OBSERVATIONS ON THE IMPACT OF THE PETROLEUM ACTIVITY IN THE SOUTH OF THE PROVINCE OF SANTA CRUZ, ARGENTINE PATAGONIA

J. Cristián de Haro
Fundación Cethus – Juan de Garay 2861 Dto. 3 (B1636AGK) Buenos Aires. Argentina
cethus@houseware.com.ar / cristiandh@hotmail.com

ABSTRACT

Santa Cruz coast has areas of important ecological and touristical value, among which is the Gallegos River estuary with an important bird species richness, and towards the south, the Cabo Virgenes Provincial Reserve (52°20´W and 68°21´S). Cabo Virgenes presents optimum conditions for the reproduction of the Magellanic penguin (*Spheniscus magellanicus*), conforming the world's australmost continental penguin colony with a population of approximately 200.000 individuals. A large kelp forest has also been observed, which is mainly composed by *Macrocystis pyrifera*, with a smaller presence of red algae like *Porphyra sp.*, brown algae (e.g. *Fucus vesiculus*) and microalgaes such as Diatoms. This intertidal ecosystem presents an enormous biodiversity, with the presence of fishes, octopus, squids, spidercrabs, starfish and polyps, as well as other species associated with marine and coastal birds. Regarding to marine mammals, the Southern right whale (*Eubalaena australis*), Commerson´s dolphins (*Cephalorhynchus commersonii*) and Killer whales (*Orcinus orca*) can be sporadically seen in this area. Meanwhile, some Southern sea lions (*Otaria byronia*) and Peale´s dolphins (*Lagenorhynchus australis*) can be found in a stable manner. The development of an insipient petrol activity in the eastern mouth of the Strait of Magellan, altogether with the operation of ships containing hydrocarbons into the Loyola Port, represent a potential risk for the above described ecosystems and the antropic activities that are being carried out there. This work analyses the background of the petrol activity in this area since its beginning (designs, simulacrums, accidents), relates the hydrometeorological conditions with possible behaviours of the petrol stain at the time at which areas of ecological sensibility are being established, oficializing one of them as a special protection area by the ordinance N° 10/97 (DPMA) of the Argentine Coast Guard (PNA).

INTRODUCTION

The production of petrol in Argentina started with the discovery of important oil fields in 1907 in Comodoro Rivadavia. Regarding Santa Cruz Province, its productions started in 1946, with a volume of 21.000 m^3. In 1999 production reached to 29.453 m^3/day (IAPG, 1999). At present statistic data show this province as the second petrol producer of the country. The Santa Cruz Province counts with two large sedimental basins, one located in the North (shared with the Chubut Province) denominated Golfo San Jorge basin, and the other one located in the south known as Austral Basin.

In 2000, Argentina's petroleum production was 44,8 million of m^3. For 1998, verified reserves reached to 437,8 million of m^3, of which 149,1 million of m^3 corresponds to San Jorge basin and

30,7 million of m^3 to the Austral basin (IAPG, 2001). These data show that petroleum activity will go on increasing during next years. If such an important activity for the development of the area is not well managed, its advance puts in risk the stability of the ecosystems of the zone. The conservation of the marine and coastal life is necessary, not only from an ecological point of view but from an economic one, since the insipient ecotouristic activity developing in Gallegos River estuary and Cabo Virgenes are a huge potential.
The objective of this paper is to bring judging elements to reduce the impact of the petrol activity to be as minimum as possible.

MATERIALS AND METHODS

In first place, a bibliographic analysis of the petrol activity, environmental characteristics of the South of Santa Cruz Province (mainly Gallegos River estuary and Cabo Virgenes), and the local fauna were made. Secondly, research and field works were done in the Gallegos River estuary-Strait of Magellan region, related to the evaluation of the petrol activity, and the marine and coastal fauna, centred principally on cetaceans, specially the Peale´s dolphin. On the other hand, negotiations with municipal and provincial authorities were made.
We also participated in the first course about "Contingency plan against spilling Hydrocarbons in the sea" gived by the SERCICO group of the PNA (March 1997), with the participation of regional authorities, local petroleum companies and the Universidad Nacional de la Patagonia Austral
The sensitivity indexes were classified as high, medium and low, and a combined index was used to group the physical, biological and human use resources. Variables such as rare, vulnerable species or in danger, seasonal and charismatic species were used in order to determine the sensitivity indexes.

RESULTS AND DISCUSION

Habitat description

-- Gallegos River Estuary
Gallegos River and mainly the estuary at its mouth present a great biodiversity. This estuary is formed by the Gallegos River and the Chico River, interacting in this area fresh water and sediments brought by fluvial courses, with salad water from the ocean. All this generates particular conditions of pH, salinity, temperature and water dynamics that support a high biologic productivity, becoming feeding areas for many species. At the same time these ecosystems favour the development of the first larval stadium of some species of invertebrates of ecological interest (Albrieu et al., 1997).
Aquatic flora is characterised by the abundance of Rhodophyceae algae and Brown algae. Clorophyts and cyanophyts algae are also observed. The last ones are of great ecological importance because of their ability to fix nitrogen (Kuhnemann, 1972).
Local fauna is represented mainly by hydrozoans, starfishes, amphipod crustaceous and molluscans such as small mussels (*Aulacomya ater*), mussels (*Mytilus edulis platensis*) and octopus (Ferrari, S. & Albrieu, C., pers.comm.). Sixteen native fish species were identified,

belonging to three families of condrictios and teleostean fishes (Caille, G., Ferrari, S. and Albrieu, C., 1995).
Gallegos River estuary presents a great diversity of bird fauna. Next to its mouth, the Isla Deseada can be found located at 51°40´S and 69°16´W, with an area of about 37 has. This island is one of the most attractive places of this zone, since seven marine and coastal bird species nestle there. Studies conducted on Isla Deseada confirmed the presence of the following species: Magellanic penguin (*Spheniscus magellanicus*), Blue-eyed cormorant (*Phalacrocorax atriceps*), Black-crowned night heron (*Nycticorax nycticorax*), Buff-necked ibis (*Theristicus caudatus*), Kelp gull (*Larus dominicanus*), Dolphin gull (*Leucophaeus scoresbii*), and Skua (*Catharacta antarctica*) (Albrieu, C. & Ferrari, S., 1994; Arrighi, A., 1997).
Some marine mammals species also appear in this zone, which is the case of Commerson´s dolphins (*Cephalorhynchus commersonii*) and occasionally Southern right whales (*Eubalaena australis*).

-- *Cabo Vírgenes*
Cabo Virgenes Provincial Reserve was created in 1986 by Provincial Law N° 1806. This zone presents Punta Dungenes as the south limit, and Cabo Virgenes as the north limit (52°20´S/ 068°21´W), with an area of about 1.230 has. This coastal strip situated on the eastern mouth of the Strait of Magellan is 8,5 km long (Map 1).
The coastal sector of this reserve represents almost its entire area, and is limited by the beach and a strip of bushes of *Lepidophyllum cupressiforme* that conforms the ideal habitat for the reproduction of Magellanic penguins. In this place exist a reproductive colony of this specie of about 90.000 reproductive couples (Gandini et al., 1997) that inhabit 47,2 has. of the reserve (Frere et al., 1996). This specie become between September and March to nestle and reproduce, that is why this area, known as “la Pingüinera”, is of great ecological and touristical interest for the province. This colony is the australmost continental penguin colony in the world and the second one in size in the country.
In the north zone of the reserve a large kelp forest of *Macrocystis pyrifera* can be observed, with a smaller presence of red algae (*Porphyra sp.*), brown algae (*Fucus vesiculus*) and microalgaes such as Diatoms. Macrocystis algae forms true aquatic forests of 1,5 kilometers of extension along the coast approximately, being important from a biogeographic and ecological point of view. The beds of these marine algae constitute regions of the highest net primary production at sea because it generates 50 to 2.000 gr. of carbon/m^3 per year (Kuhnemann, op. cit.). Consequently this ecosystem presents a huge biodiversity: 101 species of birds are registered, 23 of them nest in the area. There are also several species of fishes such as Robalo (*Eleginops maclovinus*) and Austral sprat (*Sprattus fueguensis*); octopus; squids such as Patagonian squid (*Loligo patagonica*); spidercrabs; starfishes; and polyps.
This area is sporadically frequented by Southern right whales, Commerson’s dolphins, Killer whales (*Orcinus orca*). Southern sea lions (*Otaria byronia*) and Peale´s dolphins (*Lagenorhynchus australis*) can be found in a stable manner.
In this area Peale’s dolphins present a great association with Macrocystis forest, and 96,1% of sightseeings were made in medium and low tides. Dolphins moved in small groups, with a range of 1 to 13 animals. Respiration and diving frequencies were recorded, with an interval of apnea between 1 to 130 seconds; interactions with Commerson’s dolphin, Southern right whale, Great grebe, Magellanic penguin, Kelp gull, Southern sea lions and Blue-eyed cormorant were also recorded (de Haro, J. and Iñíguez, M., 1997). Peale´s dolphins use different techniques of cooperative feeding when slow immersion swimming, coordinated and parallel movements,

quick superficial swimming, different kinds of leaps and tail slaps are commonly observed. These data show the ecological importance of this ecosystem, for being a fundamental feeding area for this specie (de Haro, J. and Iñíguez, M., 1997).

Environmental factors

Data recorded by the meteorological station located at the airport of Gallegos River city show an annual media wind speed of 22 km/h. Maximum speeds are produced between October and February, reaching gusts of 140 km/h.
A great tidal activity with maximum amplitudes up to 11 m is registered in the Gallegos River estuary. The wind action as well as water movements are very important in the dynamic of the whole estuary. These environmental factors control the transport, erosion and deposition of contaminants, influencing in a decisive way on the biological processes that occur there.
Hydrometeorological studies done at Cabo Virgenes Provincial Reserve by Hidrografía Naval Argentina (A.R.A.), show that strongest winds take place in an annual period from September to February, while less wind months are between March and August. Winds from the west are predominant (55% of the year) (Figure 1) with media maximum speed registered for SW winds (30 to 36 km/h).
Figure 2 resumes data relating to marine currents at the eastern mouth of the Strait of Magellan (Source: Servicio de Hidrografia Naval and Sipetrol, the oil company that operates in the area).

Petrol activity and environment

-- General analysis

According to data of IAPG (2001), world production of hydrocarbons for 1998 was of about 10.639.000 m^3/day. The International Tanker Owners Pollution Federation LTD (1987) estimated that the total contribution of hydrocarbons to marine environment is about 3,2 million metric tons per year, considering all sources. Contribution percentage of different possible sources were also calculated, being the land sources the biggest contributor, with a 50% mainly composed by industrial and urban residues. Exploration and production activities contribute with 2%, meanwhile accidents of tankers contribute with 5%, vessels operations with 19%, natural sources with 11% and atmospheric processes with 13%.
Losses by transport occur mainly during cleaning operations of tanks and removal of ballast if no measurements are taken to retain the residues of oil in the ship. These operations constitute a potential risk factor for the patagonic coastal environment. Different amounts of hydrocarbons discharged into the sea by ships can be controlled by means of a strict supervision and with proper installations for receiving residues, ballast dirty water and oily residues from the machines.
If accidents are evaluated analysing statistical data from the bibliography, it can be observed that 75% of them occur during routine operations such as charging and discharging while less than 10% corresponds to collisions and strandings (The International Tanker Owners Pollution Federation LTD, op. cit.).
Incidents in off-shore exploitation activities are less frequent, being the production phase of a lower risk than during exploitation. However this does not mean that controls can be neglected,

because any incident, even the little ones, could compromise the conservation of very valuable areas from an ecological point of view.

Marine environment is able to assimilate hydrocarbons, being big spills those which cause severe contamination and devastating impacts when reaching the coast (this is the first thing that must be prevented in the case of an oil spill at sea).

The moment the hydrocarbon is spilled at sea, physical and chemical changes happen (spreading, evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation, biodegradation, combined processes).

Some of these processes facilitate the disappearance of the oil stain, while others such as emulsification, difficult it. Generally all these processes occur, but in different proportions and times. All this greatly depends on several variables such as hydrocarbon type, its density, volume wasted, wind, temperature (atmospheric and water temperature) and currents.

All these aspects are fundamental to do a right evaluation of the potential risk for certain areas and the ways in which different communities are capable of giving response to a possible accident. As it was mentioned, hydrocarbon stain characteristics and the hydrometeorological conditions at which this stain is exposed are of great importance to do a proper analysis of an accident because they allow us to predict the movement that this stain could have.

It was empirically demonstrated that a floating hydrocarbon stain moves influenced by the wind to a 3% of its speed. Likewise the stain will be influenced by the presence of superficial currents in a 100% by their speed. For that reason hydrocarbon will move through a resultant vector determined by the wind and superficial currents, in the mentioned proportions, together with some other factors such as tides (The International Tanker Owners Pollution Federation LTD, op. cit.).

The effects of environmental contamination by hydrocarbons are varied, because of the toxicity on the individuals and the ecological damages that they also cause. Main damages to marine life are: direct death of organisms because of covering and asphyxia; direct death because of poisoning by contact and exposure to soluble toxics in water; death of juvenile forms of more sensitive organisms; destruction of basic feeding sources, such as phytoplankton and zooplankton, breaking food chains and damaging the ecosystem dynamics and diminution of immune response in some mammals and birds that are contaminated with petrol.

Besides hydrocarbons, petrol also contains other components such as nitrogen, sulfides and several heavy metals that finally affect animals. Oil spills produce negative effects on marine mammals at inhalatory and gastrointestinal level and by contact with skin and mucosa (Alonso Farré et al., 2002).

Simmonds, M. and Hutchinson, J. (1992) describe that however some dolphins could detect petrol on the sea surface by means of their developed biosonar system, they do not know that these stains are dangerous. That is why once an animal is into the stain, petrol could penetrate through the blowhole and mouth causing a direct intoxication on the animals. On the other hand, chemical volatile toxins present in evaporated air, goes into the respiratory system reaching the lungs. As a consequence some of the expected effects are the inflammation of the lung membrane, lung congestion and pneumonia, what proves that cetaceans are highly susceptible to this kind of pollution.

The existence of an hydrocarbon slick on the water – air interfase cause the perturbation of the gaseous exchanges, mainly between oxygen and water. Physical properties of the environment such as superficial tension, pH, redox potential and temperature are also modified (Briant, J. and Gatelier, C., 1971). The mentioned authors also describe how some predators orientate by means of chemical substances emitted by their prey; other species are attracted in the same way by their

opposed sex partners in the moment of reproduction. These functions can be perturbed by small doses of products (such as petrol).
Hydrocarbons contamination in this kind of operations can be caused mainly by collision between ships or with platforms; loss due to broken submarine and/or land oil pipelines; spill of toxic materials used with perforation fluids and spill during charging and discharging of fuel from ships to platforms.

-- *Local analysis*

Gallegos River estuary

In 1995 a tanker stranded opposite Loyola's Port at Gallegos River estuary with 21.000 tons of gasoil. Its hulk was almost broken, which would have been a real environmental disaster, but by the action of PNA it could be controlled avoiding the spill of the gasoil.
This fact proves that although the percentage of accidents is low, it cannot be assured that this accident could not affect us. On the other hand the probability is low, but if the accident occurs the damage will be comparatively greater.
Although dynamical processes (winds, tides, currents etc.) are important, residence times of several contaminants are high. Due to biogeographic characteristics of the area, if a spill occurs, this will not allow the system to be recovered causing biological diversity and human activities to be seriously damaged.

Cabo Virgenes

The instability of this zone grew up due to the fact that in 1991 the bidding for the oil exploitation was opened in the eastern mouth of the Strait of Magellan, within argentine waters, separated about 20 nautical miles from the already mentioned Cabo Virgenes Provincial Reserve. This bidding was won by a Chilean company named Sipetrol, which belongs to Chile's ENAP. This company presented its own exploration and exploitation design project. This design took into account the construction of an oil pipeline that connected the extraction platforms at sea with the dehydrator plant (BRM) in land, crossing through the penguin colony. This situation put in serious danger the Magellanic penguin's population and the rest of the local fauna. This was the reason for the development of many reports and negotiations from different institutions to revert this situation.
Later, in January 1992, we observed Sipetrol´s personnel taking measurements with the objective of installing a drainage pipe to eliminate possible residues from the BRM to the sea by the Cabo Virgenes lighthouse, over the big kelp forest (*Macrocystis sp.*). This new fact put in danger a rich but delicate intertidal ecosystem, that is why new negotiations with the company and authorities were made with environmental education campaigns to avoid this construction to take place in those terms. Finally, in both cases, the company modified its first projects because with their work they damaged the penguin colony of Cabo Virgenes and the environment of the place. Referring to the oil pipeline, it gets into the continent out of the limits of the reserve (degraded rockrose zone) and considering the drainage pipe, it has its outlet to the sea also outside the reserve, approximately 4 km north of Cabo Virgenes´ lighthouse.
These modifications cancelled two real problems that the area had, so we can conclude that nowadays the design of the constructions have ceased to be a problem. The principal problem

today is the extrict control of the whole petrol activity and specially the sewage that is poured into the sea from the dehydration plant. Referring to the conditions of such elimination, the agreement signed by the Sipetrol company and the Consejo Agrario Provincial (Agrarian Provincial Council) in 1993, demands that the maximum contents of petrol in water that will be discharged into the sea, should not exceed 15 ppm. Considering that at a worldwide level the demanded values for "outer coast" operations are between 40 ppm and 25 ppm, tending in a short term to descend to 15 ppm, we can say that this agreement offers an acceptable protection to the environment.

Anyhow, an aspect stays unresolved. That is, official organisms should accomplish a control of this sewage in the effect of testing the company's own control, to certify that the volumes eliminated are only the permitted ones. Bertrand *et al.* (1971) exhibit that 200 ppb (pp\1 billion) of hydrocarbons are enough to alter the water's odour. To prevent such an alteration, the official control of the presence of hydrocarbons in wastewater is necessary and such control shouldn't be late.

If we consider the environmental factors, plus the geographical location of the platforms, we could estimate that any of the floating elements, whose origin is situated in the same place as the platforms, would be displaced by wind effects, moving away from the coast. Anyhow, the currents produced by submarine surfaces also intervene in this process (Figure 2) for which to be able to tell in advance with exactitude the possible trajectory of a spill, both factors should be taken into account.

On the other hand, floating elements originated near the coast (e.g.: an oil pipeline leak) could reach the coast very rapidly. Furthermore, an eventual coastal contamination of the reserve by liquid hydrocarbons by platform or ship spills situated west of the Chile-Argentinean frontier could be very serious, therefore it is necessary for both countries to make an effort together to prevent environmental damages and, in any case, a potential ecological disaster.

An environmental study made by the Sipetrol company through "the Golden Companies" in March 1993, states a hypothetical oil spill in one of the platforms, supposing that the winds blow from the SE\SSE sector (>3% per year, statistical data) with an average speed of 50 km/h in November. The spill would slide towards the reserve's coast, reaching it from 9 to 10 hours after the spill had occurred. They finish the paragraph saying " this means, leaving enough time so as to intervene with efficiency so as to hold the spill".

This time may seem enough to mount a contingency operative under a possible spill and being able to prevent it from reaching the coast, but, we shouldn't forget that, in first place, this is an estimation, and secondly, there are other variables that should be taken into account such as, the quickness and efficiency of communications, availability of human resources destined for such an end and the provision of suitable equipment. If any of these fail, 10 hours can be very little time to prevent the spill causing an impact on the coast, with the consequent damage of the area.

We should bear have in mind that these are estimations that don't guarantee 100% security, a proof is the spill on 2 July 1997 that took place in the marine platforms situated in the eastern mouth of the Strait of Magellan, in front of the Cabo Virgenes Provincial Reserve. This was produced by an anchors maneuvering by one of the ships that assisted the platforms nearby, causing the damage of one of the oil pipelines. This spill, against forecasts, had an impact on the coast in the penguin colony sector. Going over statistical data, we observe that winds from the SE are likely to occur by 0,2% (Figure 1). However, the day the spill occurred, the wind blew from the SE. The meteorological station of the Hidrografia Naval Argentina (A.R.A) Service registered winds from the SE of 6 knots (11,1km/h) for 15:00 hrs. and 24 knots (44,4 km/h) for 21:00 hrs.

Fortunately, there weren't any specimens in the penguin colony yet. However, the nest zone was affected since hydrocarbon spheres were found in the shrubs of such nests. Likewise, rests of petrol were found in the vegetable covering near the coast, approximately until 11 September, being this date, date when male penguins start to arrive to occupy the nests in this reproductive zone.

This accident, that involved a loss of $10m^3$ according to company's data, confirms that this important, but at the same time risky activity, can't leave anything open to probability and forecasts.

All the variables should be considered, though some can seem insignificant, being prepared to prevent and if the sinister occurs give a quick and effective answer to the problem.

The report about the elaboration of sensitivity map (Coastal and Ocean Resources Inc.) defines the sensitive resources as those resources that are vulnerable to the petrol spills and that present probabilities of being impacted in an adverse form by petrol. Likewise, the resources that are biologically sensitive include habitats, bird nesting areas, breeding young fish areas, rare or vulnerable species, feeding zones, algae niches (e.g.: *Macrocystis*). The ecosystem described in this work is included, for various reasons, in the sensitive category of areas and resources. Based on a risk and sensitivity evaluation, taking into account the ecological value and the biodiversity, two areas of high ecological sensitivity were determined for the Gallegos River estuary – Strait of Magellan area: the Gallegos River estuary, and Cabo Virgenes and nearby areas. This designation is fundamental for the correct implementation of the contingential plan and a greater ecological protection.

The PNA, through the ordinance number 10\97 (DPMA) designates special protection zones in the argentine shore, and Cabo Virgenes was included as a special protected zone due to the negotiations carried out. This work proposes to include Gallegos River estuary in the ordinance, that has a great environmental value, to strengthen the legal frame, and in this way conserve with efficiency this valuable ecosystem. Another PNA's ordinance (number 11/97 - DPMA) establishes that tankers must navigate 20 nautical miles or more eastern its stranding isobath. Both ordinances are of great importance for making conservation works more efficient in the area.

In 2001, the Management Plan of Cabo Virgenes Provincial Reserve was completed, becoming fundamental for an appropriate negotiation, management and administration of this area. In this Plan a marine sector of six miles could be incorporated to the protected area (Map 1). A Plan of emergency of cleaning the shore in case of oil spill was also incorporated. Although this Plan of Management is a very important advance, there is still much to do specially referring to improvement of Contingencies Plans.

D'Angello (1985) exhibits that the risks of petrol contamination are so numerous and varied as the uses you can give to all the materials involved and the transport systems used. All of them are exposed to mechanical failures that can be worsened by errors or human negligence. This is why the measures taken should point towards reducing the risks to its minimum, assuming the costs to prevent the contamination and not waiting until the problem reveals itself; the conservation of the ecosystem of the south of Santa Cruz province depends on this.

CONCLUSIONS

Considering this data and knowing that the important petrol activity is growing in the area, with the potential risk it carries for the environment, we can consider that to preserve the natural

resources of the south of Santa Cruz, it is indispensable to have a "Contingencies Plan against oil spills" an integral, solid, and effective operation plan in the prevention and struggle against possible accidents. The plan has to have several essential aspects for its success, such as:

a. Precise delimitation of each institution's responsibilities

b. To count with the appropriate material resources adecuated to the environmental characteristics of this zone (oceanic contention barriers, vessels with appropriate power, etc).

c. That these material resources be enough, to be able to offer a proper answer to the problem.

d. To count with human resources (multidisciplinary) apt for the designated task.

e. Periodical training and constant simulacrum of different situations.

f. To elaborate a map of sensitivity areas for Argentine marine shore declaring, among others, the Gallegos River estuary and Cabo Virgenes Reserve zones of high ecological sensitivity. As a consequence, when a possible spill happens, the oil patch must be prevented from reaching the coasts.

g. Periodical studies of the probable behaviour of an oil slick from the platforms "offshore" situated on the eastern mouth of the Strait of Magellan and on the mouth of Gallegos River estuary.

The Contingency Plans should be included as a variable in the future Studies of Environmental Impact Evaluation (E.I.A.), because these Plans are vital to preserve the environmental quality in any region. As a consequence, they must be analysed when the feasibility studies of a project takes place and not when the project is already working or, what is worse, many years after.

On the other hand, research studies must be promoted to increase the knowledge of the flora, fauna and their habitat. Ignorance is a conservation problem itself, so if we want to preserve our resources efficiently, we must know them first. There is a need to make this kind of studies constantly and they should take into account the negative impacts that the human activities cause in these resources.

Oil activity is potentially very risky. Thus, the effort must be enhanced to prevent any kind of pollution, achieving a favourable cost-benefit balance. Prevention is comparatively cheap, it gives more security to the activity and enhances the efficiency on the environmental protection.

ACKNOWLEDGMENTS

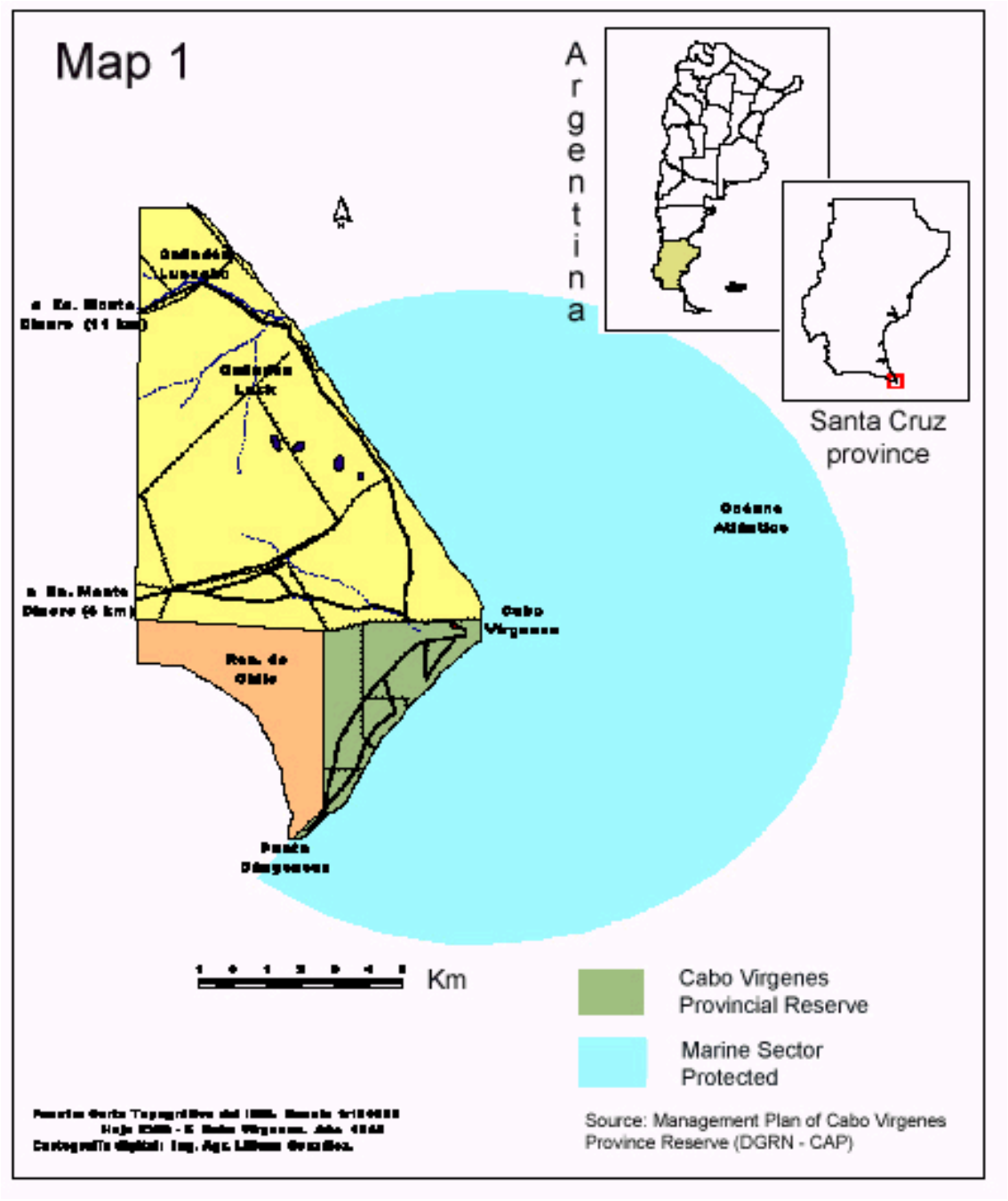
To the Prefectura de Río Gallegos e Islas Malvinas, Prefectura Zona Mar Argentino Sur, Air Station Comodoro Rivadavia (PNA), SERCICO (PNA), Dirección de Protección del Medio Ambiente de la PNA, for its constant logistical support to my research tasks. To the Universidad Nacional de la Patagonia Austral, Dirección de Fauna de Santa Cruz (CAP), Dirección General de Recursos Naturales (CAP), Subsecretaría de Medio Ambiente de Santa Cruz, Ecopasur, Dirección Municipal de Turismo de Río Gallegos, IAPG Seccional Río Gallegos, for the information given and for their support. To C. Albrieu and S. Ferrari for having given data of great importance. To F. Anglesio for his interest and support. To A. Tomsin, J. Perancho and T. Rodriguez. To M. Iñíguez for the critical reading of this paper. To the Whale and Dolphin Conservation Society (England) for the institutional and financial support.

N	6,1%	S	3,2%
NNE	2,9%	SSW	3,9%
NE	3,3%	SW	5,3%
ENE	2,8%	WSW	9,5%
E	1,6%	W	29,2%
ESE	0,6%	WNW	16,2%
SE	0,2%	NW	13,2%
SSE	1,2%	NNW	1,0%

Figure 1: Winds in Cabo Virgenes (% during the year) (Source: S.H.N.A.)

Current	Speed	Direction	Depth
Strait of Magellan current	Variable	W-NE	Superficial
Patagonic current	Variable	S-N	Superficial
Submarine current at platform depth	2.29 knots	SE-NE (295º)	40-45 mts
Submarine current at 7 km NW of the platform and at 2 km W from Banco Sarmiento	1.9 knots	W-E	25 mts
Submarine current at 1.5-2 km	1.23 knots	S-N (0.5º)	20 mts
Cabo de Hornos and Tierra del Fuego coastal current	Variable	S-N Diverted to the W and E by the Banco Sarmiento and then continues northwards	Superficial
Mouth of Strait of Magellan´s current	It increases in the direction of the oceanic current	SE-NW	Superficial

Figure 2: Marine currents at the eastern mouth of the Strait of Magellan (Source: S.H.N.A. and Sipetrol)



Map 1: Cabo Vírgenes Provincial Reserve

BIBLIOGRAPHY

- Albrieu, C. y Ferrari, S. 1994. Relevamiento de la Fauna de la Reserva Provincial de Cabo Vírgenes, Isla Deseada y Laguna Nimez mediante el sistema de pasantías. Informe sobre el proyecto. UFPA-CAP. Río Gallegos, Santa Cruz.
- Albrieu, C. 1994. Localización y abundancia poblacional de las colonias reproductoras de cormoranes en la Ria de Puerto Deseado y dos islas de la costa santacruceña. Tesina Universidad Nacional de Córdoba. Unpublished. 26 pp.
- Albrieu, C. y S. Ferrari. 1994. Aportes para el Uso Sustentable de la Isla Deseada (Provincia de Santa Cruz). En : Taller Internacional sobre Recursos Fitogenéticos, Desertificación y Uso Sustentable: 235-236. Rio Gallegos, Santa Cruz, Argentina.
- Albrieu, C., Baetti, C., Belardi, J.B., Bravo, M.E., Carballo, F., Ercolano, B., Espinosa, S.L., Ferrari, S., Manero, A., Mazzoni, E. Soto, J., Sunico, A., Vázquez, M. 1997. Estudio de Impacto Ambiental para Proyecto de construcción de oleoducto La Esperanza – Punta Loyola. Por requerimiento de YPF S.A. – Pérez Companc S.A. – ASTRA CAPSA – Santa Cruz II – Unión Transitoria de Empresas.
- Alonso Farré, J. M. y Alfredo López Fernandez. 2002. Informe preliminar del impacto del vertido del petroleo “Prestige”en tortugas y mamíferos marinos de las aguas Gallegas. Sociedad Española de Cetáceos (SEC) y Coordinadora para o Estudio dos Mamíferos Mariños (CEMMA). Vigo, España.
- Altman, J. 1974. Observational Study of Behaviour: Sampling Methods. Behaviour, 49: 227 - 265.
- ARPEL. 1992. Código de práctica ambiental. 30 pp.
- ARPEL. 1992. Guía para el tratamiento y eliminación de desperdicios de perforación de exploración y producción. 105 pp.
- ARPEL. 1997. Guía para el desarrollo de mapas de sensibilidad ambiental para la planificación y respuesta ante derrames de hidrocarburos. Guía #ARPELCIDA01CPGUI1697.
- Arrighi, A. 1997. Ecología Reproductiva del Cormorán Real o Imperial (*Phalacrocorax atriceps*), en la Isla Deseada (Santa Cruz, Argentina). Tesina Universidad Nacional de Córdoba. Unpublished. 21 pp.
- Bertrand, A. et al. 1997. Prevención y lucha contra la contaminación durante las operaciones de perforación y producción en el mar. ENAP - Magallanes, Dpto. de Exploración.
- Bertrand, A.V., J. Briant; A. Castela, P. Degobert, C. Gatellier, M. Masson, J. L. Oudin et J. Pottier. 1971. Prévention et lutte contre la pollution au cours des opérations de lorage et de production en mer. Editions Technip - Revue de L' Institut Francais du Petrole XXVI, 146 pp.
- Caille, G., S. Ferrari y C. Albrieu. 1995. Los peces de la Ria de Gallegos, Santa Cruz, Argentina. Naturalia patagónica. Ciencias Biológicas. (3): 191 -194.
- Coastal & Ocean Resources Inc. Módulo de elaboración de mapas de sensibilidad. Manual del curso Proyecto Ambiental de Arpel. 43 pp.
- D’Angello, V. 1985. El problema de la contaminación del mar por petróleo. ENAP - Magallanes. Revista Minerales, Nº 171, Vol. 40, 6 pp.
- Daciuk, J. 1979. Reservas de fauna marina en el litoral patagónico del Atlántico e Islas Malvinas: Objetivos de su creación, planificación e investigación científica. (Nº III, de la serie: Contribuciones sobre protección, conservación, investigación y manejo de la Vida Silvestre y Áreas Naturales). Acta Zool. Lilloana, 34(1):158-178.
- de Haro, J.C. 1992. Observaciones preliminares de *Lagenorhynchus australis* en Cabo

Virgenes, Santa Cruz, Argentina. Resúmenes, 5ta. Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur, Buenos Aires, 28 Sep.-2 Oct. 1992. pp.21. Abstract.
- de Haro, J.C. and Iñíguez, M.A. 1997. Ecology and Behaviour of the Peale's Dolphin, *Lagenorhynchus australis* (Peale, 1848), at Cabo Virgenes (52°30´S, 68°28´W), in Patagonia, Argentina. Rep. Int. Whal. Commn 47. Paper: SC/48/SM37.
- de Haro, J.C. and Raya A. 1994. Comportamiento y conservación del delfín austral (*Lagenorhynchus australis*) en Cabo Vírgenes, Santa Cruz, Argentina. pp.102-3. In: A. Ximenez and P.C. Simoes-Lopes (eds) Anais da 6a Reuniao de Trabalho de Especialistas em Mamíferos Aquáticos da América do Sul. Florianópolis, Brazil, 24-28 Oct. 1994. 139 pp.
- Frere, E. y Gandini, P. 1996. Aspectos particulares de la biología de reproducción y tendencia poblacional del Pingüino de Magallanes (*Spheniscus magellanicus*) en la colonia de Cabo Vírgenes, Santa Cruz, Argentina. UNPA. Seccional Puerto Deseado, Santa Cruz, Argentina.
- Gandini, P., Frere, E. y Boersma, D. 1997. Efectos de la calidad de hábitat sobre el éxito reproductivo del pingüino de Magallanes (*Spheniscus magellanicus*) en Cabo Vírgenes, Santa Cruz, Argentina. Ornitología neotropical. 8:37-48.
- Goodall, R.N.P., de Haro, J.C., Fraga, F., Iñíguez, M.A. and Norris K.S. 1997. Sightings and Behavior of Peale's dolphins, *Lagenorhynchus australis*, with Notes on Dusky dolphins, *L. obscurus*, off Southernmost South America. Rep. Int. Whal. Commn 47. Paper: SC/48/SM42.
- Goodall, R.N.P., Norris K.S., Scevill,W.E., Fraga, F., Praderi, R., Iñíguez, M.A. and de Haro, J.C. 1997. Review and update on the Biology of Peale's dolphins *Lagenorhynchus australis*. Rep. Int. Whal. Commn 47. Paper: SC/48/SM43.
- Iñíguez, M.A. 1991. Delfín austral, *Lagenorhynchus australis* (Peale, 1848). pp. 48-51. In: H.L. Capozzo and M. Junín (eds) Estado de conservación de los mamíferos marinos del Atlántico Sudoccidental. Informes y estudios del Programa de Mares Regionales del PNUMA No. 138 (UNEP). 250pp. [in Spanish].
- IAPG (Instituto Argentino del Petróleo y el Gas). 2001. El abecé del Petróleo y del Gas. Ediciones IAPG, ISBN: 987-9139-17-8. Buenos Aires, Argentina.
- IAPG (Instituto Argentino del Petróleo y el Gas). 1999. Suplemento Estadístico, Petrotecnia. Nº 3. ISSN 0031-6598.
- IAPG (Instituto Argentino del Petróleo y el Gas). 1992. Guía de recomendaciones para proteger el ambiente natural durante el desarrollo de la exploración y explotación de hidrocarburos. 47 pp.
- Knoche,W. y Borzakov,V. 1946. Clima de la República Argentina. Sociedad Argentina de Estudios Geográficos 5/6:398-432. Buenos Aires.
- Kuhnemann, O. 1972. Bosquejo fitogeográfico de la vegetación marina del litoral argentino. Physis 31 (82): 117-142.
- Lescrauwet Anne. 1990. Ecología y comportamiento del delfín austral *Lagenorhynchus australis*; un estudio preliminar - XII Región - Chile.
- Lichter, A. 1992. Huellas en la arena, sombras en el mar. De. Terra Nova, Buenos Aires, Argentina.
- Menni, R.C. , R. A. Ringuelet y R. H. Arámburu. 1984. Peces marinos de la Argentina y Uruguay. Ed. Hemisferio Sur, Buenos Aires.
- Molina, Pedro E. 1994. Santa Cruz Petróleo y gas. 365 pp.
- Plan de Manejo de la Reserva Provincial Cabo Vírgenes. 2001. Dirección General de Recursos Naturales – Consejo Agrario Provincial. Santa Cruz, Argentina.
- P.N.A. 1992. Seminario Latinoamericano sobre Protección del Medio Ambiente Marino. Actas. 136 pp.

- Pérez, F., P. Sutton y A. Vila. 1995. Aves y mamíferos marinos de Santa Cruz. Recopilación de los relevamientos realizados entre 1986 y 1994. Bol. Téc. F.V.S.A. 26: 1 - 51.
- Perrin W.F. 1989. Dolphins, Porpoises and Whales, Am. Action Plan for the Conservation of Biological Diversity. 1988-1992. pp. 28.
- Sielfeld K.W., Venegas C. and Atalah A., G. 1977. Consideraciones acerca del estado de los Mamíferos Marinos en Chile AN Inst. Pat., Punta Arenas (Chile). 8:297-315.
- Simmonds, M. and Hutchinson, J. 1992. “The Dying seas”. International Whale Bulletin, Nº 8, Summer, pp. A-4.
- Subsecretaría de Planificación Energética, Secretaría de Energía. 1988. Manual de Gestión Ambiental de conductos para hidrocarburos e instalaciones complementarias.
- The International tanker owners Pollution Federation LTD, 1987. Relación ante derrames de hidrocarburos en el mar. ISBN 0-948691-52-2. England.
- Vila, A. R. y C. Bertonatti. 1993. Situación ambiental de la Argentina. Recomendaciones y prioridades de acción. Bol. Téc. FVSA 14: 1 - 71.