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Notes on the Behaviour and Ecology of the Peale's Dolphin, *Lagenorhynchus australis*, in the Strait of Magellan, Chile

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ABSTRACT

Between March 1989 and December 1995, data on the abundance, group size, behaviour, diving patterns and habitat preference of Peale's dolphins, *Lagenorhynchus australis*, were collected on the west coast of the Strait of Magellan, Chile. The overall effective observation rate was 38.3% and based on data from land surveys only, the average group size over the entire period was 4.29 individuals per group ($n = 851$ groups, SD = 2.44 individual/group). Land-based surveys ($n = 203$) indicate that higher total counts are registered during summer months (December to February) compared to winter periods. The average of monthly maximum counts for the study period is 20.6 individuals (±6.9 individuals). The land-based surveys showed an increase in abundance in the southern compared to the central portion of the area during spring, and a more homogeneous distribution during the rest of the year. Although total abundance increases in summer, compared to the winter period, both seasons show less marked preference for a specific sector. Concentration in the southern part of the study area during spring appears to be related to the calving season that can be observed as early as October. The average diving period is 27.6 seconds (range = 3-157s, $n = 723$ recording intervals). Individual identification shows at least part of the population to be residential throughout the year, while another observation of one individual documents a range of at least 300km.

KEYWORDS: PEALE'S DOLPHIN; BEHAVIOUR; ECOLOGY; SOUTH PACIFIC; SEASONALITY; DISTRIBUTION; FEEDING; REPRODUCTION

INTRODUCTION

The Strait of Magellan, a 700km long and 6-40km wide stretch of sea that separates the southernmost tip of South America from the Archipelago of Tierra del Fuego, is home to a number of small cetaceans endemic to the southern cone of this continent (Norris, 1968; Aguayo, 1975; Sielfeld, 1983). Similarly, it has been one of the main fishing areas for southern king crab (*Lithodes antartica* and *Paralomis granulosa*) since the 1930s, a fishery that caused significant mortalities of marine wildlife, including dolphin species, especially during 1980-1986 (Sielfeld *et al.*, 1977; Torres *et al.*, 1979; Sielfeld, 1983; Cárdenas *et al.*, 1986; 1987a; b; Lescrauwaet and Gibbons, 1994).

There is little published information regarding distribution and abundance of small cetaceans in the Strait and adjacent waters, except for the Commerson's dolphin (*Cephalorhynchus commersonii*) in the eastern part of its distribution, near the Atlantic Ocean (Venegas and Atalah, 1987; Venegas, 1990; Guzmán *et al.*, 1996; Goodall *et al.*, 1997b).

Since the description by Peale (1848), publications on *Lagenorhynchus australis* have been scarce and mainly related to taxonomy (Cope, 1866; True, 1889; Fraser, 1948), sounds (Schevill and Watkins, 1971), craniometry (Fraser and Noble, 1968), external morphology and pigmentation (Mitchell, 1970; Nishiwaki, 1972), distribution (Fraser, 1948; Hamilton, 1952; Gilmore, 1971; Aguayo, 1975), reproduction (Kellogg, 1941; Claver *et al.*, 1993) and feeding (Hamilton, 1952; Iñíguez and de Haro, 1993), until the systematic effort of Goodall to collect specimens and describe external morphometry of this species (Goodall, 1978; 1989; Goodall *et al.*, 1997a; b). Long-term observation efforts at Cabo Virgeness, Argentina (de Haro, 1992; de Haro and Raya, 1994) and Puerto Montt, Chile (Andrade and von Meyer, 1992) have recently gathered information on behaviour and ecology. Still, there are insufficient data available on this species (Reeves and Leatherwood, 1994) to determine its conservation status or even to answer basic questions regarding population dynamics, abundance and distribution. An incidental sighting in the tropical East Atlantic (Leatherwood *et al.*, 1991) presents a somewhat confusing anomaly with existing literature on distribution.

Since March 1989, observations of Peale's dolphins have been made by the author between Rio Seco and San Juan, on the west coast of the Strait of Magellan, Chile. In this report information is presented that was gathered during this ongoing study and results on habitat preference, abundance, group size, behaviour and respiration patterns are discussed.

STUDY AREA

Although additional observations were made outside the study area, most of the data have been collected along the west coast of the central part of the Strait, from Rio Seco to Punta Carrera (10km north and 55km south of Punta Arenas respectively; Figs 1 and 2).

Weather conditions in this stretch are representative of the dry and cool continental Patagonia, in contrast with the rainy (over 4,000mm rainfall per year) Archipelago area, over the western part of the Strait. Air temperatures in the region average 10°C in summer and -2°C in winter, with maximum values around 20°C and minimum around -12°C. Between May and September, snow cover is usual. Annual precipitation averages 480mm. Water surface temperatures in the study area vary between 6-9°C. Especially during spring and summer months, wind strength often reaches values around 70-80km/h, with gusts of 120-140km/h. These dominant northwest winds can persist for days and strongly influence observation efforts. Visibility in the area is mainly affected by wind strength. Photographic opportunities are limited by daylight hours which fluctuate between seven hours of daylight during winter (minimum) and 18 hours during summer (maximum).

The area is accessible by means of a gravel road (approx. 0-60m elevation) along the coastline in the area north and

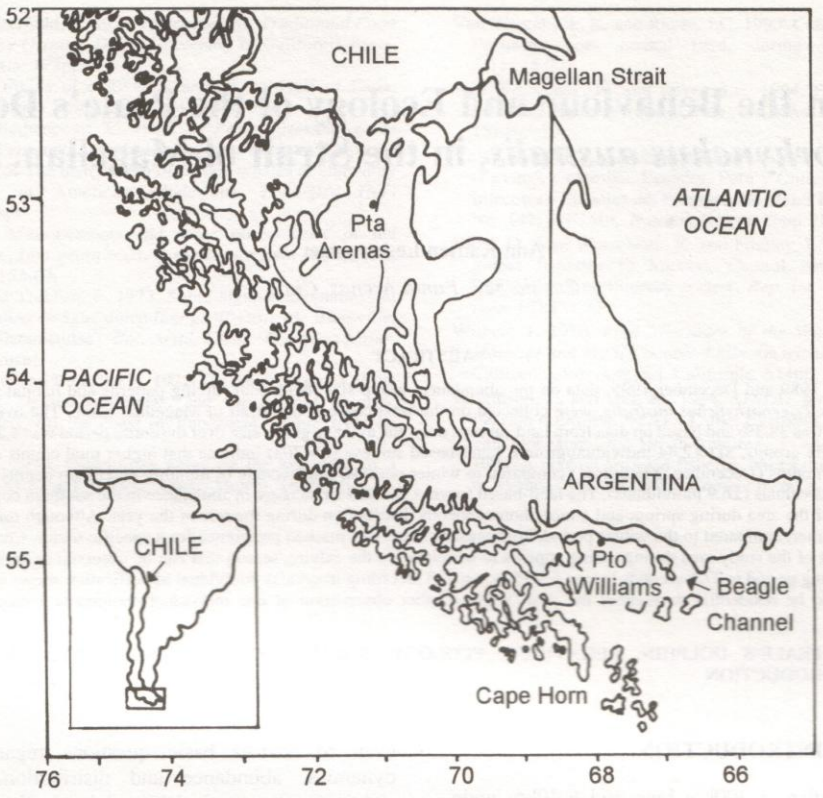

Fig. 1. Location of the study area in the Strait of Magellan, Chile.

south of Punta Arenas which is poorly inhabited. Fishing in this study area is restricted to extraction of molluscs, algae, crustaceans and some pelagic fish species. Except for limited commercial trawling in the deeper central waters of the Strait to the east, only subsistence fishing activities occur in the area.

The Strait of Magellan is a natural confluence of water masses from the Pacific and Atlantic Oceans and is closely linked to the Antarctic ecosystem. Oceanographic information available on the area refers mainly to plankton studies (Antezana, 1981; Marín and Antezana, 1985; Uribe, 1988). According to bathymetry and other characteristics, Antezana *et al.* (1992) identified different micro-basins along the main axis of the Strait, affecting zooplankton distribution. Results suggest that the shallow basin, the study area, may function as a semi-closed cell or water mass receiving limited influence from both oceans and tidal currents. About 12 small rivers bring nutrients, sediments and freshwater into this shallow basin, and the fjords of the Darwin Cordillera in the southeast bring cold and nutrient-rich freshwater to the area. Recent data show a peak in phytoplankton productivity in the area between the Segunda Angostura and Cabo Froward (Caettano and Fabiano, 1997).

Extended kelp beds (*Macrocystis pyrifera*), characteristic of the shallow waters of the area, provide a habitat and favourable conditions for a wide variety of marine invertebrates, fish and other algae (Santelices and Ojeda, 1984). The width of these giant kelp beds and the density and size of the algae components depend on the configuration and type of substrate. The coastal zone of the study area displays abundant and extensive (up to 150m wide) kelp belts at very short distances from the shoreline.

METHODS AND MATERIALS

Since March 1989, a total observation effort of approximately 1,450 hours, spread over 55 months between March 1989 and December 1995 (31 months in 1989-1991 and 24 months in 1992-1995) has been conducted to obtain data according to three different methods described as follows. Except for some aspects of abundance and group size, behavioural data obtained from approximately 550 hours of effective observations and additional land-based surveys along 55km of coastline within the study area, still need to be analysed.

Land-based surveys

Land-based surveys covered a 55km coastal road from which dolphin groups and the number of individuals in each group, were counted. These land-based surveys were used to record the abundance of dolphins in the study area (through direct counts by help of a manual counter) as well as group size, direction of movement and habitat preference. In order to detect an eventual preference in habitat, the coastline was divided into 11 5km stretches (e.g. sector 'A' from 10-5km North of Punta Arenas and sector 'K' from 40-45km south of Punta Arenas, see Fig. 2). Each of these 5km sectors was evaluated according to basic parameters such as exposure to waves, abundance of kelp and human intervention.

The areas G and I coincide with stretches of coastline that are not accessible by road and therefore less frequented by the public. Physical conditions (currents, exposure etc.) are comparable throughout the area, except for some sites such as at observation point C (sector G), which has extensive kelp beds. Sector 'A' offers better sighting conditions due to the higher elevation of observation points and the cliffs that

protect the coastline from winds, especially in spring and summer. Fishing effort in the study area is very limited and relatively equally distributed along the defined sectors. Disturbance by human activity is strongest in the areas A to C (industrial and urban areas).

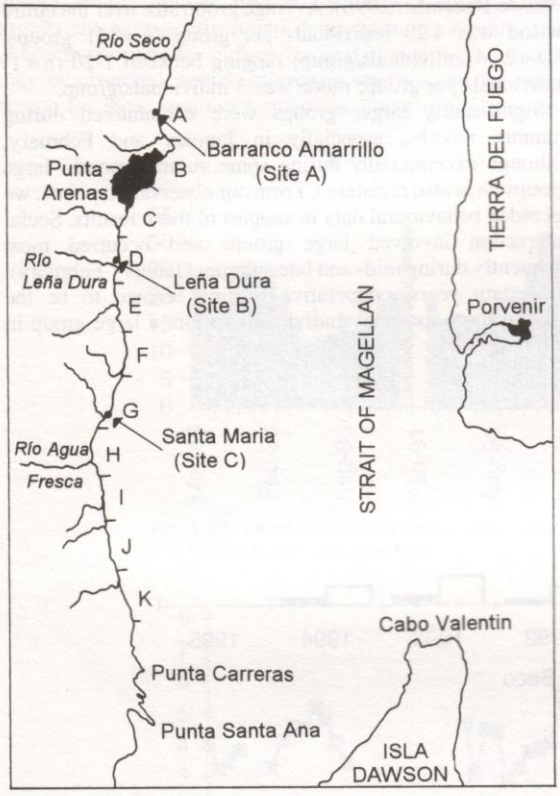

Fig. 2. Detailed map with indication of sectors A-K in study area.

Additional notes on the presence of calves and/or juveniles, the position of dolphin groups *versus* kelp beds and some behavioural aspects were made during these surveys, although these are not considered in the present data analysis.

Boat-based surveys

Surveys from a small inflatable boat were conducted in the same area described for the land-based surveys. They served the purpose of control only for data on abundance obtained from land, as both the direction of movements and group size are expected to be influenced by the presence of the zodiac. Boat surveys are ideally conducted just before or after land-based surveys, however in practice this has not always been the case.

Data represent six complete boat surveys (between Punta Arenas and Punta Carrera) and four partial surveys between Punta Arenas and Agua Fresca (25km south). Fixed imaginary points, with compass sightings to shore and fixed buoy positions were used, to zigzag between the kelp belts and up to approximately 1km offshore. Additional information from these surveys and other random excursions, include photo-identification data.

Behavioural survey

Recordings were made from three fixed observation points located at Barranco Amarrillo (Site 'A': 7km to the north of Punta Arenas), Leña Dura (Site 'B': 7km to the south of Punta Arenas) and Punta Santa María (Site 'C': 24km to the south of Punta Arenas). The presence of dolphin groups and instantaneous data on focal groups (Altman, 1974) (including information on group size, group composition, behaviour, distance from shore, position *versus*, and distance from, kelp beds and direction of movement) were recorded at three minute intervals, along with additional notes on behaviour or presence of previously identified individuals.

Diving pattern was recorded for as long as possible by following an easily identified individual within a group and recording time at the beginning of each diving sequence. Only adult animals without calves were followed. Also, whenever possible, the type of activity the animal was engaged in at that moment was recorded in order to recognise specific diving patterns according to different activities. The monitoring of diving patterns was chosen because respiration frequency is less conspicuous when animals are at rest at the surface. The main observation effort was concentrated in this behavioural survey.

RESULTS AND DISCUSSION

Observation effort (from fixed observation points)

Observation effort and corresponding effective sightings are plotted in Figs 3a, b and c for each of the three fixed observation points, sites A, B and C respectively.

The overall effective observation rate (March 1989 to February 1995) is 38.3 %, with the highest value for site B (49.6 %) and lowest for site A (34.2%).

Although monthly variations in effective observations for each fixed observation point have not been calculated, I believe that the higher success rates in sites B and C are due to seasonal shifts in preferential use of habitat. This hypothesis is supported by information on abundance between seasons and months, for the 5km intervals along the study area coastline, obtained from the land-based surveys (Figs 8 and 9).

The observation point A has a lower effective observation rate year round for each consecutive year while less and generally smaller groups are observed in this area. There were lower percentages in total effective observations in spring compared to other seasons of the year. However, at least for some years, this can be explained by data obtained from the land-based surveys, showing an increase in effective counts in areas close to site C *versus* B during spring and a more homogeneous distribution along the coastline between B and C during the rest of the year (Figs 8 and 9).

Abundance (land-based surveys)

Land-based surveys covered 57 months between March 1989 and December 1995 ($n = 203$). For the purposes of this study, data collected during return tracks of each survey are considered as a different survey. These return tracks were always conducted on the same day, immediately after completing the first track. Each track (survey) typically lasted three hours. For analysis purposes, only the track with the highest total count of both (way and back) has been included, in order to obtain independent samples. Due to the considerable differences often obtained between the two tracks, these could not be considered as replicates.

An average of 3.7 surveys was conducted per month ($n = 203$). The highest total number counted during one survey for each month is shown in Fig. 4. Months with zero values indicate that no survey was made. Higher total counts are registered during summer months (December-February) compared to winter periods (Kruskal-Wallis, $p < 0.001$). The average of monthly maximum counts for the study period was 20.6 individuals (±6.9 individuals) and ranges from 11-38 individuals/survey. The number of groups counted within each survey, ranged from one (September 1990, May 1991 and September 1993) to eight (May 1995).

The average number of groups counted in each survey was 4.24 (SD = 1.41) and the mode was four groups per survey ($n = 861$ groups/203 surveys).

Our total dolphin counts from boat surveys do not necessarily generate higher numbers for the same month, however, as mentioned before, we did not always conduct the boat surveys on the same days as the land-based surveys for that month. The data represent six complete boat surveys (between Punta Arenas and Punta Carrera) and four partial surveys between Punta Arenas and Agua Fresca (25km South of Punta Arenas) covering nine months (*versus* 57 months for land-based surveys) in the study period. Therefore, only 16% of the land-based survey data can be compared with dolphin counts from the water.

Group size (land-based surveys)

Fig. 5 shows average group size *versus* month of the year, based on data obtained from land-based surveys (March 1989 to December 1995). Average group size over the entire period was 4.29 individuals per group ($n = 851$ groups, SD = 2.44 individuals/group) ranging between 1-20 ($n = 1$) individuals per group; mode was 3 individuals/group.

Significantly larger groups were encountered during summer months, especially in January and February, although exceptionally during some autumn months large groups were also registered. From our observation points, we recorded behavioural data in support of these results. Social interaction involved large groups and occurred most frequently during mid- and late summer (January-February). In certain years, cooperative feeding seemed to be the driving force for many individuals to join a large group in autumn.

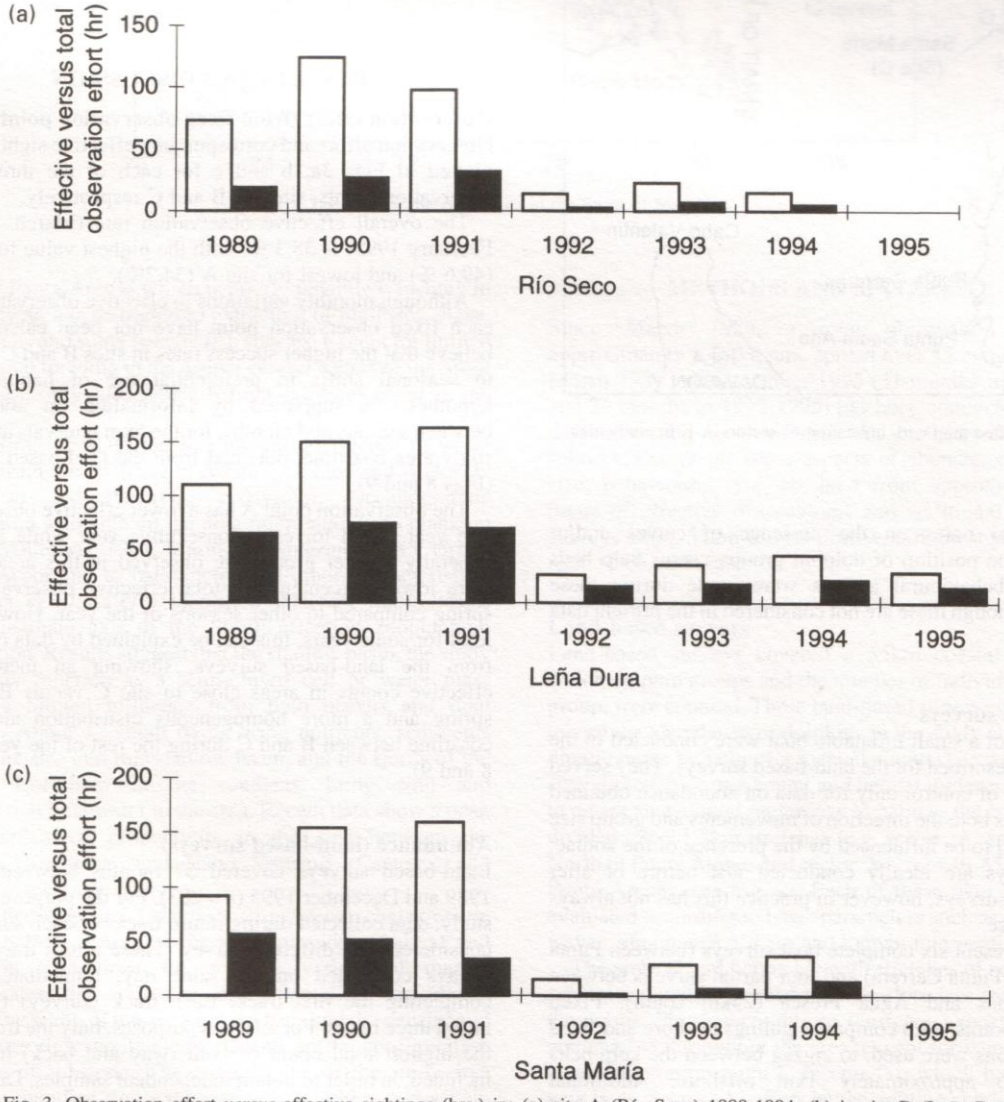

Fig. 3. Observation effort *versus* effective sightings (hrs.) in: (a) site A (Río Seco) 1989-1994; (b) in site B (Leña Dura) 1989-1995; and (c) site C (Santa María) 1989-1994.

The group size frequency histogram is shown in Fig. 6, representing 851 groups and 5,368 individuals. Groups with three ($n = 328$) and five ($n = 204$) individuals were the most commonly observed.

Peale's dolphins are commonly seen in groups of 3-7 individuals throughout most of the day. Groups of over seven individuals seem to be involved in social interaction or feeding-related activities, and often break up into smaller groups of 2-5 animals after this activity is ended. Large groups are consistently found during summer months and although cooperative surface feeding in such large groups may be observed, social interaction seems to be the main reason for these summer formations. Large groups are not frequent during autumn and winter. Groups of over 20 individuals form for cooperative feeding (e.g. in May 1990) at this time of the year. Social interaction does occur during autumn and winter, but is rarely associated with the joining of various groups for this purpose.

Groups that include young calves are generally smaller and do not exceed five individuals; when part of larger associations as described above, young calves have been observed to remain at the periphery. This movement of young calves near the periphery of schools appears similar to dusky dolphin, *L. obscurus*, group formation in Argentina (Würsig and Würsig, 1980) and New Zealand (Würsig *et al.*, 1997)

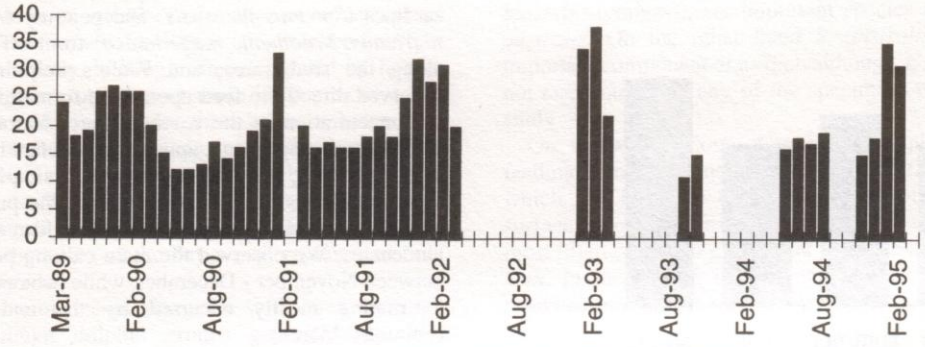

Fig. 4. Maximum number of Peale's dolphins counted in the study area per month March 1989 to February 1995 (from land-based surveys).

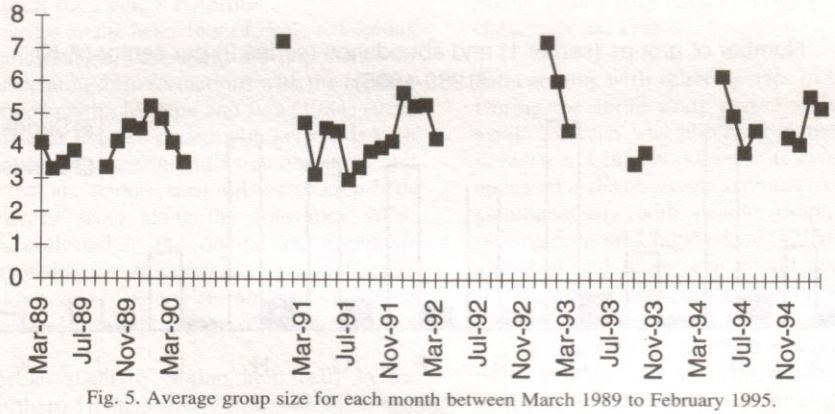

Fig. 5. Average group size for each month between March 1989 to February 1995.

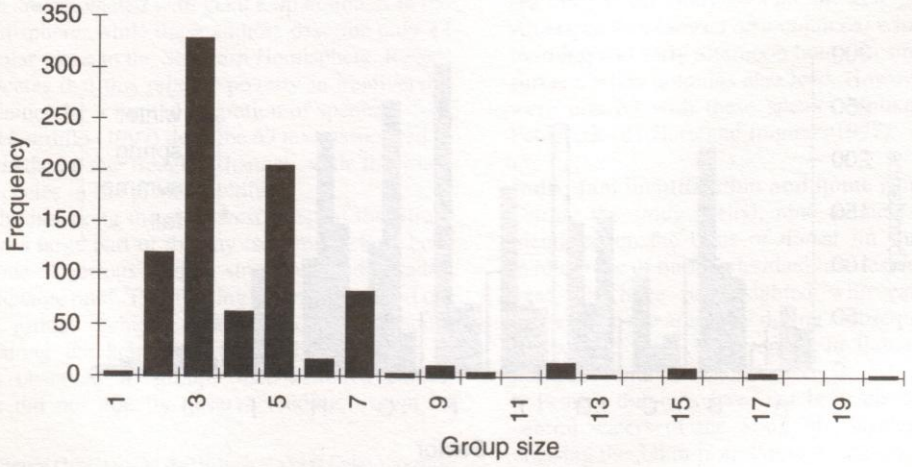

Fig. 6. Group size frequency (1989-1995) from land-based surveys.

Mean group size recorded by de Haro and Iñiguez (1997) for January and February in Patagonia was around 2 (range 1-13), considerably less than for our study.

Habitat preference (land-based surveys)

Data on abundance and group size are arranged to show shifts in preferential use of habitat according to season. The results are presented in Figs 8-9. Survey effort (number of surveys) for each season is shown in Fig. 7.

Fig. 8 shows the year round abundance and number of groups plotted for each sector. Although a slight preference for some sites is revealed (sector B, D and E to H), this preference is more clearly marked when we analyse data by seasons. Seasonal changes in abundance per sector are shown in Fig. 9. Abundance increases in summer (December-February), compared to winter (June-August), although both seasons show less marked preference for a specific sector. In summer, abundance appears more equally spread in the central part (B-H), whereas a clear preference is shown towards the southern portion (G-I) of the study area during spring (September-November), and sector D is quite frequented during autumn (March-May).

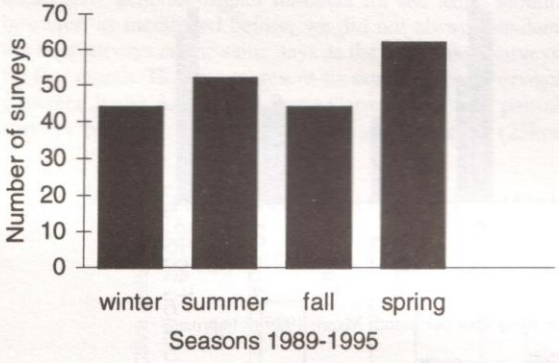

Fig. 7. Survey effort by season (1989-1995).

The summer period is generally associated with the formation of larger social groups, that later break up into smaller sub-groups again. Different groups of Peale's dolphins, more than 1-2km distant, were often observed to travel at high speed to join in larger groups for play and mating behaviour, as if triggered by a common signal. Also during these months, schools of fish such as Fuegian sardines (*Sprattus fuegensis*) and pejerrey (*Austromenidia nigricans, Notothenia magellanica*) form off the coastline, along the study area, and Peale's dolphins have been observed directly to feed upon these formations.

Concentration in the southern part (sectors G-I) of the study area during spring, appears to be related to the calving season. Calves, that can be observed as early as October, were mainly sighted in these areas in the presence of 2-3 adults. The data from boat surveys confirm these seasonal tendencies. We observed the main calving period to occur between November - December, while behaviour associated to mating mostly occurred by the end of summer (February-March).

Dolphins were also observed at a few meters from the commercial harbour facilities of Punta Arenas (sector C), mainly during summer.

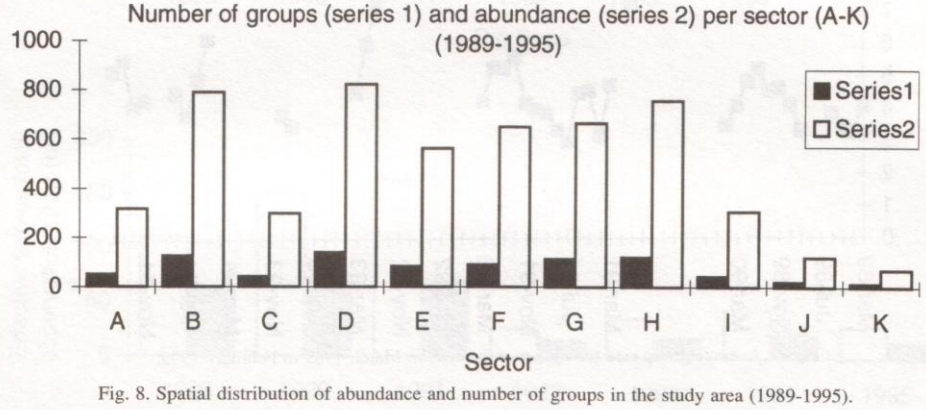

Fig. 8. Spatial distribution of abundance and number of groups in the study area (1989-1995).

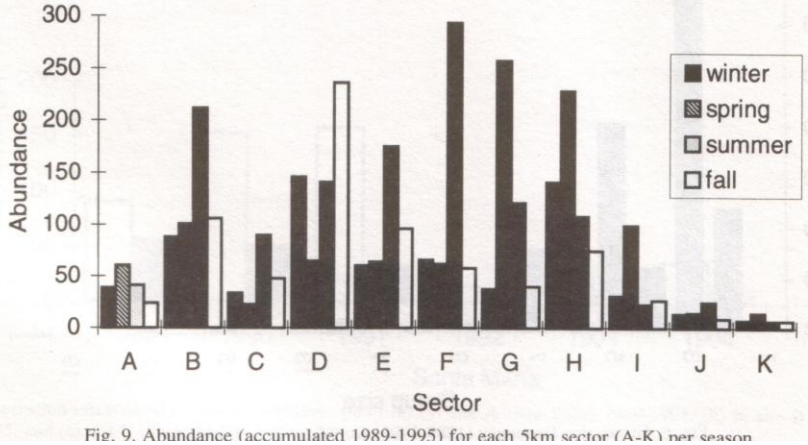

Fig. 9. Abundance (accumulated 1989-1995) for each 5km sector (A-K) per season.

Diving frequency

The average diving period was 27.6 seconds (range = 3-157s) for $n = 723$ recording intervals. A typical diving pattern consisted of three short dives, followed by a longer one, associated with feeding or the 'screening' of kelp. This interpretation is derived from slow movements around kelp contours and associated with slow and deep dives. During social activity the dolphins generally displayed short and frequent dives at the surface, while travelling over long distances involved longer dives.

Daily movements

Dolphin groups in the Strait of Magellan travel parallel to the coastline (north-south direction), at shallow depths, slowing down and moving along kelp beds during most of the day. There seemed to be an intentional direction of movement, as most groups were found swimming in one direction (north or south) simultaneously, although often separated by five or more km. Dolphin groups may remain in an area of a few hundred meters of coastline for three or more hours. The distribution and abundance of kelp appeared to be the main attraction. Dolphins observed continuously during three daytime periods (May 1991) in Bahía Agua Fresca for example, spent about 70% of their time close to the kelp formations at the edges of the bay which represented only 10% of the bay's area.

Tide-related movements along the study area were not detected, although dolphin groups generally remained farther from the coastline during low tide. More data are needed on feeding habits and prey movements.

Kelp beds as habitat for Peale's dolphins

Hamilton (1952) writes on the behaviour of Peale's dolphins around the Falkland Islands, describing the importance of kelp plants and associating kelp formations with the feeding requirements of this dolphin. Moreno and Jara (1984) stress the high dependence of fish associated with kelp beds with the ecological factors that determine this environment and state that certain fish are seldom seen outside of kelp beds which form a narrow band along the coastlines. Most important species collected in this habitat are *Eleginops maclovinus* (róbalo) *Notothenia magellanica*, *Austromenidia nigricans* (pejerrey) *Salilota australis* (bagre), *Cottoperca gobio* and six species of *Patagonotothen* sp.

Comparing species diversity within kelp beds in the Southern and Northern Hemisphere, Ojeda and Santelices (1984) conclude that biodiversity is much lower in the south. Over 100 taxa are associated with giant kelp holdfasts in the Northern Hemisphere, while these authors describe only 42 taxa for a similar niche in the Southern Hemisphere. Recent evidence indicates that this relative poverty in biodiversity could be explained by a limited migration of species.

Adami and Gordillo (1997) describe 69 taxa associated to Macrocystis beds in the Beagle Channel, with the main diversity of species in the plants' holdfast.

Peale's dolphins along the northwest coast of the Strait, seem to spend a large part of the day 'screening' kelp beds for food, as one of various feeding strategies, and possibly the most predictable one[1]. This feeding activity is carried out by smaller groups which make steady north-south movements along the kelp beds. Generally this type of activity was observed in groups that included calves. Although we did not directly observe feeding, except on small pelagic fish, experienced divers in the area claim that Peale's dolphins search for octopus between the holdfasts of the kelp plants.

In autumn, small groups gradually incorporating individuals from nearby groups have been observed to feed cooperatively on pelagic species (e.g. pejerrey) in deeper waters (>30m). Large (>20 individual) circular formations involved in cooperative feeding, as described for other dolphin species, were observed on three occasions, a few hundred meters off river deltas.

Schiavini *et al.* (1997) studied the diet of *L. australis* based on examination of nine stomachs' contents. Results indicate that *Enteroctopus megalocyathus* (pulpo colorado), together with bottom species such as *Myxine australis*, *Macruronus magellanicus* (merluza) and *Genypterus blacodes* (congrio), are important species in the diet of *L. australis*. On the other hand *S. australis* was also an important component of its diet, although *E. maclovinus* was not encountered in any of the specimens examined in this study.

On a few occasions, a group of dolphins engaged in feeding at short distances from a sea lion (*Otaria flavescens*) which was biting in two a 30-40 cm róbalo at the water surface before swallowing it. Róbalo is one of the species most often caught in gillnets set from the beach in the study area. In the fall of 1996, a young male Peale's dolphin drowned in a gillnet set for róbalo.

Behaviour

The types of behaviour observed in Peale's dolphins during this study, are extensive and a subject for separate analysis. Some preliminary notes have already been presented (Lescrauwaet, 1990).

Interactions with other species in the study area

During the entire study period, only one other species of small cetacean was observed in the study area. On three occasions, Chilean dolphins (*Cephalorhynchus eutropia*) appeared at the observation points (A and C), although never simultaneously with Peale's dolphins. During extensive observations off Chiloë island (42°S) where both species are abundant and often seen simultaneously, Peale's dolphin was generally observed closer to shore than the Chilean dolphin, and interactions seldom occurred.

The South American sea lion (*Otaria flavescens*) as well as the kelp gull (*Larus dominicanus*) is frequently observed in the vicinity of Peale's dolphin groups, and at times is harassed by some individuals of those groups. The common sea birds in the study area are the kelp gulls and the South American tern (*Sterna hirundinacea*) which feed during the morning and early afternoon hours on small fish at the kelp surface, when dolphins also feed. However, no interactions were noticed with these species, unlike the situation off Patagonia (de Haro and Iniguez, 1997).

Individual identification and home ranges

During the study period, nine animals were individually identified on the basis of dorsal fin shapes and patterns. While some of these individuals are residents throughout the year and have been sighted with calves, others were observed in the area only during (subsequent) summers, and one animal was photographed in Bahía Posesión, 300km north of Punta Arenas.

Peale's dolphins have not been observed in the deeper central waters of the Strait of Magellan, during surveys crossing the 33km from Punta Arenas to Puerto Porvenir on Tierra del Fuego. However in February 1995, a group of

[1] de Haro and Iñiguez (1997) found that in their study at Cabo Virgenes, Argentina, the Peale's dolphins spent most of their time in kelp beds.

Peale's dolphins followed our vessel during nearly two hours over 70km along the north coast of the Seno Almirantazgo in northwestern Tierra del Fuego. On the next day, the same individually identified dolphins were observed on the southern coast of this sound, having crossed a 15km wide channel.

Future field work should focus on individual identification in support of our working hypothesis for the existence of various nucleus or smaller home ranges occupied by groups of females with calves and juveniles and from which other animals may disperse to interact or mix with other groups.

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