish this information.

The biological part of the biomonitoring was focused on observations of the bottom living fauna (benthos) by means of underwater video with the ROV. So far, about 45 different locations were investigated with the ROV around Magdalena Island during January to June 2008, comprising about 180 clips of video and at least 40 hours of underwater video, considering that most transects took about 20 minutes of video. Video transects were located in the major channels (Puyuhuapi and Jacaf), the Magdalena and Pangal Fjord and some adjacent bays, fjords and estuaries and represent surely the most intensive documentation of the benthos ever made in the project area. The monitored depth range generally varied between 10 meters and 90 meters, selecting locations in the vicinity of fish farms, on places of former farm installations (not operated since a couple of years) and on locations away from any fish farm, to obtain data on the supposed normal composition of the benthos.

A first analysis of the benthic communities reveals that sessile filter feeders form the mayor components of the benthos, which fits with results from general scientific studies on the benthos in southern Chile. Attached to the rocks forming most part of the coast lines, mussels are the most abundant species in shallower depths (20m), also sea urchins, whereas different groups of corals are the typical and most abundant species found at greater depths. Bottom living fishes are present but not very abundant; the most common species found close to the sea bed are the Chilean sea hake or Merluza austral and Congrio. Some small fish species like the “Chancharro” or Scorpionfish (Sebastes spp.) are associated with the corals which are dominant in greater depths, as well as hydrozoans and bryozoans. Since these animals are very sensitive to sedimentation they are less abundant or disappear close to the fish farms. Some few flatfish were also seen

occasionally on sandy grounds, as well as a manta ray. Crustaceans like crabs and king crab form part of the mobile fauna, as well as sea stars, whereas brittle stars are less common. Crab densities were found to be high at some places, commonly on sandy bottoms and these crabs are of interest for the artisan fishermen. Another abundant species and fisheries resource are clams. Similar as the corals on hard substrate, they disappear on those locations where impact by fish farms is notable.

To estimate the impact of fish farming on the benthos in an almost quick but also accurate manner from the scientific point of view, simple criteria were applied to characterize each place according to

a) the visibility and sedimentation (presence/absence of fish feces and feed loss),
b) the composition of the fauna (normal composition/lack of typical species) and
c) the presence / absence of underwater waste (such as pen nets, dumped infrastructure or any other stuff).

Close to fish farms visibility was poor, the water was turbid and particles of significant size were floating around (obviously rests of feed and aggregated rests of fish feces). Greenish layers of sediment covered the stones, boulders and rocks or the sand, depending on the location. The worst case was a ground close to a fish cages, where all macro – benthic live already disappeared and the sea bad was covered by a thick layer of bacteria. Comparing different locations (with recently installed farms, farms operating for years or farms closed a couple of years ago), the benthos is impacted subsequently: first the typical habitants (commonly sessile organisms in the Patagonian fjords) are less abundant until they disappear, finally resulting in submarine deserts, without any invertebrates on or inside the sediment. Fishes (since moving around) do not visit such affected places. Crabs are sensitive to oxygen levels, but as scavengers they may appear close to the pen nets, as long as they tolerate the oxygen conditions. Therefore high abundances of crabs (as observed close to some farms in the Puyuhuapi channel) do not indicate necessarily that this place is less contaminated. These crabs feed on the rest of fishes (mortality of salmon, dumped by the farm workers) as well as on the rests of salmon feed. The most significant observation was the presence of a small red sea urchin *Arbacia dufresnei.* This sea urchin is a typical habitant of the Patagonian fjords, commonly on sandy ground. These sea urchins feeds as grazers and macroalgas are preferred food. However, they can also ingest any sediment organic material from the sea bed. Most probably this explains why this sea urchin was found in high abundances on places with increasing sedimentation from a nearby fish farm and especially on those locations, where a fish farm operated a couple of years ago, and *A. dufresnei* seems to be the first macro – benthic species, which recuperates sea beds damaged by intensive aquaculture.

5.5 Monitoring of law compliance

The compurgation between official farm limits and occupied locations formed part of the monitoring and law compliance, but was more related with all work on the data base. The most important work for this component was the revision of the coast lines and beaches to observe any illegal dumping of waste, hunting or other infractions against environmental laws and rules. During this year and with the ROV it was possible to include sea bed revisions as well.

A total of 16 cases of infractions were finally reported from the beginning of 2007 onwards. Most common infractions were illegal constructions on land, dumping of waste on land but also on the sea bed, hunting of sea lions and also infraction against maritime laws. All cases were reported to the lawyers of the Pumalin Foundation and the state authorities, who still work on these cases. In the same period, private persons and fishermen also reported infractions to the local and regional authorities (illegal waste dumping and illegal hunting), sometimes supported and/or assisted by the Foundation's lawyer.
The most common and visible infractions were dumping of unused aisles and rests of tubes, as part of the infrastructure of pen nets. Another part of the waste scattered along the beaches was material left by the service companies after farm construction, such as cable reels with steel cables to tie the cages, paintings and unused concrete moorings (blocks of several 1000 kilos). The area around Zañarthu Island was the most affected part and the company "Cultivos Marinos Chiloe" could be identified as the responsible enterprise (see photos in the annex). The infractions reported from this particular area finally were revised by the environmental police (as mentioned above, after interviews with project participants) and the company was punished and obligated to recollect the waste from the beaches. It was observed that part of the waste was shipped to Puerto Cisnes, but some waste was shifted only to another bay.

Apart from all waste on land it turned out that the amount of waste dumped to the sea is much higher than the waste found on the beaches. With the ROV it was possible to identify dumped pen nets, nets for the protection of sea lions, rests or entire aisles, up to a complete platform from a fish farm. Also, it was observed that sometimes fish farms choose an easy way to wash out the bivalves attached on the pen nets. They dump the nets close to a river mouth, expecting that the mussels die due to the law salinity or they dump the nets at greater depths, resulting also in the elimination of the mussels. One most consider that these nets are heavily contaminants due to the antifouling substances on the meshes.

The worst observed case was an entirely dumped fish farm (Estero Sur, next to Gala Island in the Jacaf channel). Pen nets filled with fouling fishes inside were scattered over the sea floor. Apart from this environmental disaster, the fishes were killed painfully, dying away without oxygen.

Waste was also found on nearly all locations, where farms were closed a couple of years ago. Again, rotten pen nets, aisles, tools and plastic sacks remained on the sea floor as indicates of the gone salmon business, and as mentioned above recuperation of the fauna seems to be a very sluggish process.

6. Output and Outcomes

This project contributes towards the first independent and non-governmental data base on fish farm presence in the main production areas within the XI. Region (and will be completed for the rest of Chile). On the other hand, all data from the biological environmental monitoring contribute to the knowledge of benthic communities in the Patagonian fjords. However, all analyses done so far represent only a rough description and on low taxonomic levels, but the video material is available for any further and details analyses by scientists, if required.

Project results, observations and annexed studies related to fish farm impact on the marine ecosystems (for example an analyses of algae blooms in the Patagonian fjords) was distributed to other NGOs by email and presented on the workshop of national NGOs working on marine conservation (Foro Pacifico Patagonico, FPP), held in Puerto Varas and in Valdivia during the end of 2007.

Details of the fish farm data base, and results from the environmental monitoring are presented in the attachment.

7. Partnerships

A close partnership between the Chilean NGO Centro Ecoceanos, the Centro de Conservacion Cetaceas and the Pumalin Foundation form the main alliance on the national level. The Pumalin Foundation together with AVINA and the Manfred-Hermsen-Stiftung formed the core initiators to establish the Pacific Patagonia Forum, a round-table of Chilean NGOs working in the marine conservation area in southern Chile.

Beside, close cooperation was formed with the NGO Green Worriors of Norway in Bergen, Norway, as well as with Don Staniford from the Pure Salmon Campaign in Washington, USA.
Apart from all support of the Pumalin Foundation, the consultant Dr. Matthias Gorny (Ecomar Austral / Puerto Varas) assisted in the design of the cutter, acquisition of materials, tools and equipment and was responsible for the GIS data base management, mapping and field work with ROV, image analyses of underwater inspections and any analyses of environmental conditions. Mr. Ronald Pfeil from Puerto Cisnes contributed with boat trips to monitor farm positions and law compliance during 2007, and Juan Farias (captain) and Claudio Andrade (deck hand) formed the tribulation of the "Melimoyu" during 2008. Fernando Siebald (Pumalin Foundation) assisted in legal aspects related to law compliances. Dirk Schöries from the University Austral of Valdivia assisted with occasional diving and documentation of underwater inspections (photographs) as well as Vreni Häussermann and Günther Förstera from the Huinay Foundation.

8. Impact and Sustainability

The generated data base on fish farm presence is available to other NGOs, but particular information was provided also to some governmental institutions such as the CONAMA or the environmental police department. As mentioned, these institutions manage no own data base and if needed for any revision of demands, they have to gather the same information as the project did, when the data base was generated. Both institutions finally asked the project for data support and CONAMA accompanied one of the field trips to evaluate reported infractions. Another important cooperation was established with the local municipality of Puerto Cisnes County, supporting the biomonitoring ideas and interested to obtain information on any infraction such has illegal waste dumping or illegal constructions on land.

On the other hand, one of the companies (Cultivos Marinos Chiloe) now operates an own ROV to detect waste dumped by the company to the sea bed, indicating that increasing presence of control and pressure from governmental institutions force fish farmers to react and may also to change their behavior respecting the environmental rules to avoid a more permanent presence and revisions of their farms by the governmental institutions.

9. Post-Project Follow up Activities

As part of the Marine Conservation Program of the Pumalin Foundation, biomonitoring of the waters around will continue. Actually the next expedition is prepared to monitor the

north-western part of Magdalena Island and to realize an intensive investigation of the benthic communities between Magdalena Island and Tic Toc Bay, located about 100 km in the north. In cooperation with the “Melimoyu” Foundation” the major goal of this field trip is to provide and collect information for a new project to postulate Tic Toc Bay as a Marine Park and to declare the rest of that area as an Area of Multiple Uses (MPA).

Work on the data base will also continue to include finally all regions, where salmon industry is present (X. Region and XII.). Including especially the XIIth region is important since the salmon industry claims now this region (waters around the Straits of Magellan) to recompense their losses in the northern parts of the Patagonian fjords.

A web site will be prepared soon to allow access for other NGOs on the generated maps, (especially with the data of fish farm locations and infractions observed), to the video clips produced from the underwater biomonitoring, and any other information generated about marine biodiversity of the Patagonian fjords on the one hand and on impact of the salmon industry on the other hand.

Finally the generated infrastructure such has the cutter, the ROV and all available data and maps provide an excellent platform to continue with the Marine Conservation Program along the Patagonian coasts, challenging still against the loss of its beautiful and pristine landscapes and unique marine ecosystem.

10. Attachments

10.1 Maps

10.2. Photographic Register

10.3 Results of environmental monitoring by underwater video

Puerto Varas, 15.01.2009