SC/60/SH35

Bryde's whale off Chile: a note on distribution and population genetic structure

Luis A. Pastene[1], Jorge Acevedo[2], Mutsuo Goto[1] and Anelio Aguayo-Lobo[3]

[1]*Institute of Cetacean Research, Toyomi 4-5, Chuo-ku, Tokyo 104-0055, Japan*
[2]*Fundación Centro de Estudios del Cuaternario Fuego Patagonia y Antártica (CEQUA), Avda. Bulnes 01890, Punta Arenas, Chile*
[3]*Instituto Antártico Chileno, Plaza Muñoz Gamero 1055, Punta Arenas, Chile*

ABSTRACT

The Bryde's whale has been difficult to study in several regions of the world due to its similarity with the sei whale. Whaling stations in the eastern South Pacific continued to confuse both species until 1973 (Peru) and 1983 (Chile). As a consequence information on the biology and distribution of this species in this ocean basin, is scarce. In this study we examined the information on sightings and catches of confirmed Bryde's whales to investigate its pattern of distribution in Chilean waters. In addition we conducted a preliminary genetic analyses based on mitochondrial DNA control region sequences of ten animals with the aim to confirm species identity and compare its genetic composition with Bryde's whale from other regions, including Peru. Furthermore some general biological information based on the analysis of catches, is provided. A total of 135 animals (122 sighted and 13 caught) were confirmed as Bryde's whales in the period 1960-2000. They were distributed in the latitudinal range 18º43'-37º58'S. Records were made between approximately 29ºS and 38ºS in summer (December-February) and between approximately 18ºS and 33ºS in spring (September-November). Results of the phylogenetic analysis identified the Bryde's whales in Chilean waters as Wada *et al*. (2003)'s Bryde's whale (*Balaenoptera brydei*). No statistically significant genetic differentiation was found between Bryde's whales in Chile and Peru. Striking genetic differences were found between whales from Peru and Chile and those from the western North Pacific, Fiji and Java. These results therefore are not inconsistent with a north (Peru)-south (till latitude 38ºS) movement of Bryde's whales in the eastern South Pacific in spring-summer. However this hypothesis should be further examined through the analysis of former 'sei' whale catches in Chile and larger number of genetic samples. Most of the whales caught had stomach contents composed of commercially-important fish species in Chile.

INTRODUCTION

The Bryde's whale has been difficult to study in several regions of the world due to its similarity with the sei whale. Whaling stations in the eastern South Pacific continued to confuse both species until 1973 (Peru) and 1983 (Chile). In the North Pacific, however, Japanese scientists were able to separate Bryde's and sei whale catches in the mid 1950s. As a consequence information on biology and distribution of Bryde's whales in the eastern South Pacific, is scarce.

The first record of Bryde's whale in Chile was reported by Clarke and Aguayo (1965) on the basis of an individual caught off Iquique (20°S). Subsequently Gallardo *et al*. (1983) reported the occurrence of Bryde's whale based on sighting data between 32°-36°S approximately. The finding of this species within an easy reach of the former whaling coastal station meant that all previous catches of 'sei' whales in this area should be understood as a mix of sei and Bryde's whale, probably in varying proportions.

Japan conducted whaling under special scientific permit in the western South Pacific in three seasons: 1976/77, 1977/78 and 1978/79 (Ohsumi, 1980), and that research contributed substantially to know the biology and to delineate stocks of the Bryde's whales in this ocean basin. On the eastern side of the South Pacific information was scarcer. A 'Peruvian stock' was defined from 10ºN-10ºS and from the South American coast to 110ºW, and an 'Eastern South Pacific stock' from South American coast and 150ºW,

excluding the Peruvian stock area (Donovan, 1991). Little is known about the distribution, pattern of movement and the relationship with the Peruvian stock, of whales of the Eastern South Pacific stock.

More recently Wada *et al*. (2003) described a new species of baleen whale *Balaenoptera omurai* (Omura's whale) based on the morphological and genetic analyses of nine animals. These animals resembled *B. physalus* (fin whales) in external appearance but were much smaller. Comparison of external morphology, osteology and mitochondrial DNA data grouped these animals as a single species but separated them from all known baleen whale species. Furthermore Wada *et al*. (2003) provided evidence to separate *B. brydei* (Bryde's whale) and *B. edeni* (Eden's whale) into two distinct species. The Omura's whale distributes in the Sea of Japan, the Solomon Sea and the eastern Indian Ocean near the Cocos Islands. The Eden's whale has been recorded for coastal areas in Japan and Philippines. The Bryde' whale has a pelagic distribution in all oceans of the world but limited to the regions comprised between 40°N and 40°S. It should be noted that the first evidence for considering the Solomon Islands as a separated 'stock' came from analysis of body lengths of a six individuals caught under Japanese special scientific permit around the Solomon Islands (Ohsumi, 1980).

The objective of this study is to gather additional information on sightings and catches of confirmed Bryde's whale of the Eastern South Pacific stock to investigate its pattern of distribution in Chilean waters. In addition we conducted a preliminary genetic analyses based on mitochondrial DNA control region sequences of ten animals with the aim to confirm species identity (based on Wada *et al*., 2003's classification), and compare its genetic composition with Bryde's whale from other regions, including Peru. Finally some general biological information based on the analysis of catches is provided.

MATERIALS AND METHODS

Published and unpublished documents were reviewed for records of sighting and catches of Bryde's whales. Only confirmed records by experienced researchers and whalers were considered.

Sighting data

The source of information on sighting were: Gallardo *et al*. (1983) whose summarized sightings made during a systematic sighting survey in central Chile in February 1982; Findlay *et al*. (1998) whose summarized the sighting made during the 1997/98 Southern Ocean Whale and Ecosystem Research (SOWER) survey in Chilean waters; and personal records made by scientists onboard the Yacht *Balaena* in a 2000 survey.

Catch data

The source of information on catches were: Clarke and Aguayo (1965); records and notes of whale catches in Chile in the 60's by a Japanese whaling company; and records and notes of whale catches in Chile in 1983 by a Chilean whaling company.

Genetic analysis

Samples

Skin biopsy samples were obtained from eight free-ranging Brydes's whales during the 1997/98 SOWER survey in Chilean waters (Findlay *et al*., 1998). Biopsy samples were collected using several methods including Paxarm system and crossbows. The geographical location and date of sampling of these individuals are shown in Appendix 1. In addition baleen plates of two Bryde's whale caught in Chile in 1983 were available for the genetic analysis. Relevant information on these whales is given in Appendix 1 and Table 3.

Mitochondrial DNA sequences from Bryde's whale from Western North Pacific, Western South Pacific (Fiji), Eastern South Pacific (Peru) and Eastern Indian Ocean (Java) used by Kanda *et al.* (2007) were used for comparative purposes.

Molecular genetic analysis

Genomic DNA was extracted from approximately 0.05g of the outer epidermal layer of the skin biopsy, by standard phenol/chloroform extractions (Sambrook *et al*., 1989). Extracted DNAs were stored in TE buffer (10mM Tris-HCl, 1mM EDTA, ph8.0).

The first 299 nucleotides at the 5' end of the mitochondrial control region were amplified by the polymerase chain reaction (PCR, Mullis and Faloona 1987). The oligo-nucleotides employed in the PCR amplification were MT4 (Arnason *et al*. 1993) and P2R (5'-GAA GAG GGA TCC CTG CCA AGC GG-3'). Reactions were carried out in 50 uL volumes containing 100 mM KCl, 20 mM Tris-HCl, 0.1 mM EDTA, 1 mM DTT; 0.5% Tween 20, 0.5% Nonidet P-40, 200 uM dNTPs, 2.5 pM of each oligo-nucleotide and one unit of Taq DNA polymerase. After an initial denaturation step at 95° C for 5 minutes, a PCR amplification cycle of 30 seconds at 94°C, followed by 30 seconds at 50°C and 30 seconds at 72°C was repeated 30 times. The amplification was completed with a final extension step of 10 minutes at 72°C. Subsequent cycle sequencing reactions were performed with 100ng of products generated in the above PCR amplifications using the Prism™ dRhodamine Terminator Cycle Sequencing Kit (Applied Biosystems, Inc.). The oligo-nucleotides used to prime the cycle sequencing reaction were the same as employed in the initial PCR amplification listed above. A total of 25 cycles with 10 seconds at 96°C, 20 seconds at 56°C and four minutes at 60°C were performed. The nucleotide sequence of each cycle sequencing reaction was determined by electrophoresis through a 5% Long Ranger™ (FMC, Inc.) denaturing polyacrylamide matrix on a DNA Prism™ 377 DNA Sequencer (Applied Biosystems, Inc.) under standard conditions. Both strand samples were sequenced in their entirety for all samples.

Analysis of genetic data
Genetic distances among unique sequences (haplotypes) were estimated using the Kimura's two parameters method (Kimura, 1980). The degree of mtDNA diversity within each Area was estimated using the nucleotide diversity (Nei and Li, 1979).

Heterogeneity tests among oceanic regions were conducted as described in Hudson *et al*. (1992), using the chi-square, the Hst and the Kst* statistics. The level of statistical significance was estimated from 10,000 Monte Carlo simulations as the proportion of simulations in which a similar or more extreme value of chi-square, Hst or Kst* was observed.

A phylogenetic tree of haplotypes was generated using the neighbor-joining method (Saitou and Nei, 1987). To estimate confidence intervals, 1,000 bootstrap simulations were conducted. The phylogeny was rooted using the homologous sequence from sei whale as well the Omura and Eden whales (Wada *et al*., 2003).

Other biological data
Information on body length, sex and stomach contents of whales caught in 1968 and 1983 were reviewed and summarized.

RESULTS

Distribution of sighting and catches
Appendix 1 summarized the information on sightings and catches of confirmed Bryde's whales in Chilean waters. There was a total of 135 animals confirmed as Bryde's whales, thirteen of them correspond to catches and 122 to sightings. The earliest record is on May 1960 and the later one on November 2000. Figure 1 shows the geographic distribution of sighting and catches of Bryde's whales in Chilean waters. They were distributed in the latitudinal range 18º43'S and 37º58'S. Figure 2 shows distribution of sightings and catches of Bryde's whales, by season. Records were made approximately between 29ºS and 38ºS in summer (December-February) and between approximately 18ºS and 33ºS in spring (September-November). Records in fall and winter were scarce.

Genetic analysis
Genetic diversity
In the total sample of 482 animals (including the samples examined by Kanda *et al*., 2007) there were 38 segregating sites discriminating a total of 54 haplotypes (Figure 3). Then the additional 10 samples from Chile discriminated three new haplotypes in relation the data set used by Kanda *et al*. (2007). Nucleotide diversity by geographic locality is shown in Table 1. The diversity in the Chilean Bryde's whale is at the same level as in other geographical localities.

Population differentiation
Figure 3 shows the geographical distribution of haplotypes. There was a total of seven haplotypes in the Chilean sample, four of them (representing 70% of the total samples) were shared with the Peruvian sample. Table 1 shows the net-interpopulational distances among populations. The comparison between

Bryde's whales from Peru and Chile yielded a negative value suggesting a close genetic relationship. Table 2 shows the results of the statistical test for population differentiation for several statistics. Chilean Bryde's whale differed significantly from all other populations of Bryde's whales, except that from Peru.

Phylogenetic analysis
Figure 3 shows the neighbor-joining based phylogenetic tree of Bryde's whale haplotypes. Bryde's whales in Chilean waters clustered with Wada *et al*. (2003)'s Bryde's whale (*B. brydei*). Within the brydei, no geographic specific clades were found.

Biological data
Table 3 shows some biological data obtained from the catches confirmed as Bryde's whale in 1968 and 1983. All whales in Table 3 but one were females. All these animals but two had stomach contents composed of different fish species.

DISCUSSION

This note presented the first comprehensive summary of confirmed records of Bryde's whales in Chilean waters. Genetic analysis confirmed these animals as *B. brydei* according Wada *et al*. (2003)'s classification. As reported for other oceans, Bryde's whales in the Eastern South Pacific do not occur in waters south of 38°S. For Chilean waters, whales were reported mainly in spring and summer, however, it should be noted that limited survey effort has been spent in other months.

Genetically Bryde's whales from Chile and Peru were closely related as no statistically significant mtDNA differences were found. Samples sizes used in the comparative genetic analysis between Peru and Chile's Bryde's whales, were small, 24 ad 10 samples, respectively. However, such sample sizes were large enough to detect significant genetic differences with Bryde's whales from other oceanic regions.

These results therefore are not inconsistent with the hypothesis of a north (Peru)-south (till latitude 38ºS) movement of Bryde's whales in the eastern South Pacific in spring-summer. This hypothesis should be further examined through the analysis of former 'sei' whale catches in Chile (such analyses are underway), and larger number of genetic samples.

Sightings of Bryde's whales were related to a coastal upwelling ecosystem in central Chile (Gallardo *et al*., 1983). As the stomach contents of whales examined in central Chile were composed of pelagic fishes (Table 3), the north-south migration in spring/ summer could be related to food availability. As suggested by Gallardo *et al*. (1983), Bryde's whale appears to show more correlation with the presence of food of the right kind and in the adequate quantities, than with a given range of temperature.

REFERENCES

Arnason, U., Gullberg, A. and Widegren, B. 1993. Cetacean mitochondrial DNA control region: sequences of all extant baleen whales and two sperm whale species. *Journal of Molecular Biology and Evolution* 70:960-970.

Findlay, K., Pitman, R., Tsurui, T., Sakai, K., Ensor, P., Iwakami, H., Ljungblad, D., Shimada, H., Thiele, D., Van Waerebeek, K., Hucke-Gaete, R. and Sanino-Vatier, G.P. 1998. 1997/1998 IWC-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) Blue Whale Cruise, Chile. Paper SC/SO/Rep.2 presented to the IWC Scientific Committee (unpublished). 40pp.

Clarke, R. and Aguayo, A. 1965. Bryde's whale in the south-east Pacific. *Norsk Hvalfangsttid* 54 (7):141-8.

Gallardo, V.A., Arcos, D., Salamanca, M. and Pastene, L.A. 1983. On the occurrence of Bryde's whale (*Balaenoptera edeni* Anderson 1878) in an upwelling area off Central Chile. *Rep. Int. Whal. Commn.* 33:481-488.

Donovan, G.P. 1991. A review of IWC stock boundaries. *Rep. int. Whal. Commn* (special issue 13):39-68.

Hudson, R.R., Boos, B.B. and Kaplan, N.L.1992. A statistical test for detecting geographic subdivision.

Molecular Biology and Evolution 9:138-151.

Kanda, N., Goto, M., Kato, H., Mcphee, M.V. and Pastene, L.A. 2007. Population genetic structure of Bryde's whales (*Balaenoptera brydei*) at the inter-oceanic and trans-equatorial levels. *Conservation Genetics* 8:853-864.

Kimura, M. 1980. A simple method for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. *J Mol Evol* 16:111-120.

Mullis, K.B., and Faloona, F. 1987. Specific synthesis of DNA in vitro via a polymerase-catalyzed chain reaction. *Methods in Enzymology* 155:335-350.

Nei, M. and Li, W.H. 1979. Mathematical model for studying genetic variation in terms of restriction endonucleases. *Proceedings of the National Academy of Science*, USA, 76:5269-5273.

Ohsumi, S. 1980. Population study of the Bryde's whale in the Southern Hemisphere under scientific permit in the three seasons, 1976/77-1978/79. *Rep. int. Whal. Commn* 30:319-31.

Saitou, N. and Nei, M. 1987. The neighbor-joining method: a new method for reconstructing phylogenetic tree. *Molecular Biology and. Evolution* 4(4):406-25.

Sambrook, J. and Russell, D.W. 2001. *Molecular Cloning. A laboratory manual*. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

Wada, S., Oishi, M. and Yamada, T. 2003. A newly discovered species of living baleen whale. *Nature* 426:278-281.

Table 1. Nucleotide diversity (on the diagonal) and net-interpopulational distances among populations of Bryde's whale. In parenthesis is the SE (WNP= western North Pacific)

	WNP n=401	Fiji n=24	Peru n=24	**Chile n=10**	Java n=23
WNP	0.0101 (0.0006)	0.0012	0.0048	**0.0058**	0.0115
Fiji		0.0072 (0.0018)	0.0069	**0.0080**	0.0130
Peru			0.0104 (0.0018)	**-0.0004**	0.0089
Chile				**0.0083 (0.0019)**	
Java					0.0063 (0.0029)

Table 2. Results of the statistical test for genetic heterogeneity (WNP= western North Pacific).

	Hst	Kst*	Chi-square
WNP-Fiji	0.0215 (P=0.0000)	0.0166 (P=0.0000)	P=0.0000
WNP-Peru	0.0140 (P=0.0000)	0.0377 (P=0.0000)	P=0.0000
WNP-**Chile**	**0.0077 (P=0.0000)**	**0.0216 (P=0.0000)**	**P=0.0000**
WNP-Java	0.0528 (P=0.0000)	0.0885 (P=0.0000)	P=0.0000
Fiji-Peru	0.1366 (P=0.0000)	0.2347 (P=0.0000)	P=0.0000
Fiji-**Chile**	**0.1275 (P=0.0000)**	**0.2522 (P=0.0000)**	**P=0.0000**
Fiji-Java	0.3760 (P=0.0000)	0.4722 (P=0.0000)	P=0.0000
Peru-**Chile**	**-0.0125 (P=0.8535)**	**-0.0163 (P=0.9601)**	**P=0.8932**
Peru-Java	0.2377 (P=0.0000)	0.3336 (P=0.0000)	P=0.0000
Chile-Java	**0.2511 (P=0.0000)**	**0.3514 (P=0.0000)**	**P=0.0000**

Table 3. Biological data of 12 Bryde's whale caught in Chile (see also Appendix 1).

Catch date	Catch location	Sex	Body length (m)	Stomach contents	Other observations
16 Feb 1968	35º21'S;75º32'W	F	13.1	Fish*	
16 Feb 1968	35º18'S;75º25'W	M	12.5	None	
17 Feb 1968	34º32'S;75º20'W	F	14.6	Fish*	
20 Feb 1968	34º45'S;75º11'W	F	14.6	Fish*	
24 Feb 1968	35º15'S;75º19'W	F	14.9	Fish*	
24 Feb 1968	34º40'S;75º30'W	F	12.5	Fish*	
25 Feb 1968	35º10'S;76º16'W	F	12.6	Fish*	
3 Mar 1968	37º58'S;75º29'W	F	13.4	None	
4 Mar 1968	36º55'S;74º22'W	F	12.6	Fish*	
10 Apr 1983	33º55'S;72º46'W	F	14.3	Fish**	Pregnant
12 Apr 1983	35º19'S;73º09'W	F	10.3	Fish***	
15 Apr 1983	33º20'S;72º21'W	F	13.0	Unk	

*= Whalers identified those fishes as juvenile of the 'choicy ruff' ('cojinova') (*Seriolella porosa*)
**= Scientists identified those fishes as 'king gar' ('agujilla') (*Scomberesox saurus scombroides*)
***= Scientists identified those fishes as 'jack mackerel' ('jurel') (*Trachurus murphyi*)

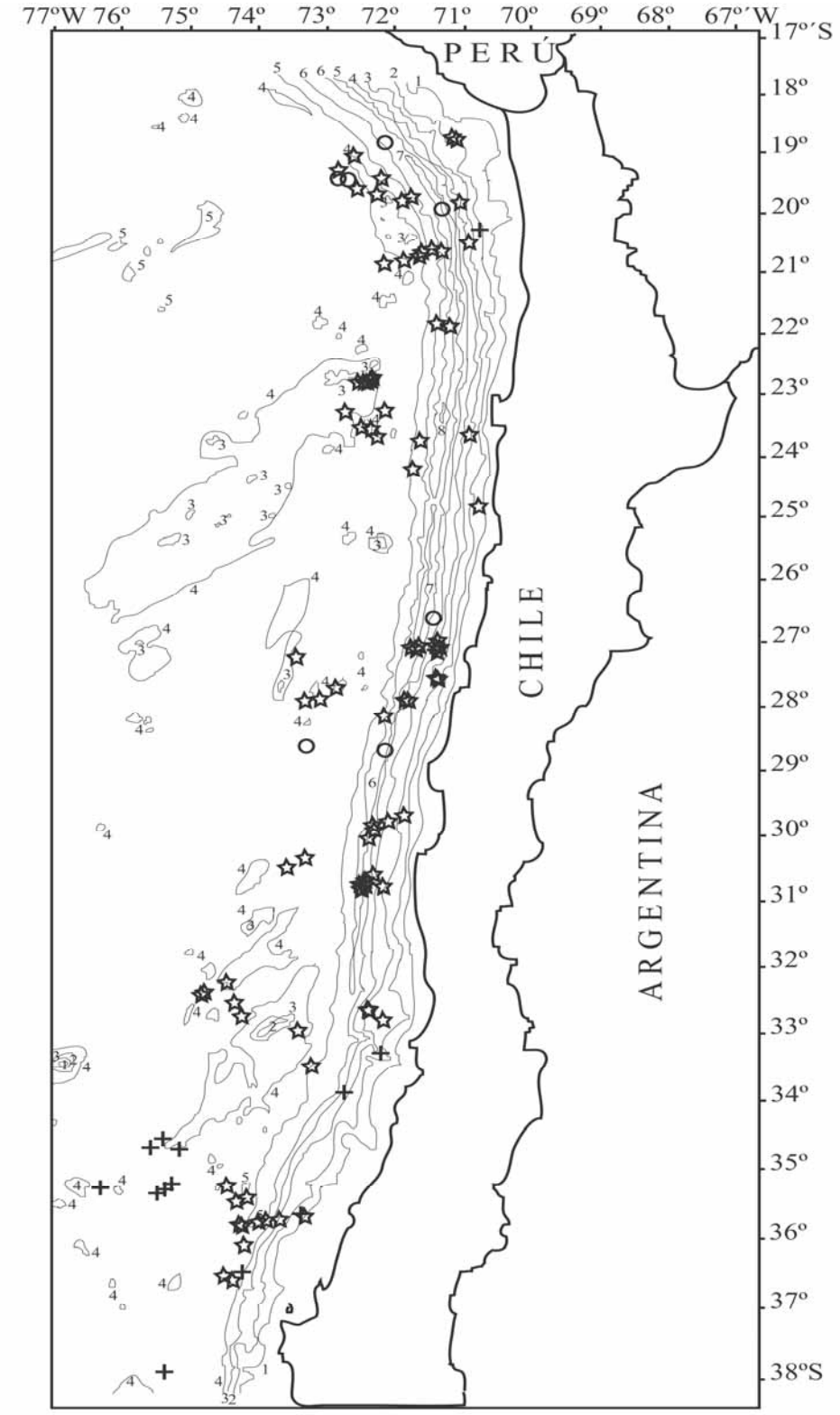


Figure 1. Distribution of sightings and catches of Bryde's whale in Chilean waters (sightings in stars, catches in cross, like Bryde's whales in circle).

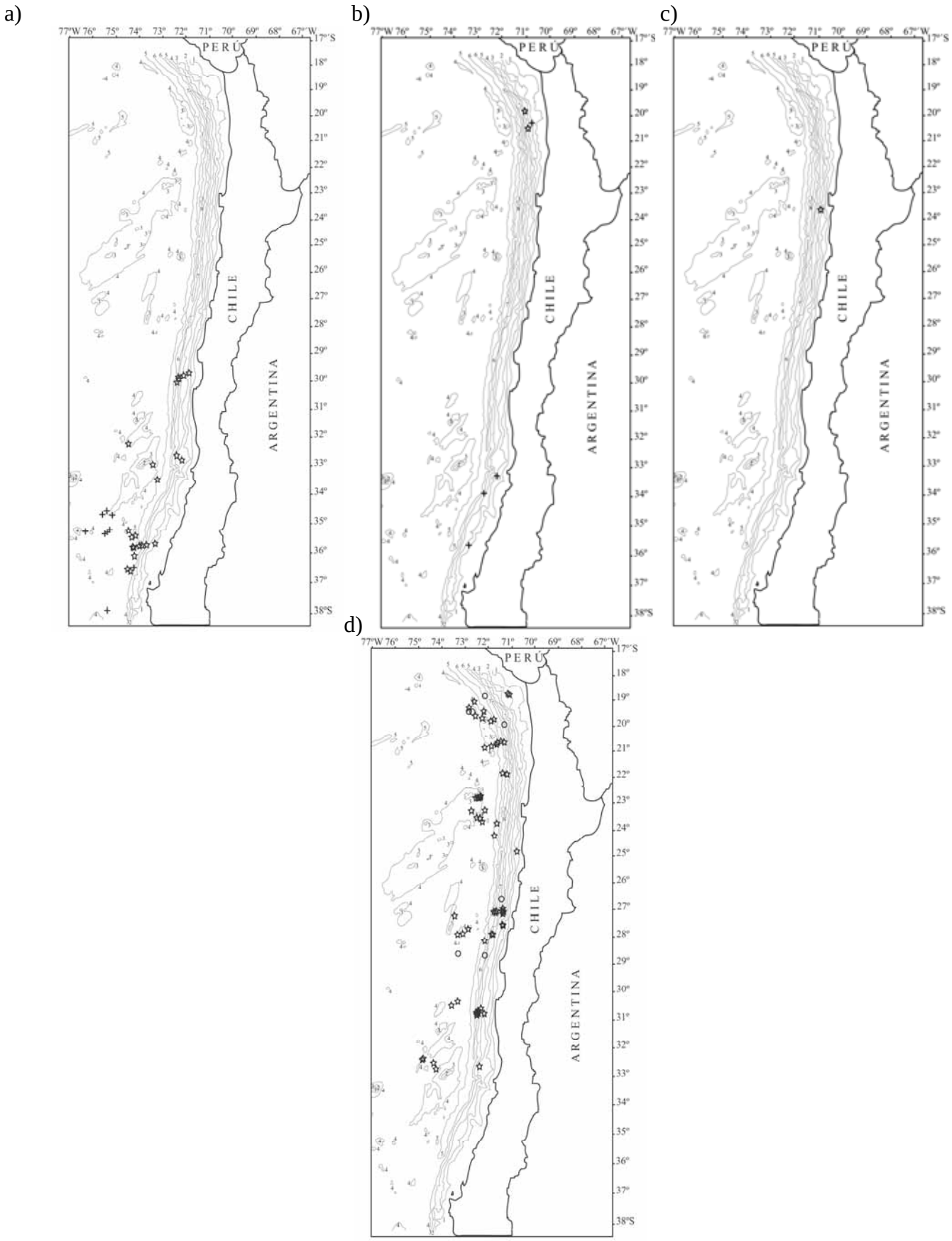
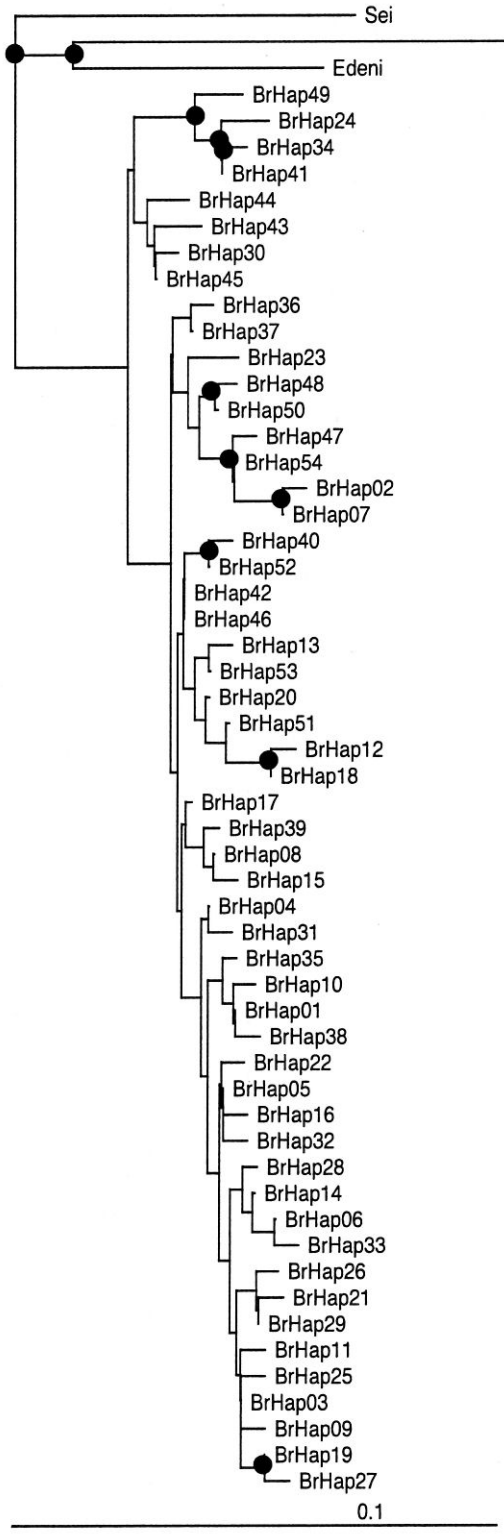


Figure 2. Distribution of sightings and catches of Bryde's whales in Chilean waters, by season: summer (a), fall (b), winter (c) and spring (d) (sightings in stars, catches in cross and like Bryde's whales in circle).



Hap	WNP	Fiji	PERU	Chile	JAVA	Sum
49	0	0	0	0	2	2
24	2	0	0	0	0	2
34	2	0	0	0	0	2
41	0	0	1	0	0	1
44	0	0	1	0	0	1
43	0	0	1	0	0	1
30	2	0	0	0	0	2
45	0	0	3	2	0	5
36	2	3	1	1	0	7
37	0	2	0	0	0	2
23	2	0	0	0	0	2
48	0	0	0	0	19	19
50	0	0	0	0	1	1
47	0	0	1	0	0	1
54	0	0	0	1	0	1
2	2	0	0	0	0	2
7	14	0	0	0	0	14
40	0	0	1	0	0	1
52	0	0	0	1	0	1
42	0	0	5	3	0	8
46	0	0	5	1	0	6
13	5	0	0	0	0	5
53	0	0	0	1	0	1
20	4	0	0	0	0	4
51	0	0	0	0	1	1
12	4	0	0	0	0	4
18	14	0	0	0	0	14
17	2	0	1	0	0	3
39	0	0	1	0	0	1
8	14	0	1	0	0	15
15	8	0	0	0	0	8
4	3	0	0	0	0	3
31	1	0	0	0	0	1
35	1	0	0	0	0	1
10	6	0	0	0	0	6
1	50	15	0	0	0	65
38	0	1	0	0	0	1
22	5	0	0	0	0	5
5	156	3	1	0	0	160
16	6	0	0	0	0	6
32	1	0	0	0	0	1
28	6	0	0	0	0	6
14	1	0	0	0	0	1
6	8	0	0	0	0	8
33	3	0	0	0	0	3
26	7	0	0	0	0	7
21	3	0	0	0	0	3
29	8	0	0	0	0	8
11	5	0	0	0	0	5
25	7	0	0	0	0	7
3	35	0	1	0	0	36
9	3	0	0	0	0	3
19	8	0	0	0	0	8
27	1	0	0	0	0	1
Sum	401	24	24	10	23	482

Figure 3. Neighbor-joining based tree of Bryde's whale mtDNA haplotypes. Haplotype frequencies by locality are also shown. Closed circles indicate high bootstrap values (over 50% in 1,000 simulations).

Appendix 1. Sightings and catches of confirmed Bryde's whale in Chilean waters.

N	Species	Date	Sighting (S) Match (C)	Latitude (S)	Longitude (W)	Number of whales	Source
1	Bryde's whale	5 May 1960	C	20º17	70º45	1	Clarke & Aguayo (1965)
2	Bryde's whale	16 Feb 1968	C	35º21	75º32	1	Nitto Whaling Co. records
3	Bryde's whale	16 Feb 1968	C	35º18	75º25	1	Nitto Whaling Co. records
4	Bryde's whale	17 Feb 1968	C	34º32	75º20	1	Nitto Whaling Co. records
5	Bryde's whale	20 Feb 1968	C	34º45	75º11	1	Nitto Whaling Co. records
6	Bryde's whale	24 Feb 1968	C	35º15	75º19	1	Nitto Whaling Co. records
7	Bryde's whale	24 Feb 1968	C	34º40	75º30	1	Nitto Whaling Co. records
8	Bryde's whale	25 Feb 1968	C	35º10	76º16	1	Nitto Whaling Co. records
9	Bryde's whale	3 March 1968	C	37º58	75º29	1	Nitto Whaling Co. records
10	Bryde's whale	4 Mar 1968	C	36º55	74º22	1	Nitto Whaling Co. records
11	Bryde's whale	5 Feb 1982	S	32º14	74º27	2	Gallardo *et al*. (1983)
12	Bryde's whale	6 Feb 1982	S	32º58	73º26	2	Gallardo *et al*. (1983)
13	Bryde's whale	7 Feb 1982	S	33º27	73º10	1	Gallardo *et al*. (1983)
14	Bryde's whale	10 Feb 1982	S	35º40	73º20	1	Gallardo *et al*. (1983)
15	Bryde's whale	10 Feb 1982	S	35º42	73º40	5	Gallardo *et al*. (1983)
16	Bryde's whale	10 Feb 1982	S	35º43	73º55	3	Gallardo *et al*. (1983)
17	Bryde's whale	10 Feb 1982	S	35º45	74º00	2	Gallardo *et al*. (1983)
18	Bryde's whale	10 Feb 1982	S	35º27	74º10	1	Gallardo *et al*. (1983)
19	Bryde's whale	10 Feb 1982	S	35º15	74º28	1	Gallardo *et al*. (1983)
20	Bryde's whale	11 Feb 1982	S	35º31	74º21	1	Gallardo *et al*. (1983)
21	Bryde's whale	11 Feb 1982	S	35º50	74º17	1	Gallardo *et al*. (1983)
22	Bryde's whale	11 Feb 1982	S	35º53	74º15	1	Gallardo *et al*. (1983)
23	Bryde's whale	11 Feb 1982	S	36º05	74º09	1	Gallardo *et al*. (1983)
24	Bryde's whale	12 Feb 1982	S	36º33	74º25	1	Gallardo *et al*. (1983)
25	Bryde's whale	13 Feb 1982	S	36º28	74º35	2	Gallardo *et al*. (1983)
26	Bryde's whale	10 April 1983	C	33º55	72º46	1**	Macaya Whaling Co. records
27	Bryde's whale	12 April 1983	C	35º19	73º09	1**	Macaya Whaling Co. records
28	Bryde's whale	15 April	C	33º20	72º21	1	Macaya Whaling Co. records

		1983					
29	Bryde's whale	2 Sept 1994	S	26º26	81º02	1	Aguayo *et al*. (1998)*
30	Bryde's whale	3 Sept 1994	S	26º59	86º31	1	Aguayo *et al*. (1998)*
31	Bryde's whale	14 Dec 1997	S	23º54	71º41	2	Findlay *et al*. (1998)
32	Bryde's whale	14 Dec 1997	S	24º08	71º45	1**	Findlay *et al*. (1998)
33	Bryde's whale	14 Dec 1997	S	18º43	71º09	1	Findlay *et al*. (1998)
34	Bryde's whale	14 Dec 1997	S	18º44	71º11	1	Findlay *et al*. (1998)
35	Bryde's whale	14 Dec 1997	S	18º54	72º07	1	Findlay *et al*. (1998)
36	Bryde's whale	15 Dec 1997	S	28º36	73º21	1	Findlay *et al*. (1998)
37	Bryde's whale	15 Dec 1997	S	19º05	72º37	1	Findlay *et al*. (1998)
38	Bryde's whale	15 Dec 1997	S	19º15	72º49	1	Findlay *et al*. (1998)
39	Bryde's whale	15 Dec 1997	S	19º27	72º15	1	Findlay *et al*. (1998)
40	Bryde's whale	15 Dec 1997	S	19º29	72º44	1	Findlay *et al*. (1998)
41	Bryde's whale	15 Dec 1997	S	19º31	72º40	1	Findlay *et al*. (1998)
42	Bryde's whale	15 Dec 1997	S	19º33	72º32	1	Findlay *et al*. (1998)
43	Bryde's whale	15 Dec 1997	S	19º38	72º17	1	Findlay *et al*. (1998)
44	Bryde's whale	16 Dec 1997	S	32º25	74º48	1	Findlay *et al*. (1998)
45	Bryde's whale	16 Dec 1997	S	32º27	74º50	1	Findlay *et al*. (1998)
46	Bryde's whale	16 Dec 1997	S	19º47	71º51	1	Findlay *et al*. (1998)
47	Bryde's whale	16 Dec 1997	S	19º58	71º18	2	Findlay *et al*. (1998)
48	Bryde's whale	17 Dec 1997	S	20º37	71º17	1	Findlay *et al*. (1998)
49	Bryde's whale	17 Dec 1997	S	20º33	71º26	1	Findlay *et al*. (1998)
50	Bryde's whale	17 Dec 1997	S	20º35	71º37	1	Findlay *et al*. (1998)
51	Bryde's whale	18 Dec 1997	S	20º44	71º40	1	Findlay *et al*. (1998)
52	Bryde's whale	18 Dec 1997	S	20º47	71º52	1	Findlay *et al*. (1998)
53	Bryde's whale	18 Dec 1997	S	20º54	72º05	1	Findlay *et al*. (1998)
54	Bryde's whale	19 Dec 1997	S	21º46	71º15	1**	Findlay *et al*. (1998)
55	Bryde's whale	19 Dec 1997	S	21º47	71º09	1	Findlay *et al*. (1998)
56	Bryde's whale	20 Dec 1997	S	22º46	72º18	1	Findlay *et al*. (1998)
57	Bryde's whale	20 Dec 1997	S	22º46	72º18	2	Findlay *et al*. (1998)
58	Bryde's whale	20 Dec 1997	S	22º48	72º23	1	Findlay *et al*. (1998)
59	Bryde's whale	21 Dec 1997	S	22º49	72º25	1	Findlay *et al*. (1998)

60	Bryde's whale	21 Dec 1997	S	22º47	72º25	1**	Findlay *et al*. (1998)
61	Bryde's whale	21 Dec 1997	S	22º51	72º34	3	Findlay *et al*. (1998)
62	Bryde's whale	21 Dec 1997	S	22º50	72º39	1**	Findlay *et al*. (1998)
63	Bryde's whale	21 Dec 1997	S	23º19	72º41	2	Findlay *et al*. (1998)
64	Bryde's whale	21 Dec 1997	S	23º32	72º29	1	Findlay *et al*. (1998)
65	Bryde's whale	21 Dec 1997	S	23º36	72º19	2	Findlay *et al*. (1998)
66	Bryde's whale	21 Dec 1997	S	23º38	72º17	1	Findlay *et al*. (1998)
67	Bryde's whale	24 Dec 1997	S	27º02	71º38	1**	Findlay *et al*. (1998)
68	Bryde's whale	24 Dec 1997	S	27º04	71º38	1	Findlay *et al*. (1998)
69	Bryde's whale	26 Dec 1997	S	32º45	74º17	2	Findlay *et al*. (1998)
70	Bryde's whale	26 Dec 1997	S	32º37	74º25	1	Findlay *et al*. (1998)
71	Bryde's whale	26 Dec 1997	S	27º41	72º54	1**	Findlay *et al*. (1998)
72	Bryde's whale	26 Dec 1997	S	27º33	71º21	1	Findlay *et al*. (1998)
73	Bryde's whale	26 Dec 1997	S	27º32	71º22	1	Findlay *et al*. (1998)
74	Bryde's whale	27 Dec 1997	S	27º13	71º23	1	Findlay *et al*. (1998)
75	Bryde's whale	27 Dec 1997	S	27º11	71º22	1	Findlay *et al*. (1998)
76	Bryde's whale	27 Dec 1997	S	27º06	71º23	1	Findlay *et al*. (1998)
77	Bryde's whale	27 Dec 1997	S	27º00	71º23	1	Findlay *et al*. (1998)
78	Bryde's whale	27 Dec 1997	S	26º38	71º27	1	Findlay *et al*. (1998)
79	Bryde's whale	27 Dec 1997	S	26º39	71º35	1	Findlay *et al*. (1998)
80	Bryde's whale	28 Dec 1997	S	30º40	72º25	2	Findlay *et al*. (1998)
81	Bryde's whale	29 Dec 1997	S	30º36	72º16	1	Findlay *et al*. (1998)
82	Bryde's whale	29 Dec 1997	S	30º46	72º11	1	Findlay *et al*. (1998)
83	Bryde's whale	29 Dec 1997	S	27º57	73º04	1	Findlay *et al*. (1998)
84	Bryde's whale	29 Dec 1997	S	27º59	73º22	2	Findlay *et al*. (1998)
85	Bryde's whale	29 Dec 1997	S	27º16	73º31	2	Findlay *et al*. (1998)
86	Bryde's whale	30 Dec 1997	S	30º52	72º26	1	Findlay *et al*. (1998)
87	Bryde's whale	30 Dec 1997	S	30º50	72º28	2	Findlay *et al*. (1998)
88	Bryde's whale	30 Dec 1997	S	30º53	72º32	1**	Findlay *et al*. (1998)
89	Bryde's whale	30 Dec 1997	S	30º51	72º34	1	Findlay *et al*. (1998)
90	Bryde's whale	30 Dec 1997	S	30º49	72º28	1**	Findlay *et al*. (1998)
91	Bryde's whale	30 Dec	S	30º48	72º26	2	Findlay *et al*. (1998)

		1997					
92	Bryde's whale	30 Dec 1997	S	27º58	71º33	1	Findlay *et al*. (1998)
93	Bryde's whale	30 Dec 1997	S	27º59	71º49	1	Findlay *et al*. (1998)
94	Bryde's whale	31 Dec 1997	S	30º26	73º43	1	Findlay *et al*. (1998)
95	Bryde's whale	31 Dec 1997	S	30º23	73º29	1	Findlay *et al*. (1998)
96	Bryde's whale	31 Dec 1997	S	28º22	72º09	1	Findlay *et al*. (1998)
97	Bryde's whale	31 Dec 1997	S	28º26	72º05	1	Findlay *et al*. (1998)
98	Bryde's whale	2 Jan 1998	S	30º02	72º24	1	Findlay *et al*. (1998)
99	Bryde's whale	2 Jan 1998	S	29º59	72º19	1	Findlay *et al*. (1998)
100	Bryde's whale	2 Jan 1998	S	29º56	72º19	1	Findlay *et al*. (1998)
101	Bryde's whale	2 Jan 1998	S	29º53	72º08	1	Findlay *et al*. (1998)
102	Bryde's whale	2 Jan 1998	S	29º49	71º54	1	Findlay *et al*. (1998)
103	Bryde's whale	3 Jan 1998	S	32º48	72º14	2	Findlay *et al*. (1998)
104	Bryde's whale	3 Jan 1998	S	32º38	72º28	1	Findlay *et al*. (1998)
105	Bryde's whale	15 April 2000	S	20°29	70°56	2	Records by Yacht Balaena
106	Bryde's whale	13 May 2000	S	19°56	71°03	2	Records by Yacht Balaena
107	Bryde's whale	26 Sept 2000	S	23°38	70°56	1	Records by Yacht Balaena
108	Bryde's whale	3 Oct 2000	S	19°38	71°50	1	Records by Yacht Balaena
109	Bryde's whale	28 Oct 2000	S	24°49	70°51	1	Records by Yacht Balaena
110	Bryde's whale	23 Nov 2000	S	23°10	72°04	1	Records by Yacht Balaena

*Sightings made around Eastern Island (not in the maps of Figures 1 and 2).
** Samples used in the genetic analysis.