Autopsy of cetaceans incidentally caught in fishing operations 1997/98, 1999/2000, and 2000/01

DOC SCIENCE INTERNAL SERIES 119

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff, or external contractors funded by DOC. It comprises progress reports and short communications that are generally peer-reviewed within DOC, but not always externally refereed. Fully refereed contract reports funded from the Conservation Services Levy (CSL) are also included.

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ISSN 1175–6519

ISBN 0–478–22416–8

In the interest of forest conservation, DOC Science Publishing supports paperless electronic publishing. When printing, recycled paper is used wherever possible.

This report was prepared for publication by DOC Science Publishing, Science & Research Unit; editing by Helen O'Leary and layout by Ian Mackenzie. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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PART 3—AUTOPSY REPORT FOR 2000/01

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Part 1 Autopsy report for 1997/98

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ABSTRACT

Morphological characteristics, estimated age, gender, reproductive status and stomach contents were determined for 12 Hector's dolphins (*Cephalorhynchus hectori*) and 2 dusky dolphins (*Lagenorhynchus obscurus*). The dusky dolphins and 3 of the Hector's dolphins were killed incidentally in commercial fishing operations. The dusky dolphins were caught in the Cook Strait and north of the Auckland Islands, while two Hector's dolphins were captured at the mouth of the Rangitata River in the Canterbury Bight, and one off the north Canterbury coast. The remaining 9 Hector's dolphins were either retrieved from set nets (n = 3) or found beachcast along the Canterbury Coast. One carcass was not labelled. Morphological characteristics of the animals were similar to those in the literature. The stomachs of all dolphins contained bones and otoliths of teleost fish. The Hector's dolphins had also eaten invertebrates such as crab and squid. Dolphins were aged using thin, stained sections of teeth. The age frequency distribution for Hector's dolphins was similar to that previously reported for this species with an over-representation of immature animals. Reproductive characteristics were also as previously reported with the single female Hector's dolphin sexually immature at 5 years old. All the males were immature apart from the oldest, which was estimated to be 7 years old. The dusky dolphins were sexually mature females as indicated by the presence of a corpus albicans on one ovary. They were estimated to be 7 and 8 years old. Histological characteristics of the older animal suggest that it had experienced at least one pregnancy. Of the eight dolphins known to have been entangled in nets, all had lesions consistent with death from entanglement and asphyxiation. Of the remaining six Hector's dolphins that were beachcast, three had lesions indicative of entanglement, two had lesions suggestive of this fate and one had some of the suite of lesions associated with death by asphyxiation.

Keywords: dolphins, Hector's, *Cephalorhynchus hectori*, dusky, *Lagenorhynchus obscurus*, autopsy, stomach contents, estimated age, North Island, South Island, New Zealand

Duignan, P.J. 2003. Part 1: Autopsy report for 1997/98. Pp. 5–28 in Duignan, P.J.; Gibbs, N.J.; Jones, G.W.: Autopsy of cetaceans incidentally caught in fishing operations 1997/98, 1999/2000, and 2000/01. *DOC Science Internal Series 119*. Department of Conservation, Wellington. 66 p.

1. Introduction

The primary objective of this study was to fulfil the requirements of DOC contract CSL 96/3040 by recording and interpreting data on each animal (see Appendix 2 for Data sheet form). These data included species, sex, size, body condition, age, reproductive status, and stomach contents. This report details the findings pertinent to this objective and includes data on 12 Hector's dolphins (*Cephalorhynchus hectori*) and 2 dusky dolphins (*Lagenorhynchus obscurus*) killed incidentally in fishing operations.

A second objective was to examine the carcasses for evidence of disease and to collect material for ongoing and future research projects. To this end, entire skeletons were collected for the Museum of New Zealand Te Papa, Wellington (Anton van Helden), genetic samples were collected for the University of Auckland (Dr Scott Baker) and the Massey University Institute of Molecular Biosciences, Palmerston North (Prof. David Penny). Anatomical specimens were provided for post-graduate studies, blubber for eco-toxicology (Dr Paul Jones and Dr Hamish Reid, Institute of Environmental Science and Research, ESR) and foraging studies. Studies on pathology and disease are ongoing and include the epidemiology of viral infections (dolphin distemper or morbillivirus infection), parasite and bacterial infections. These studies on pathogens and disease are of particular importance in regard to the status of the endemic Hector's dolphins as relatively little is known of their health status and susceptibility to disease.

Hector's dolphin is a small coastal species and New Zealand's only endemic cetacean (Baker 1978). The total population is estimated to be 7270 animals (Slooten et al. 2002). Four genetically distinct and largely geographically isolated populations of *Cephalorhynchus hectori* are found off the northwest coast of the North Island, and the west, east, and southern coasts of the South Island (Pichler et al. 1998). The life history characteristics of the species are similar to other members of the genus *Cephalorhynchus*, such as Commerson's dolphin (*C. commersoni*) and are characterised by a low potential for growth (Lockyer et al. 1988; Slooten & Lad 1990). This, combined with a low rate of female dispersal between populations, increase the vulnerability of the species to local extinction if mortality rates exceed recruitment. Entanglement appears to be one of the most significant factors negatively impacting the species and was the impetus for establishment of a Marine Mammal Sanctuary around the Bank's Peninsula in November 1988 (Dawson & Slooten 1992). Causes of natural mortality are not well understood, but predation by sharks may be of significance (Slooten & Dawson 1994). Although most research to date has focused on establishing life history parameters to construct predictive models of fisheries impacts (Slooten & Lad 1990; Martien et al. 1999), there is clearly a need for more research into the natural causes of morbidity and mortality.

The dusky dolphin is also an inshore species, but it has a more circumpolar distribution in warm-temperate and cold-temperate waters of the Southern Hemisphere (Leatherwood et al. 1983). In New Zealand, it is found commonly from East Cape to as far south as Campbell Island (Baker 1999a). Group sizes vary seasonally, at least in Cook Strait, where hundreds may be seen in summer, but pods of 6–15 are more common in winter (Leatherwood et al. 1983). Causes of mortality for dusky dolphins include stranding (Duignan unpubl. data), predation (Constantine et al. 1998) and entanglement (Leatherwood et al. 1983; Van Bressem et al. 1993). Little is known about causes of disease among New Zealand dusky dolphins, but dolphin pox and herpes-like viral infections are common in this species off Peru (Van Bressem et al. 1993). Parasitic mastitis caused by *Crassicauda* sp. is thought to be a cause of reproductive failure for a related species, the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) (Geraci & St. Aubin 1987). A similar parasitic infection was found in the mammary gland of one of the dusky dolphins in this study and has been observed in stranded individuals of this species in New Zealand (Duignan et al., this paper). Further investigation of the causes of morbidity and mortality for dusky dolphins is required.

2. Materials and methods

2.1 MATERIALS

A total of 12 Hector's dolphin carcasses were received, consisting of 1 female and 11 male dolphins. In addition, there were 2 female dusky dolphins. For the 3 Hector's dolphins and 2 dusky dolphins retrieved from trawl nets the observer's data are recorded with the catch date, time, and coordinates (Appendix 1, Table 1.1). The 3 Hector's dolphins that were caught in trawl nets were captured off the Canterbury coast south of Kaikoura (n = 1) and at the mouth of the Rangitata River in the Canterbury Bight (n = 2). The coordinates reported for one of these dolphins placed its capture location within the river itself (Fig. 1.1). Of the two dusky dolphins caught in trawl nets, one was captured in the Cook Strait and the other to the north of the Auckland Islands. The remaining Hector's dolphins were either removed from set nets (n = 3), found beachcast (n = 5), or are of unknown origin (n = 1). The Hector's dolphins retrieved from set nets included two from the same net at Gore Bay, Canterbury, and one from a net approximately 2 nautical miles from Sumner Head (Appendix 1, Table 1.2). The remaining dolphins of known origin came from Leithfield Beach, Canterbury, in the vicinity of Saltwater Creek (Table 1.2). The unlabelled dolphin was also thought to have come from the Canterbury coast.

The dolphin carcasses were delivered to Massey University frozen and wrapped in clear plastic bags and woven nylon sacks. Five were identified by Conservation Services Levy (CSL) observer data sheets inserted into their mouths, 10 dolphins had orange tags tied to their tailstocks and one had no identification. On receipt, the dolphins were stored at –20°C until necropsy.

All the Hector's dolphins were removed from the freezer together and retagged as they were unwrapped. The dusky dolphins were examined singly on receipt. Species and sex were recorded based on external morphology and photographs

Figure 1.1. Capture locations for Hector's and dusky dolphins incidentally caught in fishing operations, 19997/98 season.

of the external characteristics of each carcass. A unique code and pathology number was assigned to each animal as follows:

For example:

WB98-10Ch

WB—whale bycatch, 98—year, 10—animal number, and Ch—abbreviation of species scientific name; in this case *Cephalorhynchus hectori*.

2.2 METHODS

2.2.1 Necropsy protocol

Pathological examination and sampling was conducted according to a standard protocol adapted from published small cetacean necropsy protocols (Geraci & Lounsbury 1993; Jefferson et al. 1994). The procedure included recording the body weight (kg), external measurements (m), and examination of the carcass for external lesions such as trauma, net marks, tissue loss, scars, etc. Carcasses were placed with the left side down and an incision made through the blubber from the cranial insertion of the dorsal fin to the ventral midline. Blubber depth (m) was measured dorsally, laterally and ventrally along this incision. Then the carcass was carefully flensed and the subcutis examined for evidence of trauma. Lesions in the blubber and subcutis were sampled for histopathology by fixing tissue in 10% buffered formalin. A blubber sample was taken and stored at –20°C for future fatty acid analysis. A sample of blood (10 ml) was collected from one of the large vessels of the heart. The internal organs were examined systematically for lesions and tissues sampled for histopathology, virology, parasitology, bacteriology (faeces routinely and tissues where appropriate), toxicology (liver, kidney, bile), genetics (skin, heart muscle), and anatomical studies. The stomach was removed, tied off, and stored chilled until the contents could be examined the following day. At least three of the largest teeth from the middle of the dental arcade of the mandible were extracted, washed and stored in 70% ethanol until they were prepared for age determination. The reproductive organs were carefully dissected, measured (mm), weighed (g), and stored in 10% buffered formalin. The females' reproductive tracts were photographed.

2.2.2 Stomach contents

The full stomachs were weighed (kg), then opened with scissors and all material washed into a 1 mm sieve. The stomach was then re-weighed to allow the weight of the stomach contents to be determined. Large, relatively undigested material was removed at this stage, and if possible an axial length (mm) was measured for fish and squid. Smaller, more digested material was gradually sorted using a black-bottomed tray. Otoliths were clearly visible against this background, and as they are denser than most of the other material, they sank to the bottom of the tray. Otoliths, squid beaks and other relevant food material were also removed and stored in 70% ethanol. Parasites were collected and preserved in 5% buffered formalin. Lesions in the gastric mucosa were described, counted, and examples photographed.

2.2.3 Age determination

Age determination was based on a modification of a published protocol for Hector's dolphins (Slooten 1991). Briefly, the teeth were weighed (g) using a Mettler PM 4800 Delta Range balance, and the length and greatest diameter (mm) measured using Vernier callipers. The teeth were then washed in tap water and decalcified for 24 hours in 5% nitric acid using at least 100 mL per gram of tooth. After an overnight soak in water, the teeth were immersed in formol formic acid for 24 hours and then washed overnight in running tap water. The teeth were then soft enough to cut approximately one-third away using a microtome blade. The cut surface was placed face down in a plastic cassette and embedded in paraffin wax. The cassettes were processed by a Citadel Tissue Processor (Shandon, UK) as for soft tissues. Sections were cut at 2–4 µm intervals using a microtome (Microtek Cut 4055F) and stainless steel disposable microtome blades (S35 Feather Safe Razor Co. Medical Division, Japan). Multiple sections were cut through each tooth and at least two teeth were processed per animal. The sections were stained with toluene blue, washed in water, dehydrated in absolute alcohol, cleaned in xylene, and mounted on glass slides using rapid mounting medium.

The tooth sections were read independently by two observers at 16–80× magnification and the number of dentinal growth layer groups (GLGs) assigned by consensus between the readers.

2.2.4 Reproductive status

Females

Reproductive tracts were dissected out and examined grossly. The uterine horns were opened and examined for signs of pregnancy. A sample of each horn was removed, fixed in 10% buffered formalin, embedded in paraffin, sectioned at 4 µm intervals, and stained with hematoxylin for microscopic examination. The length and diameter of the ovaries were measured (mm) using Vernier callipers, and the ovaries weighed (g) using a Mettler PM 4800 Delta Range balance. The ovaries were sliced at 2 mm intervals along their long axis with a scalpel. The slices were examined for the presence of corpora lutea (CL) and corpora albicantia (CA), both macroscopically and using a dissecting microscope at 10× magnification. Sections were processed for microscopic examination as described above. Sexual maturity was defined as the age at which a female had ovulated at least once, and established by the presence of at least one corpus in the ovaries (Harrison et al. 1972). The CAs were classified as per Marsh & Kasuya (1984) and Slooten (1991) as follows:

Large CAs (mean diameter 7–10 mm) were clearly visible as a mass on the surface of the ovary and had a clearly defined stigma. Based on microscopic examination, there were few if any luteal cells, abundant fibrous connective tissue and numerous blood vessels. As the CA ages, the volume of connective tissue decreases relative to the number of vessels.

Medium CAs (mean diameter 3.5–7 mm) protruded less from the surface of the ovary. Histologically, most of the connective tissue had been removed and the blood vessels were more prominent.

Small CAs (mean diameter 1.5–3.5 mm) were visible on the surface of the ovary as small wrinkled scars. Histologically there was very little fibrous tissue and blood vessels formed the bulk of the tissue.

Histological sections of the uterine horns were classified as follows (Lockyer & Smellie 1985; Bacha & Wood 1990):

Immature The endometrium was thin and lined by a simple cuboidal epithelium. The glands were sparse and small with no clear lumen. The stratum vasculare was poorly developed and the arteries had a thin intima and smooth muscle tunic.

Mature-anoestrus The endometrium was thicker than in the immature uterus but the glands were equally sparse and relatively small. However, the tunica vasculare was prominent and the arteries had a tunica intima thickened by elastic fibres and smooth muscle.

Mature-lactating Similar to the previous class, except that the endometrium appeared more vascular post-parturition.

Mature-prooestrus and *Mature-oestrus* These stages were characterised by increasing depth of the endometrium and progressively greater development and complexity of the endometrial glands.

The mammary glands of all females were dissected to determine the degree of development and to look for evidence of milk secretion. Where milk was present, a sample was frozen at –80°C and stored for future research.

Males

The length and midline diameter of the testes (excluding epididymis) were measured (mm) using Vernier callipers and weighed (g) using a Mettler PM 4800 Delta Range balance. The epididymis was weighed (g) separately. Testes were sectioned at 3 mm intervals using a scalpel and examined for evidence of pathological changes. Histological samples taken from the centre of the testis and epididymis, were embedded in paraffin wax, sectioned at 4 mm intervals, mounted on glass slides and stained with haematoxylin and eosin. The sections were then examined microscopically at 16–80× magnification to assess the maturity of the seminiferous tubule epithelium and for the presence of spermatozoa. Because the cell associations forming the epithelium vary segmentally in mammalian testes, the predominant association in the section was used to classify the stage of maturity. The gonads were classified as immature, pubertal, mature-inactive, or mature-active (Collet & Saint Girons 1984; Slooten 1991).

Immature The seminiferous tubules/cords were narrow and often had no apparent lumen. Sertoli cells and spermatogonia lined the tubules but no further differentiation of germinal cells was apparent. There were abundant interstitial cells. The duct of the epididymis was lined by simple cuboidal epithelium and had a completely empty lumen.

Pubertal The seminiferous tubules were larger than for immature animals and there was consequently less interstitial tissue. The epithelium of the tubules contained spermatogonia, spermatocytes and occasional spermatids but no spermatozoa.

Mature-inactive The seminiferous tubules occupied most of the cross-sectional area and had a defined lumen. The epithelium had sertoli cells, spermatogonia, spermatocytes and early spermatids. Occasional tubule sections may have contained late spermatids. The interstitial cells occupied very little space between the seminiferous tubules. The ducts of the epididymis did not contain spermatozoa.

Mature-active The majority of tubule sections in the testis were lined by an epithelium that has a sequence of differentiation from spermatogonia through to spermatozoa. There was relatively little interstitial tissue present. The lumen of the epididymis might be full of spermatozoa.

2.3 STATISTICAL ANALYSES

Analyses of correlation between age and length in male Hector's dolphins was carried out using InStat software (Graph Pad Software Inc., San Diego, California, U.S.A.).

3. Results for 1997/98

3.1 MORPHOMETRICS

An extensive set of standard measurements were taken from each carcass (Appendix 1, Table 1.3). Certain measurements were not available for one animal (WB98-29Ch) because the abdominal region had been scavenged by a shark.

3.2 STOMACH CONTENTS

The weight of the contents of each compartment were recorded for each animal; when data was available, the total weight of the complete full and empty stomach was recorded (Appendix 1, Table 1.4). The contents were not identifiable to species for any animal. The dusky dolphins had fish bones and otoliths in the first chamber but no identifiable items in the remaining two chambers. All the Hector's dolphins had fish otoliths, and in most cases fish bones, in at least one stomach compartment. In addition, two Hector's dolphins had pieces of a crab in the stomach and one animal had a single squid beak. Otoliths and invertebrate parts have been stored in 70% ethanol to allow more detailed analysis of diet. Blubber samples were stored for future analysis of fatty acid signatures.

3.3 AGE DETERMINATION

Data on tooth size and the number of dentinal GLGs counted are given in Appendix 1, Table 1.5. For Hector's dolphins (n = 12) the mean tooth weight was 0.1 g, mean length 12.1 mm and mean diameter 2.5 mm. These sizes are similar to previous reports (Slooten 1991). The teeth did not have obvious incremental layers in the cementum but there were clearly defined bands in the dentine. Accepted protocol for small cetaceans is that one dark band (stained) and one light band (unstained) constitute one year's growth (Perrin & Myrick 1980; Slooten 1991). Based on this assumption, the Hector's dolphins ranged in age from 1 to 7 years (mean 3.9 years) and the dusky dolphins were 7 and 8 years old. The Hector's dolphins all died in January or February at the completion of an unstained band or start of a stained band. This is similar to a previous study on a larger sample of dolphins (Slooten 1991). The Hector's dolphin sample was biased, with young animals 5 years or less over-represented and no animals older than 7 years (Fig. 1.2). This is similar but even more marked than the age bias reported by Slooten (1991) in which 41 of 60 specimens (68%) were 5 years or under.

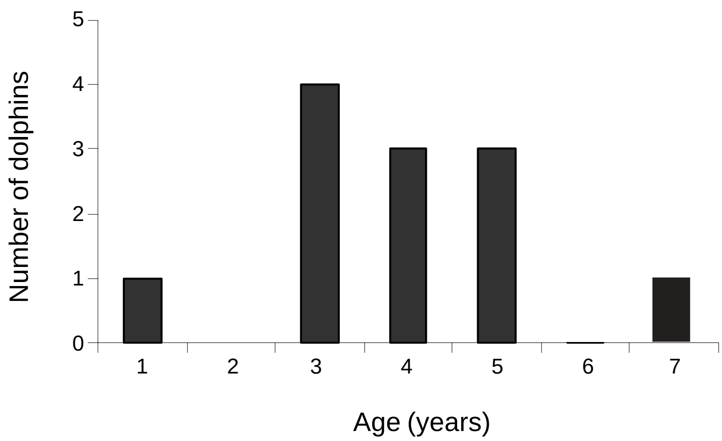


Figure 1.2. Age-frequency plot for Hector's dolphins.

For male Hector's dolphins (n = 11) there was no significant association between standard body length (Std L) and age (Fig. 1.3). This is similar to findings of Slooten (1991) where growth slowed after 2 years. However, when one particularly small dolphin (WB98-28Ch) was removed from the data set the association between length and age became significant for the remaining 10 males (r = 0.7, P = 0.028).

The female Hector's dolphin was 5 years old and at 1.3 m was larger than the two males of similar age, which measured 1.17 m and 1.19 m. This apparent sexual dimorphism agrees with the findings of Slooten (1991) in which a larger sample of animals was available.

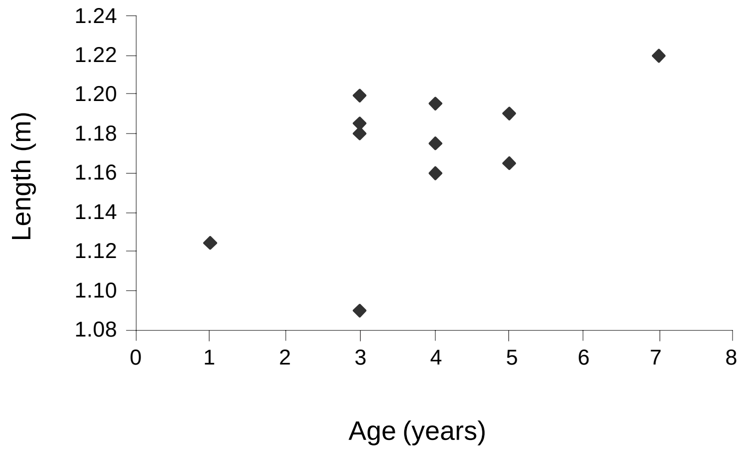


Figure 1.3. Age–length distribution of male Hector's dolphins (the very small 3-year-old male was removed for the statistical analysis).

3.4 REPRODUCTIVE STATUS

Females

Morphometric data on reproductive tracts are given in Appendix 1, Table 1.6. One dusky dolphin (WB98-04Lo) was aged 8 years. She had a large CA on her right ovary that histological examination found to be composed of a mature collagen-rich fibrous stroma with well-developed blood vessels. There were no apparent luteal cells. The histology of the uterine horns was consistent with her being mature-anoestrus based on the criteria given in Section 2.2.4. It is possible that this female had already given birth because the histology of the uterus was consistent with that of animal that had experienced parturition (Bacha & Wood 1990). The second dusky dolphin (WB98-31Lo), although larger than the first, was estimated to be only 7 years old. She also had a large CA, but it was more regressed than that of the first, with less fibrous tissue and blood vessels more closely apposed. On histological examination, the uterus was found to be in a similar mature-anoestrus stage but the tunica vasculare was not as well developed as in the first dolphin, suggesting that WB98-31Lo had not experienced pregnancy and parturition. Neither dolphin had milk in the mammary glands but one animal (WB98-31Lo) had a nematode parasite (*Crassicauda* sp.) in the ducts of the left mammary gland.

The five-year-old female Hector's dolphin had small smooth ovaries with no evidence of either a CL or CA. The uterine wall was also histologically immature and there was no evidence of lactation. These findings are similar to those for three other four-year-old Hector's dolphins reported in Slooten (1991).

Males

The oldest male (WB98-18Ch) was 7 years old and had a combined testicular mass (includes epididymis) of 267 g (Appendix 1, Table 1.7). This is slightly below the range of testicular maturity weight reported by Slooten (1991) in which mature males had combined testicular weights ranging from 304 g to

1210 g. However, the male in this study has to be regarded as mature based on histology as it had active spermiogenesis and large volumes of spermatozoa in the epididymis. The remaining dolphins (n = 9) in this study were immature with a mean combined testicular and epididymal mass of 31 g.

Unsexed animals

One dolphin (WB98-29Ch) could not be sexed because most of its abdominal region had been scavenged by a shark.

3.5 PATHOLOGY

Pathological findings were not covered by the terms of the contract. However, in view of the fact that some of the dolphins were beachcast rather than retrieved directly from nets, data are included on pathological findings related to death by entanglement (Appendix 1, Table 1.8). It should be stated that freezing will compromise the interpretation of subtle pathological changes.

Among the pathological changes associated with death from entanglement are traumatic lesions directly attributable to fishing gear (Garcia Hartmann et al. 1994; Kuiken 1994; Kuiken et al. 1994). This includes superficial skin lesions encircling the rostrum, head or any extremity; cleanly-cut pieces from extremities; or deep puncture wounds. Pathological changes in deeper tissues include evidence of blunt trauma such as fractures or contusions. Changes consistent with death from asphyxiation include pulmonary oedema, congestion, alveolar or bullous emphysema, stable froth in airways, and pleural congestion. There may also be congestion of pericardial vessels and ecchymotic haemorrhages (haemorrhagic spots) on the endocardium or epicardium. Less highly associated with entanglement is body condition and evidence of recent feeding (Kuiken 1994). In general, poor body condition and/or lack of food in the stomach might indicate some other cause of death. All organ systems should be examined by a pathologist competent in the diagnosis of disease in cetaceans to rule out all possibilities.

Both dusky dolphins were removed from nets and although they had lesions indicative or suggestive of entanglement, only one had skin lesions associated with net entanglement (Appendix 1, Table 1.8).

Among the Hector's dolphins, three were entangled in commercial nets and had distinct skin lesions (see Fig. 1.4, next page). Three were retrieved from recreational nets (WB98-23Ch, WB98-28Ch and WB98-29Ch), but only two had distinct skin lesions while the third (WB98-23Ch) had severe blunt trauma to subcutaneous tissues. Of the remaining six dolphins the probability of entanglement, based on skin lesions (see Fig. 1.5), was high for three, moderate for two animals, and low for the last animal. However, even for the three with no skin lesions, or equivocal lesions, there were pulmonary lesions that would suggest asphyxiation.

In all of the dolphins examined there were no other apparent pathological changes that could have caused death.

Figure 1.4. WB98-22Ch showing encircling skin lesions indicative of probable entanglement.

Figure 1.5. WB98-25Ch showing braided skin lesion indicative of probable entanglement.

4. Discussion

The dolphins examined for this contract were received frozen and double-bagged. In general the packaging was of a high standard and the animals were usually identified by the observer's report placed in the oral cavity. However, the data sheet or tag was missing for one of the Hector's dolphins. A system of double-labelling using sheep ear tags inserted into a flipper might prevent recurrence of this problem. In terms of record keeping, it would also be of benefit to the contractor if a list of animals being shipped could be forwarded by mail or e-mail to allow a cross-check between animals shipped and those received. In that way, any animal that arrived without the observer's report could be traced. From a health and safety aspect, the packaging was sufficient to prevent contamination of the environment by the carcasses, provided they remained frozen.

The number of dusky dolphins examined in this study is too small to make any inferences about the species, except that it confirms that the species occurs in Cook Strait and as far south as the subantarctic islands. Both animals were female and both apparently sexually mature. The younger of the two dolphins at approximately 7 years may have been closer to puberty than full maturity, but the 8-year-old may have had at least one calf. Dusky dolphins are thought to reach sexual maturity at approximately 1.65 m (Leatherwood et al. 1983) and both females in this study were near or above this length. Although one of the females had a nematode parasite within one of her mammary glands there was no indication of mastitis as reported in Atlantic white-sided dolphins with similar infection (Geraci & St. Aubin 1987). Both of the dusky dolphins were caught as a result of commercial fishing activities, but only one had unequivocal skin lesions attributable to entanglement. This emphasises that pathological lesions other than skin lesions alone need to be considered in determinations of cause of death.

The Hector's dolphins incidentally caught by commercial fishers were captured off the north Canterbury coast and at the mouth of the Rangitata River, sites within the range of the species (Cawthorn 1988; Slooten & Dawson 1994). The dolphins caught by recreational nets and those found beachcast were also from an area of the Canterbury coast with a high Hector's dolphin population (Slooten & Dawson 1994). Morphological features of these animals were consistent with those reported previously (Mörzer Bryuns & Baker 1973; Slooten 1991; Slooten & Dawson 1994). It was also found that most of the animals were immature, which is consistent with previous reports of incidentally caught Hector's dolphins (Slooten 1991; Dawson 1991). Unlike previous studies, the animals submitted for this investigation were predominantly male. In a study that included 60 Hector's dolphins (Slooten 1991), the ratio of male to female was approximately equal. The bias in this study is more likely to reflect a sampling bias than the structure of the population.

Determination of the species of fish and invertebrates ingested by the dolphins was beyond the scope of this investigation, but all hard parts removed from the stomachs were archived for future studies. All animals had some remains of fish, squid, or other invertebrates, suggesting that they had eaten shortly before death.

Age determination in cetaceans, based on counting growth layers or annuli in teeth, is commonly used on a variety of species (Perrin & Myrick 1980). Although widely used, the technique is subject to difficulties in methodology, interpretation, reader variability, variability among teeth, and the lack of known-age animals (Dapson 1980). The method used to section teeth can also introduce marked biases into the interpretation of age. For this reason, and because teeth from known-age Hector's dolphins were not available, it was decided to employ a method similar to that used previously on this species (Slooten 1991) and on the related Commerson's dolphin (Lockyer et al. 1988). The results obtained are comparable to those reported by Slooten (1991) and are in agreement with other findings on the animals such as reproductive status and morphology. Even though most of the males were immature, there was no good correlation between age and Std L indicating that they achieved adult size early. This agrees with the findings of Slooten (1991). Only one male had active spermatogenesis—and at seven years old was slightly younger than the youngest male with active testes reported by Slooten (1991). In the latter study, there was one six-year-old male that was classed as pubertal and the next youngest males were nine years old. From this, it may be concluded that sexual maturity in males may be achieved as early as seven years. Only one five-year-old female was examined and she had an immature reproductive tract. This agrees with the findings of Slooten (1991) for a female of this age.

The pathological findings indicate that there is a high probability that entanglement caused the deaths of both the dusky dolphins, and 9 of the Hector's dolphins examined. This is based on a consideration of external lesions, internal lesions, body condition, presence of food material in the stomach and the absence of any other pathology that could have caused death (Garcia Hartmann et al. 1994; Kuiken 1994; Kuiken et al. 1994). Two of the beachcast Hector's dolphins were regarded as having a moderate probability of having died as a result of entanglement. One had parallel linear cuts in the skin encircling the rostrum that were probably caused by a net; but the other dolphin only had a few nicks in the dorsal fin and leading edges of the flukes that may or may not have been caused by a net. Both had similar lung pathology to the other dolphins and there was no other cause of death determined. The dolphin that was ranked with a low probability of entanglement had no skin lesions or evidence of trauma. However, it did have oedematous lungs with stable froth in the airways which is consistent with asphyxiation. As with one of the dusky dolphins, and described in other studies (Kuiken 1994), traumatic lesions are not always apparent in animals known to have been entangled. Detailed pathological examination of incidentally caught and stranded Hector's dolphins by an experienced veterinary pathologist is required to determine more precise criteria for cause of death in this species.

5. References

For details of references quoted in Part 1, see the combined reference list at the end of Part 3 (pp. 58–60).

Appendix 1

TABLES OF RESULTS

TABLE1.1. CAPTURE DATA FOR HECTOR'S AND DUSKY DOLPHINS, 1997/98.

CODE	PATHOLOGY NO.	DATE	TIME	LATITUDE	LONGITUDE	SEX
Dusky dolphin						
WB98-04Lo	28950	16 Feb 98	2000	50ºS	166ºE	F
WB98-31Lo	29634	17 Aug 98	2030	41ºS	174ºE	F
Hector's dolphin						
WB98-18Ch	29383	17 Feb 98	1700	44ºS	171ºE	M
WB98-19Ch	29384	1 Mar 98	1859	42ºS	173ºE	M
WB98-22Ch	29387	19 Jan 98	0900	44ºS	171ºE	M

TABLE 1.2. STRANDING DATA FOR HECTOR'S DOLPHINS, 1997/98.

CODE	PATHOLOGY NO.	DOC TAG NO.	DATE	CIRCUMSTANCES	LOCATION	COMMENTS
Hector's dolphin—Female						
WB98-25Ch	29390	H18/98	12 Feb 98	Beachcast	Woodend Beach	
Hector's dolphin—Male						
WB98-20Ch	29385	No tag	–	–	–	
WB98-21Ch	29386	H15/98	4 Feb 98	Beachcast	Leithfield beach, 200 m north of Saltwater Creek	
WB98-23Ch	29388	H17/98	8 Feb 98	Entangled in set net	Gore Bay	
WB98-24Ch	29389	H13/98	2 Jan 98	Beachcast adjacent to set net	Leithfield Beach	
WB98-26Ch	29391	H12/98	2 Jan 98	Beachcast adjacent to set net	Leithfield Beach	
WB98-27Ch	29392	H14/98	4 Jan 98	Beachcast	Saltwater Creek, 320 m north of mouth	
WB98-28Ch	29393	H16/98	8 Feb 98	Entangled in set net	Gore Bay	
Hector's dolphin—Unknown sex						
WB98-29Ch	29394	H19/98	16 Jan 98	Entangled in set net	2 nautical miles off Sumner Head	Scavenged

– Indicates data is not available.

TABLE 1.3. MORPHOMETRIC DATA FOR HECTOR'S AND DUSKY DOLPHINS, 1997/98.

CODE	PATHOL-OGY No.	Wt (kg)	Std L (m)	Sn-An (m)	Sn-Gen (m)	Sn-ODF (m)	Sn-OF (m)	FL (m)	FW (m)	DF Ht (m)	DF BL (m)	Flk W (m)	Gt Pec (m)	Blub.D (m)	Blub.L (m)	Blub.V (m)
Hector's dolphin—Female																
WB98-25Ch	29390	34.8	1.30	0.92	0.82	0.63	0.28	0.18	0.08	0.09	0.21	0.37	0.72	0.018	0.013	0.016
Hector's dolphin—Male																
WB98-18Ch	29383	34.6	1.22	–	0.71	0.60	0.30	0.20	0.08	0.09	0.21	0.40	0.74	0.018	0.016	0.018
WB98-19Ch	29384	27.7	1.18	0.85	0.75	0.58	0.30	0.19	0.07	0.07	0.19	0.36	0.75	0.013	0.011	0.014
WB98-20Ch	29385	26.6	1.16	0.83	0.70	0.56	0.30	0.18	0.08	0.08	0.18	0.32	0.64	0.018	0.016	0.017
WB98-21Ch	29386	28.2	1.19	0.81	0.67	0.58	0.29	0.17	0.75	0.75	0.18	0.32	0.70	0.018	0.017	0.021
WB98-22Ch	29387	30.4	1.18	0.83	0.69	0.59	0.30	0.19	0.08	0.08	0.18	0.35	0.70	0.014	0.014	0.016
WB98-23Ch	29388	27.8	1.13	0.82	0.71	0.54	0.30	0.02	0.07	0.07	0.18	0.33	0.73	0.02	0.017	0.019
WB98-24Ch	29389	28.9	1.17	0.85	0.73	0.58	0.30	0.17	0.08	0.06	0.20	0.33	0.71	0.018	0.013	0.017
WB98-26Ch	29391	29.1	1.19	0.86	0.75	0.57	0.39	0.20	0.07	0.08	0.20	0.36	0.72	0.017	0.014	0.016
WB98-27Ch	29392	33.3	1.20	0.85	0.75	0.59	0.30	0.18	0.08	0.07	0.19	0.38	0.77	0.019	0.014	0.013
WB98-28Ch	29393	27.2	1.09	0.72	0.63	0.56	0.24	0.18	0.07	0.08	0.18	0.34	0.64	0.015	0.013	0.015
Hector's dolphin—Unknown sex (scavenged)																
WB98-29Ch	29394	13.0	1.20	0.94	–	0.60	0.35	0.18	0.07	0.06	0.18	0.32	–	0.017	0.013	–
Dusky dolphin—Female																
WB98-04Lo	28950	64.6	1.62	1.13	1.07	0.75	0.35	0.31	0.10	0.20	0.23	0.40	0.92	0.017	0.013	0.015
WB98-31Lo	29634	70.6	1.77	1.30	1.19	0.79	0.43	0.36	0.11	0.22	0.27	0.47	1.03	0.014	0.013	0.014

Wt = weight; Std L = standard body length; Sn-An = snout to anus length; Sn-Gen = snout to genital slit length; Sn-ODF = snout to origin of dorsal fin length; Sn-OF = snout to origin of flipper ; FL = flipper length; FW = flipper width; DF Ht = dorsal fin height; DF BL = dorsal fin length at base; Flk W = fluke width; Gt Pec = girth at pectoral flippers; Blub. D = dorsal blubber depth; Blub. L = lateral blubber depth; Blub. V = ventral blubber depth.

– Indicates data is not available.

TABLE 1.4. STOMACH MORPHOMETRICS AND CONTENTS FOR HECTOR'S AND DUSKY DOLPHINS, 1997/98.

CODE	PATH-OLOGY NO.	STOMACH		COMPARTMENT 1		COMPARTMENT 2		COMPARTMENT 3		PARA-SITES	ULCERS
		FULL WT (kg)	EMPTY WT (kg)	CONTENTS WT (kg)	COMPOSITION	CONTENTS WT (kg)	COMPOSITION	CONTENTS WT (kg)	COMPOSITION		
Hector's dolphin—Female											
WB98-25Ch	29390	–	–	0.0613	Fish parts, otoliths	TLTM	Fish otoliths	TLTM	Fluid only	Y	–
Hector's dolphin—Male											
WB98-18Ch	29383	–	–	0.428	Fish otoliths, invertebrate	0.0075	Fish otoliths	TLTM	Fluid only	Y	–
WB98-19Ch	29384	–	–	TLTM	Fish otolith	TLTM	Fish otolith	TLTM	–	Y	–
WB98-20Ch	29835	–	–	0.014	Fish otolith	0.015	Fish otoliths	0.014	Fluid only	Y	–
WB98-21Ch	29386	–	–	0.034	Fish bones, otoliths	TLTM	Fish bones	TLTM	Fish otoliths	Y	–
WB98-22Ch	29387	–	–	TLTM	Fish otoliths	TLTM	Fish otoliths	TLTM	Fish otoliths	Y	–
WB98-23Ch	29388	–	–	0.454	Fish bones, otoliths, crab pieces	0.0004	Fish bones, otoliths	TLTM	Fluid only	Y	–
WB98-24Ch	29389	–	–	TLTM	–	TLTM	–	TLTM	Fish otolith	Y	–
WB98-26Ch	29391	–	–	0.0011	Fish otoliths	0.0112	Crab carpace	0.0003	Fluid only	Y	–
WB98-27Ch	29392	–	–	0.526	Fish (342 mm), otoliths, squid beak	0.0022	Fluid only	TLTM	Fluid only	Y	–
WB98-28Ch	29393	–	–	0.279	Fish parts, otoliths	TLTM	Fish otoliths	TLTM	Fluid, fish otoliths	Y	–
Dusky dolphin—Female											
WB98-04Lo	28950	–	–	0.113	Fish bones, otoliths	TLTM	Fluid only	TLTM	Fluid only	N	–
WB98-31Lo	29634	2.25	1.95	0.297	Fish bones, otoliths	TLTM	Fluid only	TLTM	Fluid only	Y	2 in C2

TLTM = Too little to measure; C1, C2, etc. = compartment 1, 2, etc.

– Indicates data is not available.

TABLE 1.5. AGE ESTIMATION BASED ON DENTINAL GROWTH LAYER GROUPS FOR HECTOR'S AND DUSKY DOLPHINS, 1997/98.

CODE	PATH-OLOGY NO.	TOOTH WT (g)	L (mm)	D (mm)	AGE (y)
Hector's dolphin—Female					
WB98-25Ch	29390	0.09	12.2	2.3	5
Hector's dolphin—Male					
WB98-18Ch	29383	0.13	13.1		7
WB98-19Ch	29384	0.09	12.2	2.5	4
WB98-20Ch	29385	0.10	11.7	2.5	4
WB98-21Ch	29386	0.09	11.6	2.3	5
WB98-22Ch	29387	0.12	12.5	2.7	3
WB98-23Ch	29388	0.07	10.5	2.2	1
WB98-24Ch	29389	0.08	12.3	2.6	5
WB98-26Ch	29391	0.10	12.6	2.4	3
WB98-27Ch	29392	0.10	11.8	2.3	4
WB98-28Ch	29393	0.11	12.4	2.6	3
Hector's dolphin—Unknown sex (scavenged)					
WB98-29Ch	29394	0.08	12.3	2.4	3
Dusky dolphin—Female					
WB98-04Lo	28950	0.25	11.8	3.2	8
WB98-31Lo	29634	0.30	12.0	3.0	7

TABLE 1.6. FEMALE REPRODUCTIVE TRACT MORPHOMETRICS AND CHARACTERISTICS FOR HECTOR'S AND DUSKY DOLPHINS, 1997/98.

CODE	PATH-OLOGY NO.	RIGHT OVARY				LEFT OVARY				UTERINE MATUR-ITY	GRAVID*	MILK PRES-ENT
		WT (g)	L×W×D (mm)	CA (mm)	CL	WT (g)	L×W×D (mm)	CA (mm)	CL			
Hector's dolphin												
WB98-25Ch	29390	0.8	23 × 10 × 6	–	–	0.6	21 × 11 × 4	–	–	IM	N	N
Dusky dolphin												
WB98-04Lo	28950	6.9	42 × 20 × 8	12 × 10 × 10	–	3.3	40 × 19.5 × 8	–	–	MA	N	N
WB98-31Lo	29634	3.0	37 × 14 × 8	–	–	6.0	40 × 18 × 16	9 × 9 × 9	–	MA	N	N

* Determined by the presence of a grossly detectable embryo or foetus.

– Indicates data not available.

CA = Corpus albicens; CL = Corpus luteum; IM = Immature; MA = Mature-anoestrus; N = No

TABLE 1.7. MALE REPRODUCTIVE MORPHOMETRICS AND CHARACTERISTICS FOR HECTOR'S DOLPHINS, 1997/98.

CODE	PATH-OLOGY NO.	RIGHT TESTIS Wt+epid (g)	RIGHT TESTIS Wt–epid (g)	RIGHT TESTIS L×W×D (mm)	LEFT TESTIS Wt+epid (g)	LEFT TESTIS Wt–epid (g)	LEFT TESTIS L×W×D (mm)	TESTIS MATURITY	COMBINED TESTICULAR MASS* (g)
WB98-18Ch	29383	137.1	113.2	130 × 34 × 56	129.3	106.2	138 × 32 × 51	MA	266.5
WB98-19Ch	29384	16.7	8.1	57 × 21 × 12	16.8	8.9	59 × 18 × 9	IM	33.5
WB98-20Ch	29385	17.5	11.1	70 × 20 × 12	16.5	10.3	65 × 19 × 13	IM	34.0
WB98-21Ch	29386	4.4	4.4	48 × 18 × 7.5	7.5	4.6	50 × 18 × 8	IM	11.9
WB98-22Ch	29387	18.2	10.2	72 × 18 × 19	16.6	9.7	61 × 20 × 9	IM	34.8
WB98-23Ch	29388	9.0	4.8	51 × 12 × 15	8.3	4.0	50 × 16 × 10	IM	17.3
WB98-24Ch	29389	22.7	13.5	74 × 22 × 16	25.1	15.7	77 × 22 × 16	IM	47.8
WB98-26Ch	29391	12.3	5.8	54 × 10 × 16	13.1	8.3	53 × 10 × 14	IM	25.4
WB98-27Ch	29392	21.4	12.5	71 × 24 × 10	22.1	13.4	73 × 27 × 11	IM	43.6
WB98-28Ch	29393	15.2	7.2	60 × 13 × 16	13.1	7.5	60 × 16 × 11	IM	28.3

IM = Immature; MA = Mature-active.

* Includes epididymis weight.

TABLE 1.8. PATHOLOGY OF HECTOR'S AND DUSKY DOLPHINS, 1997/98.

CODE	PATH-OLOGY NO.	BODY CONDI-TION	SKIN LESIONS	SUBCUT-ANEOUS LESIONS	LUNG PATHOLOGY	RECENT FEEDING	ENTANGLE-MENT PROBABILITY
Hector's dolphin—Female							
WB98-25Ch	29390	Good	Yes	NVL	–	Yes	High
Hector's dolphin—Male							
WB98-18Ch	29383	Excellent	Yes		Oedema	Yes	High
WB98-19Ch	29384	Good	Yes	NVL	Oedema, stable froth	Yes	High
WB98-20Ch	29385	Excellent	Yes	NVL	Oedema	Yes	High
WB98-21Ch	29386	Excellent	Possible	NVL	Congested	Yes	Moderate
WB98-22Ch	29387	Good	Yes	NVL	Oedema, stable froth	Yes	High
WB98-23Ch	29388	Excellent	Possible	Severe trauma	Oedema	Yes	High
WB98-24Ch	29389	Good	No	NVL	Oedema, stable froth	No	Low
WB98-26Ch	29391	Good	Yes	NVL	Oedema	Yes	High
WB98-27Ch	29392	Good	Yes	NVL	Oedema, stable froth	Yes	Moderate
WB98-28Ch	29393	Good	Yes	NVL	Oedema	Yes	High
Hector's dolphin—Unknown sex (scavenged)							
WB98-29Ch	29394	Good	Yes	NVL	Scavenged	Scavenged	High
Dusky dolphin							
WB98-04Lo	28950	Good	No	NVL	Oedema	Yes	High
WB98-31Lo	29634	Good	Yes	NVL	Oedema	Yes	High

NVL = No visible lesions.

– Indicates data not available.

Appendix 2

HECTOR'S DOLPHIN DATA SHEET

Specimen # WB00- __________
Pathology # _______________
Date of Capture: ______________ Necropsy Date: _____________
Sex: ________ Age: Juv., SubAd., Ad.

Measurements:

1. Weight:	2. Total length:
3. Snout-anus:	4. Snout-genital slit:
5. Snout-origin dorsal fin:	6. Snout-origin flipper:
7. Flipper length:	8. Flipper width:
9. Dorsal fin height:	10. Dorsal fin lt. Base:
11. Fluke width:	12. Pectoral girth:
13. Blubber: Dorsal Lateral Ventral	

GROSS PATHOLOGY

External Examination (see diagram and eyes, ears, flippers)

Internal Examination (Blubber, subcutis, mammary gland, fascia, muscle, skeleton)

Alimentary system (mouth, teeth, oesophagus, stomach, small intestine, large intest., liver, pancreas, peritoneum, lymph nodes).

Respiratory system (sinuses, larynx, trachea, bronchi, lungs, pleura, lymph nodes)

1

Cardiovascular (Heart, pericardium, great vessels)

Urogenital system (kidneys, bladder, ureters, urethra, gonads, vagina/penis/prepuce)

Lymphatic (thymus, spleen, lymph nodes)

Endocrine (thyroid, adrenals)

Nervous system (only if head trauma).

REPRODUCTIVE SYSTEM
Female:

Ovaries:	Weight	Dimensions (L × W × D)	CA(#, Size)	CL (size)
Right:				
Left:				

Pregnant: Yes / No Milk: Yes / No
Foetus: Length (crown–rump, mm):______ Weight: _______kg. Sex: M / F

Male:

Testes:	Weight + epidid (kg)	Weight – epidid (kg)	Length x diameter (mm).
Left:			
Right:			

2

STOMACH

	Chamber 1	Chamber 2	Chamber 3
Contents Wt.			
Type			
Lesions			

Parasites collected: Yes / No

SAMPLE CHECKLIST

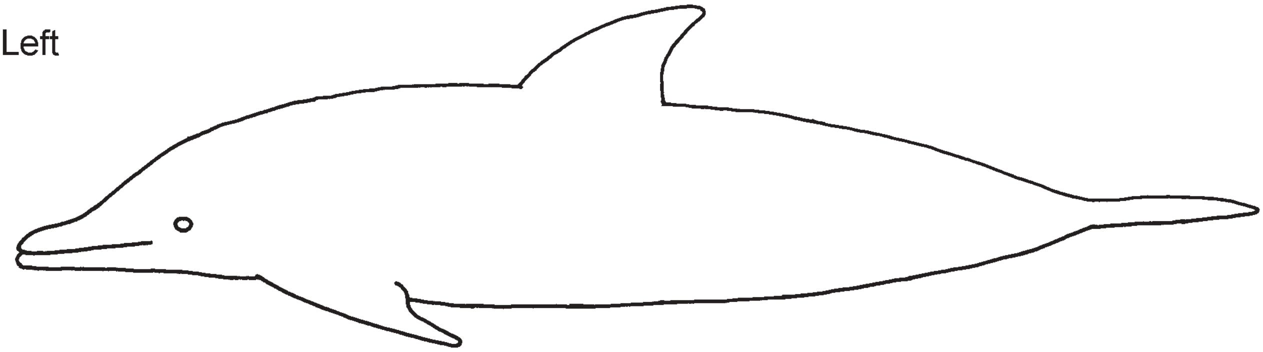
Discipline	Tissue	Storage	Check
Histopathology	Lung, Heart, Liver, Spleen, Thyroid, Trachea, Kidney, Diaphragm, Adrenals, CNS, Any lesion, Gonads, Mammary gland, foetus.	Formalin	
Toxicology/Diet	Blubber	Freezer (300g, whirlpack)	
Age determination	Teeth (approx. 4)	To Gareth	
Museum	Skull	Big freezer	
Bacteriology	Lesion	pottle	
Parasitology	Lung GIT	Alcohol To Barb	
Genetics	Skin	Alcohol vial	
Serology	Blood	- 80 freezer	

DIAGNOSIS

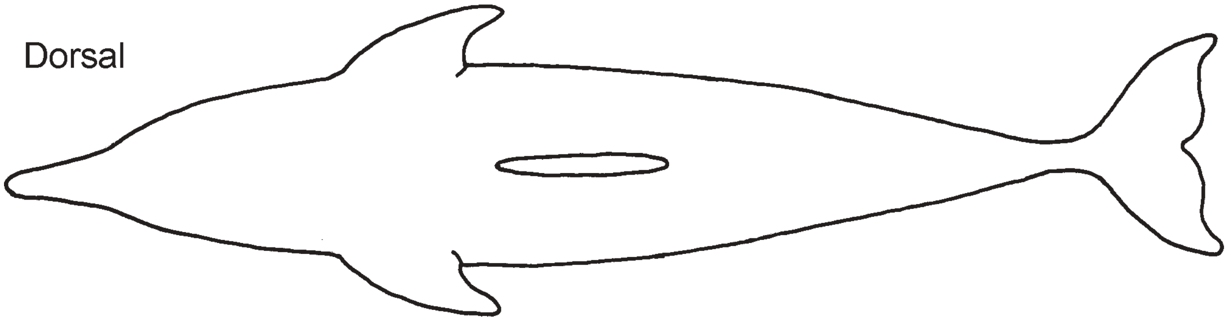
Examiner(s): (Please sign)

3

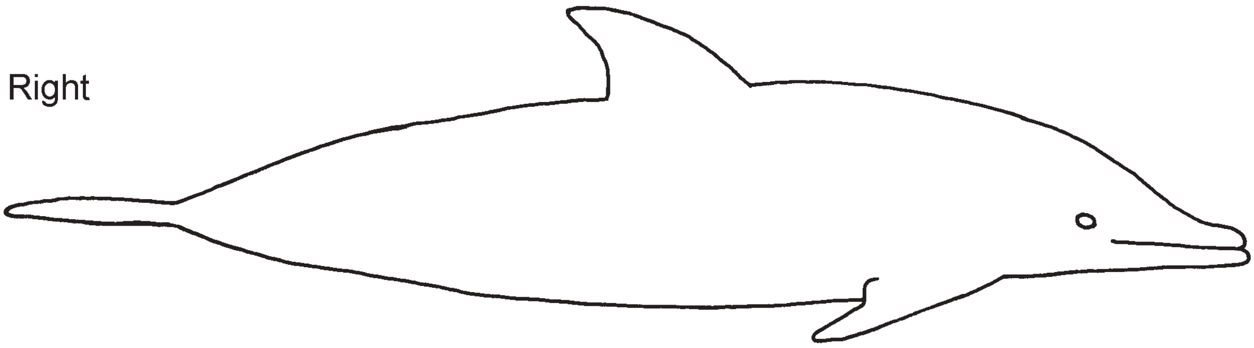
Left



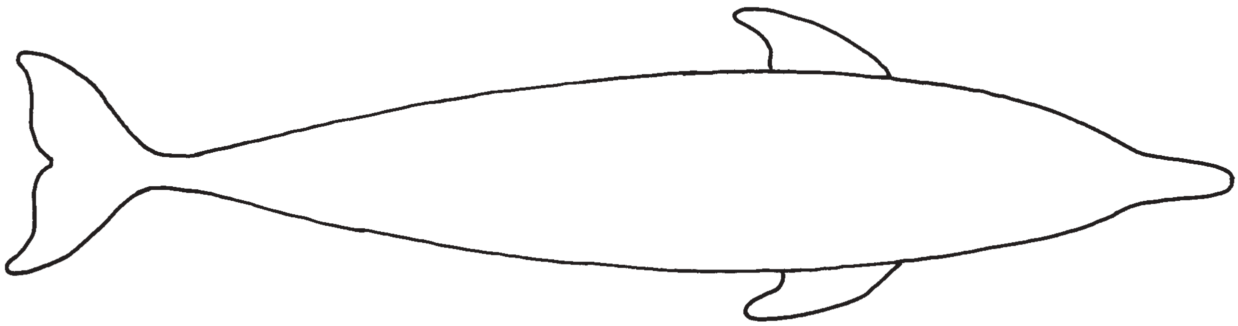
Dorsal



Right



Ventral



4

Note: No CSL autopsy contract was let during 1998/1999 because of the New Zealand sea lion mortality event in January–February of 1998 (see Baker 1999b). Therefore, there is no autopsy report for that period.

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