

Figure 7. Frequency of group size of A. feeding and B. travelling Brydes whales—1999–2003 data from Hauraki Gulf and northeast coast of New Zealand combined.

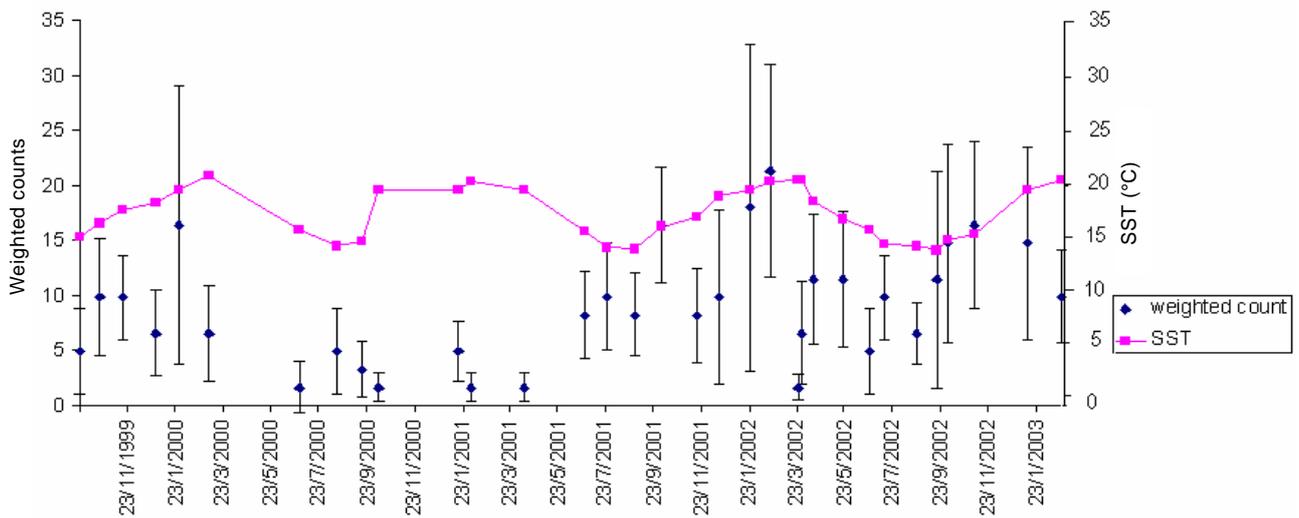
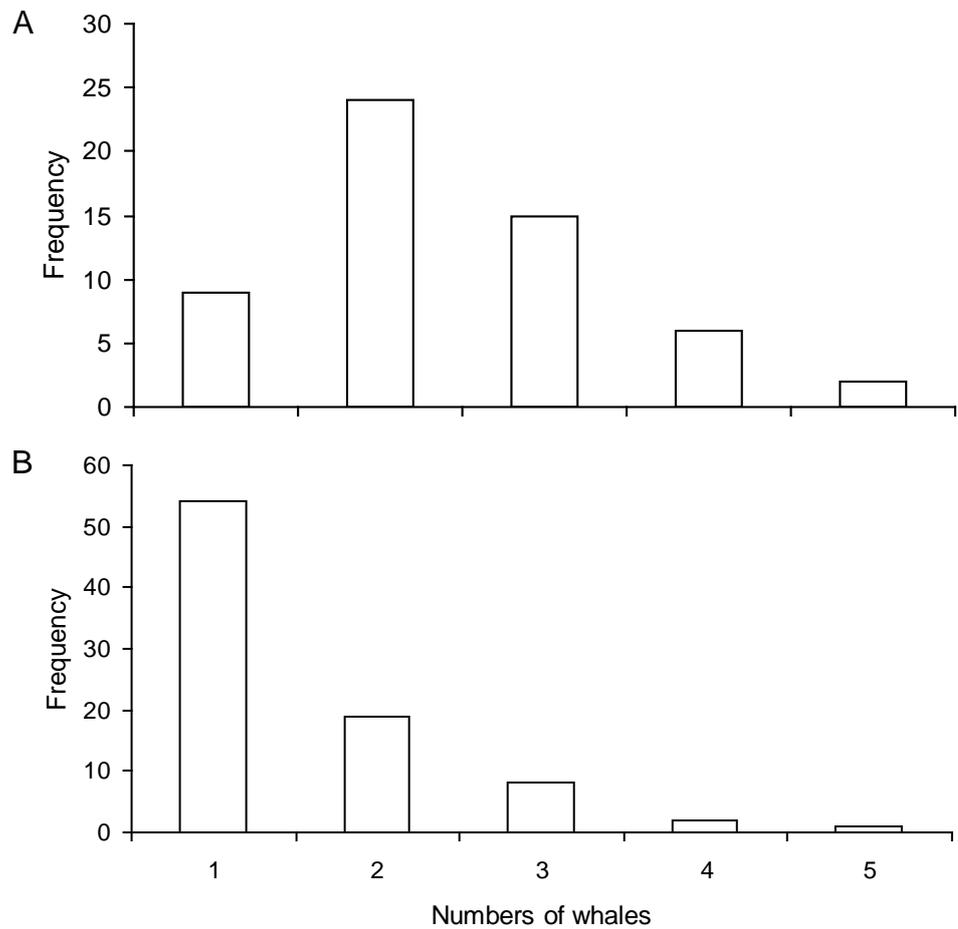


Figure 8. Weighted mean counts (± SEM) of Bryde's whales and sea surface temperatures (SST) in the Hauraki Gulf. Temperature data from Goat Island Marine Laboratory.

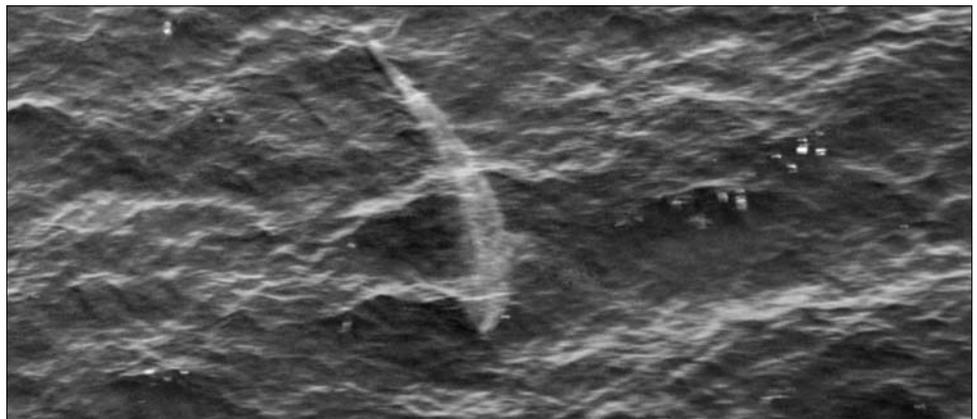
Figure 9. Bryde's whale feeding on side, telephoto from 800 ft.



Figure 10. Compact 'package' of exhaled bubbles from a submerged Bryde's whale, telephoto from 800 ft.



Figure 11. Bryde's whale swimming underwater, telephoto from 800 ft.



3.3 DISTRIBUTION OF BRYDE'S WHALES IN THE HAURAKI GULF

To ascertain whether Bryde's whales favoured particular parts of the Hauraki Gulf, the area was divided into an inner and an outer part at 36°14'S; the 'outer' Gulf being essentially the area north of Little Barrier Island (water c. 50-90 m deep), and the 'inner' Gulf being south of the island (water < c. 50 m deep). The weighted mean densities of whales in the outer and inner Gulf were significantly different ($P < 0.05$), with more whales recorded in the inner Gulf than the outer during the study period. This difference in distribution may be due to the concentration of planktonic and pelagic food in the Jellicoe and Cradock Channels in spring and summer (Fig. 1). A 1-knot southerly current flows through those channels in summer and would enhance the concentration of pelagic food in that area (Royal New Zealand Navy Hydrographic Office Chart NZ53).

The dataset was also split into summer (September to February) and winter (March to August) for the inner and outer Hauraki Gulf combined. There was a higher density of whales in summer than in winter, which is most likely temperature- and food-related. No statistically significant seasonal difference was found, however ($P > 0.05$), which could be due to the small sample size. The seasonal occurrence of Bryde's whales in the Hauraki Gulf is shown in Fig. 8, plotted against sea surface temperature (SST).

Whales were recorded within the Hauraki Gulf in sea surface temperatures that ranged from 14.1°C to 21.6°C. Bryde's whales are known to be stenothermic (i.e. can tolerate only a small range of temperatures) and this temperature range is similar to that recorded for these whales elsewhere, although it is wider than the range recorded in South Africa (15°C–18°C; Best 1960) and Chile (Gallardo et al. 1983).

We regard the Bryde's whales from South Africa to be *B. brydei* rather than *B. edeni*, based on the type locality of *B. brydei* being southern South Africa, and the molecular analyses carried out by Wada et al. (2003). The Chilean species requires further study, but is probably *B. brydei* as well, given its temperate location and large size (Clarke and Aguayo 1965). In tropical areas of the South Pacific (e.g. the Solomon Islands), 'Bryde's whales' (probably *B. omurai* in this case) have been recorded in waters with temperatures up to 30.1°C (Shimada & Pastene 1995).

In all of the years surveyed, the number of sightings of Bryde's whales in the Hauraki Gulf increased noticeably in late October, when SST rose markedly. For example, in late October 2001, the SST in the Gulf rose 1.6°C over a period of 3 weeks to 17°C, and 18 Bryde's whales were seen on one day in the second week of this period (when the temperature reached 16.7°C), heading inshore in a southwesterly direction from the outer Gulf. This increase in whale sightings in spring, and the subsequent decrease in sightings in autumn as the ocean cooled, indicated some seasonal movement of whales in and out of the Hauraki Gulf to the north and south depending on the season.

The survey did not detect any definite pattern of longitudinal migration, however, and it was clear that not all whales left the Gulf in the cooler parts of the year, as there were always some sightings in mid-winter in the inshore areas, especially in the southern parts of the Gulf. Bryde's whales in other parts of the world are not known to migrate long distances, and limited geographical shifts have been attributed to seasonal changes in water temperatures and the movement of food fishes (Best 1960, 1975, 2001).

3.4 DISTRIBUTION OF BRYDE'S WHALES ALONG NORTHLAND'S EAST COAST BEYOND THE HAURAKI GULF

The search flights parallel to the eastern coast of Northland recorded Bryde's whales at many locations within 27 n.m. of the coast, mainly in summer (Figs 1, 4 & 5). Although the numbers of Bryde's whales were low on the coast during winter, there was no evidence of an along-shore shift northwards in the population prior to the cooler season, although there could have been an offshore movement

eastwards towards the Kermadec Islands which would not necessarily have been detected by the coastal search flights. The whales were concentrated in certain coastal areas during summer months, such as the Parry Channel between Bream Head and the Hen and Chickens Islands, Cape Brett, the Cavalli Islands and Cape Karikari. These locations intersect the warm, southward-flowing East Australian Current, and are known by fishermen for their high productivity. It is not surprising, therefore, to find large whales frequenting these areas.

3.5 OVERALL DISTRIBUTION OF BRYDE'S WHALES IN NEW ZEALAND WATERS

In New Zealand waters, Bryde's whales are known from the northeastern coastal region between East Cape and North Cape (Gaskin 1963, 1968) (Fig. 1). There is one at-sea record of four individual Bryde's whales (reported as *B. edeni*) just west of the Chatham Islands, at 44°S (Privalikhin & Berzin 1978). Records south of East Cape (37°41'S) are mostly of strandlings which may have drifted south (after death) on the East Australian Current. Twenty-five Bryde's whales strandings have been recorded in the Auckland and Northland provinces (some early records were misidentified as sei whales, *B. borealis*). Of these 25, one record was from the northwest coast, at Moremonui (35°54'S 173°42'E), and another was from the North Island's northernmost coast, at Spirits Bay (34°26'S 172°49'E). The remaining 23 strandings were between the Bay of Islands in the north and the Firth of Thames in the south. Although most of the earlier records did not include data on cause of death, some of the more recent records do. Within the Gulf, one whale drowned following entanglement in a mussel farm spat line at Great Barrier Island in 1996 (Lloyd 2003). Another whale was fatally struck and caught by the bow bulb of a container vessel, and two others showed tissue and skeletal damage which could have been caused by ship strikes (Thelma Wilson, DOC, Auckland, pers. comm. to ANB 03 March 2006; records in the New Zealand Whale Stranding Database; Van Waerebeek et al. 2006). The port of Auckland is one of New Zealand's major destinations for incoming cargo and passenger vessels, and many ships enter the inner Hauraki Gulf through the Jellicoe, Cradock, and Colville Channels, and cross the Gulf towards Auckland, passing through the major Gulf habitat of Bryde's whales. The strike records thus far are probably an under-representation of the actual number of fatalities due to collisions with large ships in the area, because unless a whale is actually caught on a ship's bow bulb, it may drift around the Gulf after a collision and decompose unseen, or wash ashore in such a poor state that it is not possible to attribute a cause of death.

Bryde's whales are also the target of commercial whale-watching tourism vessels in the Hauraki Gulf, Bream Bay, Tutukaka, the Bay of Islands, and Doubtless Bay (Fig. 1).

3.6 OCCURRENCE OF CALVES

Ten Bryde's whale calves, with estimated lengths of 4–6 m, were observed on six occasions during the survey. Eight were seen in the Hauraki Gulf in the months of August, October, November, and January, and two were seen in the Bay of Islands in October. A female Bryde's whale containing an early foetus

115 cm long was taken by the whaling station on Great Barrier Island (Aotea Island) in the Hauraki Gulf on 15 July, 1961 (Mr Charlie Heberly, former manager of the whaling station, pers. comm. to ANB, August 1999). A juvenile (7.1 m long) stranded at Spirits Bay (34°26'S, 172°49'E) in June 1995. New-born calves of this species are between 3.81 m and 3.96 m in length (Best 2001), and the gestation period is thought to be 1 year, although the whales may not necessarily give birth every 2 years, as is common in cetaceans (Cummings 1985). These records indicate a late winter to early spring calving season on New Zealand's northeastern coast, or in nearby oceanic Pacific waters.

In South African waters, the inshore population of Bryde's whales breeds throughout the year and the offshore population only during autumn (Best 1975, 2001).

3.7 OTHER MARINE SPECIES SEEN IN ASSOCIATION WITH BRYDE'S WHALES

Other species of cetaceans were observed in the Hauraki Gulf during the survey: blue whales *Balaenoptera musculus intermedia*, fin whales *B. physalus*, sei whales *B. borealis*, minke whales (both Antarctic *B. bonarensis* and dwarf *B. acutorostrata*), beaked whales of the genus *Mesoplodon*, long-finned pilot whales *Globicephala melas*, killer whales *Orcinus orca*, short-beaked common dolphins *Delphinus delphis*, and common bottlenose dolphins *Tursiops truncatus* (Fig. 12). O'Callaghan & Baker (2002) also recorded some of these species in the Hauraki Gulf during the spring/summer period of 2000/2001. Common dolphins were the species most often observed in association with Bryde's whales in feeding aggregations, and a large population apparently exists in the Gulf (pods of between 200 and 300 dolphins were often seen during the survey). Common dolphins were the most frequently seen cetaceans on the search flights between the Hauraki Gulf and North Cape, and their distribution along the continental shelf frequently coincides with that of Bryde's whales (Figs 4 & 13). This common distribution may relate in part to similarity of favoured prey species. Common bottlenose dolphins were only recorded twice in feeding workups with Bryde's whales.

Figure 12. Bryde's whale travelling with four common bottlenose dolphins escorting.





Figure 13. Northeastern New Zealand, showing all sightings of common short-beaked dolphins between 1999 and 2003. Circles may represent more than one individual at that location.

It was possible to broadly identify birds from the plane based on size and colour pattern; also, there was confirmation of some sightings by Birding New Zealand observers on boats in the area at the time of some survey flights. Feeding workups were invariably also attended by large numbers of actively diving gannets, as well as shearwaters (e.g. Buller's shearwater *Puffinus bulleri*, flesh-footed shearwater *P. carneipes*, fluttering shearwater *P. gavia*, petrels (e.g. Cook's petrel *Pterodroma cookii*, white-faced storm petrel *Pelagodroma marina*), terns (e.g. white-fronted tern *Sterna striata* and, near the Mokohinau Islands, grey ternlet *Procelsterna cerulean*).

Killer whales were not observed feeding, but were seen travelling, including (on one occasion) 'tailing' a Bryde's whale in the mid Hauraki Gulf. Common bottlenose dolphins were observed on two occasions close in under the head of a fast-moving Bryde's whale (Fig. 12). Manta rays *Mobula japonica* were observed feeding near one workup in the outer Hauraki Gulf in April 2001. Other species such as striped marlins *Tetrapturus audax* and tiger sharks *Galeocerdo cuvier* were also seen from the aircraft in the vicinity of Bryde's whales; these were possibly coincidental occurrences.

4. Acknowledgements

This study was funded by the Department of Conservation (Science Investigation No. 3225). I am grateful to Ian West for support during the research, and to many other departmental staff and others who assisted in the aerial survey or by reporting whale sightings. In particular, Lynette Wilson, Peggy Reindel, Katrina Upperton, Darrell Lim Yock, Alan Fleming, Tara Ross-Watt, Ciarian Edwards, and Jenny and Tony Enderby. Pilots from Salt Air Ltd, Bay of Islands, New Zealand Aerial Mapping, Albany, and Christian Air, Ardmore, provided safe, accurate, and timely flying. Pilot Allan Smallfield was especially obliging. Jo Evans, University of Auckland Marine Laboratory, Leigh, provided monthly sea surface temperatures. Rosemary Tully and Birding New Zealand provided regular reports on the occurrence of sea birds and whales in the Hauraki Gulf. Peggy Reindel, University of Dresden, Federal Republic of Germany, and Craig Buchanan, and Terry Conaghan, Northland Conservancy, Department of Conservation, developed a GIS from the survey and other data. Dr Ingrid Visser provided the cover photograph, and collected a sample of Bryde's whale faecal matter. Elaine Myson of the International Whaling Commission, U.K., and Dr John Bannister, Perth, Western Australia, provided information on aerial survey techniques, and Dr Luis A. Pastene, The Institute of Cetacean Research, Japan, kindly provided literature on Bryde's whales not readily available in New Zealand. Anton van Helden, Museum of New Zealand Te Papa Tongarewa, provided data from the Department of Conservation's New Zealand Whale Stranding Database. Dr Tadasu Yamada, National Science Museum, Japan, advised on the taxonomic status of Bryde's whales around Australasia. Dr Koen Van Waerebeek, Peruvian Centre for Cetacean Research (CEPEC), kindly commented on a draft of the manuscript.

5. References

- Auckland Regional Council 2005: Hauraki Gulf Forum. Hauraki Gulf State of the Environment Report. P. 223.
- Baker, A.N. 1999: Whales and dolphins of New Zealand and Australia. An identification guide. Victoria University Press. 133 p.
- Best, P.B. 1960: Further information on Bryde's whales (*Balaenoptera edeni* Anderson) from Saldanha Bay, South Africa. *Norsk Hvalfangst-Tidende* 49: 201–215.
- Best, P.B. 1974: Status of the whale populations off the west coast of South Africa and current research. Pp. 53–81 in Schevill, W.E (Ed.): The whale problem. A status report Harvard University Press, Cambridge, Mass., USA.
- Best, P.B. 1975: Status of Bryde's whales (*Balaenoptera edeni* or *brydei*). FAD Advisory Committee on Marine Resources Research, Marine Mammal Symposium.
- Best, P.B. 1977: Two allopatric forms of Bryde's whales off South Africa. *Report of the International Whaling Commission* (Special Issue 1): 10–38.
- Best, P.B. 2001: Distribution and population separation of Bryde's whale *Balaenoptera edeni* off southern Africa. *Marine Ecological Progress Series* 220: 277–289.
- Buckland, S.T.; Anderson, D.R.; Burnham, K.P.; Laake, J.L.; Borchers, D.L.; Thomas, L. 2004: Advanced Distance Sampling. Oxford University Press. 416 p.
- Burnham, K.P.; Anderson, D.R.; Laake, J.L. 1980: Estimation of density for line transect sampling of biological populations. *Wildlife Monographs* 72. 220 p.
- Chittleborough, R.G. 1961: *B. brydei* Olsen on the west coast of Australia. *Norsk. Hvalfangst-Tidende* 48: 62–66.
- Clarke, R.; Aguayo, A. 1965: Bryde's whales in the south-east Pacific. *Norsk. Hvalfangst-Tidende* 51(7): 141–148.
- Cummings, W.C., 1985: Bryde's whale *Balaenoptera edeni* Anderson, 1878. Pp. 137–154 in Harrison, Sir R.; Ridgway, S.H. (Eds): Handbook of marine mammals volume 3. The sirenians and baleen whales. Academic Press London.
- Dawbin, W.H. 1956: Whale marking in South Pacific waters. *The Norwegian Whaling Gazette* 9: 485–508.
- Eberhardt, L.L.; Chapman, D.G.; Gilbert, J.R. 1979: A review of marine mammal census methods. *Wildlife Monographs* 63: 5–46.
- Gallardo, V.A.; Arcos, D.; Salamanca, M.; Pastene, L. 1983: On the occurrence of Bryde's whales (*Balaenoptera edeni* Anderson, 1878) in an upwelling area off central Chile. *Report of the International Whaling Commission* 33: 481–488.
- Gaskin, D.E. 1963: Whale marking cruises in New Zealand waters made between February and August 1963. *Norsk Hvalfangst-Tidende* 11: 1–12.
- Gaskin, D.E. 1965: New Zealand whaling and whale research. *New Zealand Science Review* 23: 19–22.
- Gaskin, D.E. 1968: The New Zealand Cetacea. *Fisberies Research Bulletin* (New Series) 1: 1–92.
- Gaskin, D.E. 1972: Whales dolphins and seals with special reference to the New Zealand region. Heinemann Educational Books, London. 200 p.
- Greig, M.J. 1990: Circulation in the Hauraki Gulf, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 24: 141–150.
- Heberly, H. 2004: Last of the whalers—Charlie Heberly's story. Cape Catley, Auckland. 212 p.
- Ivashin, M.V. 1980: On the populations of Bryde's whales (*Balaenoptera edeni* Anderson, 1878). *Report International Whaling Commission* 30: 233–236.

- Jillett, J.B. 1971: Zooplankton and hydrology of Hauraki Gulf New Zealand. *New Zealand Department of Scientific and Industrial Research Bulletin 204*: 103 p.
- Junge, G.C.A. 1950: On a specimen of the rare fin whale, *Balaenoptera edeni* Anderson, stranded on Pulu Sugi near Singapore. *Zoologische Verhandelingen 9*: 1-26.
- Kendrick, T.H.; Francis, M.P. 2002: Fish assemblages in the Hauraki Gulf, New Zealand. *New Zealand Journal of marine and Freshwater Research 36*: 699-717.
- Lloyd, B.D. 2003: Potential effects of mussel farming on New Zealand's marine mammals and seabirds: a discussion paper. Department of Conservation, Wellington, New Zealand. vii + 34 p.
- O'Callaghan, T.M.; Baker, C.S. 2002: Summer cetacean community with particular reference to Bryde's whales in the Hauraki Gulf, New Zealand. *DOC Science Internal Series 55*: 5-18.
- Olsen, O. 1913: On the external characteristics and biology of Bryde's whale (*Balaenoptera brydei*) a new rorqual from the coast of South Africa. *Proceedings of the Zoological Society of London*. Pp. 1073-1090.
- Omura, H. 1962: Further information on Bryde's whales from the coast of Japan. *Scientific Reports of the Whales Research Institute 16*: 7-18.
- Paul, L.J. 2000: New Zealand fishes. Identification, natural history and fisheries. Reed, Auckland, New Zealand. 253 p.
- Perrin, W.F.; Dolar, L.L.; Orega, E. 1996: Osteological comparison of Bryde's whales from the Philippines with specimens from other regions. *Report International Whaling Commission 46*: 409-413.
- Privalikhin, V.I.; Berzin, A.A. 1978: Abundance and distribution of Bryde's whales in the Pacific Ocean. *Report International Whaling Commission 28*: 301-302.
- Ramírez, A.P. 1992: Tres notas sobre la 'Ballena Bryde' (*Balaenoptera brydei*): alimentacion, contenido estomacal y distribucion. *Boletín de Lima 82*: 15-28.
- Rice, D. 1998: Marine mammals of the world. Systematics and distribution. Special Publication Number 4, The Society for Marine Mammalogy. The Allen Press, Lawrence, Kansas, USA. 232 p.
- Seber, G.A.F. 1986: A review of estimating animal abundance. *Biometrics 42*: 267-292.
- Shimada, H.; Pastene, L. 1995: Report of a sighting survey off the Solomon Islands with comments on Bryde's whale distribution. *Report International Whaling Commission 45*: 413-418.
- Thompson, K.F.; O'Callaghan, T.M.; Dalebout, M.L.; Baker, C.S. 2002: Population ecology of Bryde's whales (*Balaenoptera brydei* sp.) in the Hauraki Gulf, New Zealand: preliminary observations. *Report International Whaling Commission 54*: 1-8.
- Van Waerebeek, K.; Baker, A.N.; Felix, F.; Iniguez, M.; Sanino, G.P.; Secchi, E.; Slocrum, G.; Sutaria, D.; van Helden, A.L.; Wang, Y. 2006: Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere; building a standardized database. *Reports of the International Whaling Commission*. 14 p., SC/58/BC6.
- Visser, I.N. 1999: Benthic foraging on stingrays by killer whales (*Orcinus orca*) in New Zealand waters. *Marine Mammal Science 15*: 220-227.
- Wada, S.; Oishi, M.; Yamada, T.K. 2003: A newly discovered species of living baleen whale. *Nature 426*: 278-181.