ECOLOGY AND CONSERVATION OF THE CHILEAN AND PEALE'S DOLPHINS IN SOUTHERN CHILE

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1. INTRODUCTION

A full three quarters of the area of our blue planet lies underwater, and the whole of the worlds' ocean is theoretically capable of supporting life (Sullivan Sealey and Bustamante, 1999). Life in the sea is diverse, exciting and provides a myriad of services to humanity, many of which we barely even comprehend. Human activities now pose serious threats and are the primary cause of changes to the ocean biodiversity and their capacity to support productive fisheries, recreation, water purification and other services we take for granted (Roberts and Hawkins, 2000). A large proportion of the world's coastal habitats are in various stages of degradation, and regardless of biogeographic province, the litany of abuse of coastal habitats is similar, with similar key problems identified: eutrophication, coastal development (including aquaculture), habitat modification and destruction, disruption of coastal hydrological cycles, release of toxins and pathogens, introduction of exotic species, fouling by plastic litter, build-up of chlorinated hydrocarbons, unsustainable exploitation of resources, noise pollution, disturbance by boat traffic and global climate change and variability (Alongi, 1998).

Until recently by far the most important human activity affecting marine species was uncontrolled exploitation. This is the case of many marine mammal species, for which some species suffered catastrophic declines (Groombridge and Jenkins, 2000). Marine mammals can serve as "strong interactors" or keystone species in marine ecosystems. Because their large body size and abundance, they are thought to have a major influence on the structure and function of some marine communities (Harwood, 2001). Although marine mammals are found widely across the world's ocean and fresh water bodies, their distribution is patchy, and some areas are more frequently used than others (Harwood, 2001). An adequate identification of these key habitats within a population's home range is an important part of the understanding the species' ecology and crucial for the conservation and management of any wild animal population and their habitats (Karczmarski *et al.*, 2000).

The Chilean dolphin (*Cephalorhynchus eutropia*) is the only endemic species in Chile, distributed from Valparaiso (33º S) to Navarino Island, Cape Horn (55º S). It is a coastal species, inhabiting sheltered bays, channels, fjords and exposed coast (Goodall *et al.*, 1988). Peale's dolphin has also a very restricted coastal distribution, inhabiting the waters of only Argentina and Chile, in southern South America, ranging from Valparaiso, Chile (33º S), around Tierra del Fuego up to Golfo San Matias, Argentina (38º S) (Aguayo-Lobo *et al.*, 1998). Basic knowledge on their biology and ecology are still very scarce and there are no data available on abundance, population structure and dynamics, home range size and movement patterns (Goodall *et al.*, 1988), a consequence of which their current conservation status still correspond to Data Deficient as listed by the IUCN (Hilton-Taylor, 2000).

In the present, the main concern for the conservation of these two dolphin species is the incidental catch in local fisheries and the progressive destruction of potential critical areas, mainly due to aquaculture activities (for mussel and salmon), which have expanded rapidly in the sheltered bays, channels and fjords of southern Chile (Sullivan Sealey and Bustamante, 1999).

In the present report, we detail the progress achieved up to now on the original main and specific objectives of this project, which were to obtain relevant information on important areas for these dolphin species by designing a model of dolphin habitat selection and movement pattern at a spatio-temporal scale, identify current and potential conservation

threats to dolphins and their habitat, and raise public awareness on marine conservation issues through environmental education considering the Chilean and Peale's dolphin as flagship species.

2. PROJECT AREAS AND METHODOLOGY

The project was developed in southern Chile, mainly in two subareas: Comau fjord (42º22'S, 72º24'W) and Reñihue fjord (42º34'S, 72º30'W) (Fig. 1). Data were also taken in Tic-Toc bay (43º36'S, 72º55'W).
This fjord area presents part of the intricate array of inner passages, abrupt coast, channels, fjords and archipelagos of southern Chile (Fig. 1), characterized by unique features of cold-temperate marine environments, with strong tidal currents, fresh water influence of glacier melt and pluviosity, strong winds and rough weather, with an average sea surface temperature ranging from 6-12ºC during summer.

2.1. Marine surveys and dolphin group follows

Fieldwork was conducted from December 2003 through April 2004 and included marine surveys and dolphin group follows.
Survey refers to encountering groups or individual dolphins for brief periods to census the number of animals and record location, identification and behaviour state. Marine linear transect surveys were performed on a 4.5m semi-rigid boat with an outboard four stroke engine. Observers looked for dolphins by naked eye or binocular 10x50 covering a strip of about 500m. At the beginning of each survey, and thereafter every 15 minutes, data on date, time, location, weather conditions, oceanographic variables (sea surface temperature and water visibility) and human activities (salmon farms locations, boat traffic and floating garbage distribution) were recorded. Field observations were restricted to Beaufort sea states three or less.

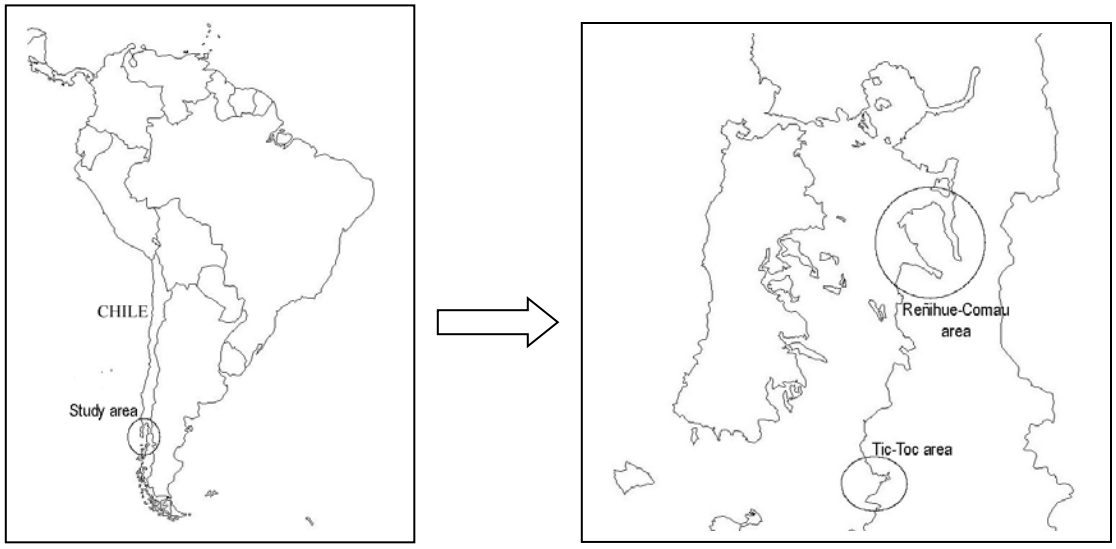

Figure 1. Study area where the project was carried out, southern Chile, South America.

Whenever dolphins (a group or a solitary individual) were sighted, the transect track was interrupted in order to record dolphin geographical position (GPS), group size, angle of sighting and distance estimation. Data on oceanographic variables as well as weather conditions were recorded after every sighting.
Data were also obtained on behavioural states, recording foraging, travelling, socializing, foraging/travelling and resting.
During dolphin encounters, photo-identification, as well as skin-swabbing sampling (for genetic analysis), were attempted for up to 30 minutes, then the transect track was continued. Photographs of dorsal fin pigmentation patterns, scars, edge detail and incrustations are used to identify individuals within the population. Every photograph, taken with a digital camera Canon EOS 10D was stored digitally into a database along with essential information on date, time, group composition, geographical position and behavioural state.
Group follows refers to encountering groups or individual dolphins and track them (follow them) for periods of 40 minutes to register behaviour. Every 40-minute session was divided into two minutes sampling interval to register behavioural state, events and scanning.
The software *SSPS* was used for the main statistical tests utilized for data analysis.

3. PRELIMINARY RESULTS AND OBJECTIVES ACHIEVEMENT PROGRESS

3.1. Effort and sighting data

From 212.75 effort hours accomplished during the five months study period, more than 159 hours were of marine surveys and 53 hours of group follows.
During the study and within the area, seven species of marine mammals were registered. Four species of small cetaceans (three dolphin species and one porpoise), two pinnipeds (sea lions and elephant seal) and one great whale species (Table 1).
81 dolphin sightings were made during surveys (68 sightings of Peale's, 9 Chilean and 1 Bottlenose dolphin and 3 of Burmeister's porpoise).
Peale's dolphin was the species that presented more overall sightings, with most of them in Comau fjord. This species was seen almost all over this fjord. On the other hand, Chilean dolphins were only registered in Reñihue fjord and restricted to the base of the fjord. Chilean dolphins were observed with much less frequency than last season when comparing number of sightings, especially during February.
Sea lions were seen in all areas, while the elephant seal was observed several times in a single beach in Reñihue fjord. According to one of the Pumalin park rangers, the seal was seen during the whole month of February, resting on the same beach. These sightings are very important, since these animals are rarely seen.
Three sightings of Burmeister's porpoises were made, all of them restricted in a single bay in Reñihue fjord. Group size varied from 6 to 10. Two calves were seen, which were photographed clearly. These are very timid animals and difficult to see. The blue whales were observed right outside Tic-Toc bay and counted for 5 animals in three different groups. They were at less than two nautical miles from shore.

Table 1. Diversity of marine mammals registered in all areas surveyed during the study period

Common name	Scientific name	Area where species was observed
South American sea lion	*Otaria flavescens*	Comau, Reñihue and Tic-Toc
Southern elephant seal	*Mirounga leonina*	Reñihue
Peale's dolphin	*Lagenorhynchus australis*	Comau and Tic-Toc
Chilean dolphin	*Cephalorhynchus eutropia*	Reñihue
Bottlenose dolphin	*Tursiops truncatus*	Reñihue
Burmeister's porpoises	*Phocoena spinipinnis*	Reñihue
Blue whale	*Balaenoptera musculus*	Tic-Toc

3.2. Habitat selection

From a general view, there seems to be a marked habitat segregation between dolphins species and porpoises. Burmeister's porpoises were mainly seen in a small bay called Fiordo Largo. Although the general geographical distribution described for both Chilean and Peale's dolphins overlaps, at the smaller scale, habitat selection seems to be interestingly segregated and specific for both species. Within the potential home range, Chilean dolphins seemed to select certain habitats, which we could consider as core.
From the whole area surveyed in Reñihue fjord (divided into 29 line-shore sections of approximately 1 km), Chilean dolphins were not evenly distributed. They concentrated their activities in only four sections, which were very close to the main river of the fjord.
Even though Peale's dolphin showed a more wide-ranging distribution in Comau fjord, there was still a significant difference in their distribution in the area (divided into 49 line-shore sections of approximately 1 km). They concentrated their activities in 18 sections, which means that 36.7% of the area was principally used.
In relation to environmental variables, Chilean dolphins seemed to prefer colder surface waters when comparing with Peale's dolphin. In addition to this, Chilean dolphins showed a preference for turbid waters.
Both species showed association to river mouths and shallow waters in all areas surveyed (Chilean dolphins in Reñihue and Peale's dolphins in Comau and Tic-Toc). Nevertheless, since Peale's dolphins inhabit a deeper fjord (Comau), they seemed to prefer deeper waters than Chilean dolphins.

3.3. Behavioural patterns and group size

Chilean dolphin average group size was 5 and ranged from 3 to 8 animals per group. Peale's dolphins average group size was also 5 ranging from 2 to 12 animals per group.
Activities of Chilean dolphins were not observed uniformly, with feeding the most important activity. On the other hand, travelling and feeding were the most frequent activities observed for Peale's dolphins.
Peale's dolphin behavioural patterns were significantly different in relation to dolphin's average group size (*ANOVA, F*=11.72, *df*=2, $p<0.05$) (number of sightings of Chilean dolphins were not enough for analysis). Travelling was the activity that explained the difference, with less number of animals per group.

3.4. Photo-identification

Approximately 3500 photographs were randomly taken of dolphins that surfaced in close vicinity of the research boat. From preliminary results, about 15 Chilean and 45 Peale's dolphins have been identified, many of these were seen in the same areas last season. Some animals seemed to be resident, while others seem to be transient. There are special cases for identified dolphins that have been sighted several times (different days) within an area of less than 20 km^2 during this and last season. This represents a high degree of residency.

3.5. Threats identified on dolphins

Within the study area in the fjords, eight salmon farms have been set up so far, while there are other facilities constructed related to the salmon industry. These not only use suitable areas for dolphins and other animals, but there is also increased boat traffic in the whole fjord, increased land-shore occupation (offices, housing and warehouse), and chemical and organic pollution (eutrophication, garbage disposal, etc.) Unfortunately, much of these activities are in areas where high occurrence of dolphins has been observed. Human impact is not only driven by the aquaculture activities. A great amount of garbage was recollected during surveys and this came in part from aquaculture activities, but also from fishing gear and domestic sources (plastic and glass bottles, bags, ropes, etc.).
Tic-Toc area is restricted from aquaculture activities since its concession belongs to the navy. Nevertheless, due to its very isolated condition, no fishing control is possible made, hence direct dolphin killing takes place especially to use its meat as bait for local fishing.

4. PUBLIC AWARENESS

4.1. Presentations, environmental education and training

During December 2003 through March 2004, work on public awareness and training was done at Universidad Austral de Chile, the school and Fundacion San Ignacio del Huinay facilities in Huinay village and at the Pumalin Park facilities in Reñihue.
The main objectives of general presentations and talks, to general and specialized public, students, regional authorities, company managers and workers and tourists, were to present the project's objective, dissemination of current results, update of fieldwork progress and preliminary conclusions.
The main objective of the environmental education component in this project is to establish a long-term programme to raise public awareness at the local, regional and national level on marine conservation issues considering dolphin and other cetaceans species as flagship and umbrella species. Raising as well awareness about their locally resident dolphin populations, the environment they live in and the threats that they might be facing.
Specific objectives were to give an understanding on basic marine ecosystem processes, marine ecology, food net dynamics, cetacean biology (especially dolphins) and habitat requirements, links to the terrestrial environment and coastal conservation and threats. The focus of the classes and workshops were on the role that every organism plays in the marine environment, how the human activities (anthropogenic) have influenced and affect ecological processes and the importance of conservation and respect towards all living creatures. Workshops, classes, talks and outdoors activities were developed for

schoolchildren and teachers. We always addressed and connected topics discussed with our own work with dolphins.
The main goal of the training component of this project was to prepare future students and community members for conservation work, both in research and environmental education and dissemination. Chilean as well as International volunteers participated energetically in this project, whose contribution was incredible valuable.

4.2. Institutional work

General dissemination is still in course through the re-design of our web page. This page have the overall aims and missions of our new NGO, as well as our projects' objectives, goals and results. Our dolphin project established cooperative work with the Conservation Land Trust (which manages the most important and largest private park in Chile), the World Wildlife Fund (WWF) in Chile and San Ignacio del Huinay Foundation. A formal document is being prepared in cooperation with the Natural Resource Defence Council (NRDC) and CONAMA (National Committee for the Environment), to discuss bases and recommendation for the establishment of marine protected areas taking into consideration cetacean species.

5. DISCUSSION

The results obtained are of great importance since the information gathered showed and corroborated (from last season) a very important diversity of cetaceans at such small scale. This particular area named Chiloensis Province (Sullivan Sealey and Bustamante, 1999) is probably one of the most important sites or hot spot for marine mammal diversity, as well as other marine biota, in Chile.
We were able to find a very marked habitat segregation between the Chilean and Peale's dolphin. Chilean dolphins used approximately 14% of the total area surveyed in Reñihue fjord, while Peale's dolphin used about 37% of the total area in Comau fjord. Chilean dolphins had a preference for more turbid waters, lower sea surface temperatures when compared to Peale's dolphins. Most studies on coastal dolphins suggest that habitat use and selection patterns occur principally in function to the distribution, movement and abundance of their prey species and secondarily in pursue of refuge and protection against predators (Karczmarski *et al.*, 2000). The activities most often seen made by dolphins were feeding and travelling, the first highly localized in the selected areas, suggesting that these areas had some prey availability or patch predictability.
The activities derived from aquaculture might negatively affect movement, distribution and behavioural patterns, representing a potential threat to the local dolphin populations. The exclusion from core areas, in addition to the very restricted, high site fidelity distribution of these species, could be severely affecting important biological and social activities, as observed for other species (Würsig and Galley, 2002). The main environmental impact from aquiculture is the organic enrichment (eutrophication) of the water and sediment, which modifies the primary productivity and benthonic community (Wu, 1995). The effects of this impact could be reflected in the trophic chain and affect prey availability for a top predator, such as dolphins. Other potential impacts include the release of antibiotics, exotic diseases, alteration of native fish communities from escaped salmon, chemical and solid residues pollution and increased boat traffic (Würsig and Galey, 2000). The environmental

impacts resulting from escaped salmon are very severe, such as disease transmission, habitat and prey competition, as well as predation on native fish, which might also have an effect on the abundance and diversity of dolphins' original prey species. Increased boat traffic might cause significant behavioural alterations in cetaceans (Williams *et al.*, 2002), including fatal collisions (Wells and Scott, 1997). It is probable that noise and boat presence not only alter dolphins' behaviour, but also their preys (Aleen and Read, 2000). It is also possible that the impact from vessel traffic is not only restricted to the time they approach to a group of dolphins, but also their behaviour might be affected by the noise pollution and the constant "alert-state" that dolphins maintain (Richardson *et al.*, 1995). Impacts caused by boat traffic might restrict or exclude animals from important areas, producing long-term effects (Richardson *et al.*, 1995).

The loss and destruction of habitat is one of the main threats to global biodiversity and one of the greatest current concerns on cetacean conservation (Whitehead *et al.*, 1999). Protecting important areas for dolphins might be crucial to ensure not only the conservation of the dolphin population, but also for the whole complex system they inhabit. By knowing the ecological role of marine mammals and considering them as flagship and umbrella species, recommendations for the conservation of marine ecosystems and the establishment of marine protected areas (MPA) can be made.

6. RECOMMENDATIONS AND FUTURE WORK

From our results of the last two seasons it is strongly recommended that important or core areas for dolphins must be protected. It is also necessary to take into account the movement and habitat selection patterns (at different scales) of small cetaceans when assessing suitable areas for aquaculture. In addition, it will be important to be able to measure, qualitative and quantitatively, the dolphin energetic requirements by studying the animals' tropic ecology.

Habitat selection modelling of both species is under designed, for which data from two seasons will be used.

Before establishing or setting up aquaculture farms, it will be extremely essential to measure the environment capacity to support such activities.

Population abundance estimates, home range size, site fidelity, and habitat selection of dolphins at large scales is highly needed. The educational programme must expand to new areas comprising more children and teachers. A book on the natural history of cetaceans is on the short-term future plans of this educational programme. Special meetings will be organized with authorities, general public and workers of aquaculture industry.

7. PROBLEMS ARISEN AND SOLUTIONS ADOPTED (CHANGES)

Our main concern arose from logistical problems, especially in coordinating our work in Tic-Toc area, which is an extremely isolated fjord. Since our 50 Hp engine broke down in January 2004, we had the necessity to stay with only one engine and leave it to work in the Reñihue-Comau fjord area. Our surveys in Tic-Toc were then limited to boat lending and airplane travel support by the Conservation Land Trust.

No other financial grant was received, so we had to change and adjust our budget to the amount given by Rufford Grant. Many items not in the budget had to be bought with this grant, while others were not bought at all.
No skin sample was taken since the methodology chosen (skin-swabbing) did not work for these species. Hence, our specific objective of describing the genetic population structure of dolphins will not be possible. For future work and if any genetic analysis is required, air-pressure rifle or crossbow would be needed.

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9. EXPENDITURE

Items	Cost (£)
Itemised equipment	
1 outboard engine Honda four stroke 20 Hp	1910
1 digital SLR Camera Canon EOS D10	1004
1 lens Canon EF 75-300mm f/4-5.6 IS USM	340
1 Hondex Digital Depth Sounder	110
1 CD reader and burner TDK and computer accessories	70
1 Standard HX350S Hand-Held VHF Radio Submersible	136
Expendable equipment	
Boat accessories and navigation	91
Photography and video accessory	158
General Tools	23
First Aid kit	15
Travel expenses	
Transportation Valdivia - Puerto Montt	48
Transportation Puerto Montt - fjords	32
Field running costs	
Food and accommodation for 3 team members for 5 months	375
Boat fuel/oil	363
Office Costs and educational material	
Report production	38
General material	51
Total Expended	**4764**