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# Short Note

## Stomach Contents of Dolphins (*Delphinus delphis* and *Lissodelphis borealis*) from North Pacific Ocean

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**Lien-Siang Chou, Andrea M. Bright and Shean-Ya Yeh (1995)** Stomach contents of dolphins (*Delphinus delphis* and *Lissodelphis borealis*) from the North Pacific Ocean. *Zoological Studies* **34**(3): 206-210. Nine dolphins (two *Lissodelphis borealis* and seven *Delphinus delphis*), killed incidentally by the driftnet fishery in the North Pacific Ocean, were collected during the periods from May to August 1991 and from September to November 1992. Stomach contents of each animal were weighed, sorted, examined, and counted. Prey species were identified to the lowest possible taxon. One stomach of *D. delphis* contained only a milky substance. In the other six of *D. delphis* and the two stomachs of *L. borealis*, fish otoliths numerically comprised 94% and 89% of the diet contents, respectively. Myctophid fish were the most abundant and commonly occurring fish group and numerically comprised 89% (*L. borealis*) and 95% (*D. delphis*) of all fish prey found. Among thirty-three fish prey species belonging to twelve families, *Ceratoscopelas warmingi* and *Lampanyctus jordani* were the most common and abundant species. Squid comprised proportionately less (<11%) of these dolphins' diet. Among thirteen species belonging eight families, the most common and dominant squid species were *Abraliopsis felis* and *Onychoteuthis borealijaponica*.

**Key words:** *Delphinus delphis, Lissodelphis borealis*, Stomach contents, North Pacific Ocean.

Research on food habits of cetaceans may help reveal the relationships between higher trophic levels in the oceanic environment. An understanding of these interactions could provide valuable information for solving to the conflict between fisheries enterprises and cetacean conservation. Research on cetacean food habits has previously been carried out on specimens of small delphinids (Fitch and Brownell 1968, Jones 1981, Walker and Jones 1991) and harbour porpoise (Smith and Gaskin 1979, Recchia and Read 1988). In this study, we examined stomach contents of *Delphinus delphis* and *Lissodelphis borealis* collected from the Taiwanese driftnet fishery in the North Pacific Ocean. These species have also been studied in the eastern North Pacific, off the California coast (Fitch and Brownell 1968, Evans 1976, Leatherwood and Walker 1979, Jones 1981). To date, some information about stomach contents of these two species has been reported (Brownell 1968, Jones 1981, Walker and Jones 1991). Dolphins caught incidentally by high seas driftnets are no longer available for study due to the international moratorium on the use of driftnet gear. The purpose of this report is to document and make available these data for future comparison.

**Materials and Methods**—Stomachs from seven *D. delphis* and two *L. borealis* were examined. Samples were obtained from incidental catches by Taiwanese vessels employing high seas driftnets. The sampling periods lasted from May to August 1991 and September to November 1992. Dolphin stomachs consist of an esophagus, forestomach, main stomach, and pyloric stomach. Only the forestomach and main stomach contents were studied. Each sampling was weighed and examined separately. Contents were sieved and sorted into the following categories: whole fish, whole squid, squid beak pairs, sagittal otolith pairs, and isolated squid beaks or sagittal otoliths. In the first four categories, "pairs" were retrieved from prey tissue. Isolated squid beaks were sorted into upper and lower beaks. Some squid species identification was possible using nine partially digested whole squids found in a *L. borealis* male (No. 2). Ih-Hsiu Tung of the Institute of Fishery Biology at National Taiwan University examined the beaks from these bodies and verified the identification of these squid species. Other squid beaks and fish otoliths were identified to the lowest possible taxon by referring to the collection of Bill Walker at the Alaskan Fisheries Science Center, Seattle, WA, U.S.A. The mininum number of fish prey in each stomach was estimated by dividing the total number of isolated otoliths by two and adding the total number of otolith pairs. The maximum number of upper/lower beaks plus the total number of beak pairs provided an estimate for the minimum number of squids in each stomach.

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**Table 1.** Life history information and number of ingested prey items of two *Lissodelphis borealis* and seven *Delphinus delphis*

| | Dolphin No. | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | L-2 | L-5 | D-1 | D-3 | D-4 | D-7 | D-8 | D-9 | D-6 | |
| Body length (cm)[a] | 169 | 192 | 99 | 139 | 129 | 160 | 158 | 172 | 188 | |
| Age (year)[a] | <2 | 7 | <1 | 2 | <2 | 4 | 3 | 11 | 12 | |
| Sex[a] | m | m | m | f | f | f | f | f | m | |
| Reproductive status[a] | im | im | im | im | im | im | im | pg | >pp | |
| Forestomach content wt. | 980 | 720 | <10 | <10 | <10 | 40 | 1,300 | 1,280 | 1,160 | |
| Main stomach content wt. | <10 | 20 | <10 | <10 | <10 | 40 | 120 | <10 | 10 | |
| No. otolith pairs | 74 | 0 | 0 | 0 | 0 | 0 | 47 | 44 | 7 | 172 |
| No. isolated otoliths | 361 | 192 | 0 | 105 | 188 | 62 | 404 | 454 | 2,802 | 4,568 |
| No. beak pairs | 14 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 4 | 22 |
| Max. lower/upper beaks | 22 | 6 | 0 | 0 | 0 | 23 | 0 | 0 | 112 | 163 |
| Min. no. fish prey | 255 | 96 | 0 | 53 | 94 | 31 | 249 | 271 | 1,408 | 2,456 |
| Min. no. squid prey | 36 | 7 | 0 | 0 | 0 | 24 | 2 | 0 | 116 | 185 |

[a]Chou et al. 1993.
[b]wt. = weight (g), D- = *D. delphis*, L- = *L. borealis*, m = male, f = female, im = immature, >pp = at least prepubescent, pg = pregnant.

**Results**—Table 1 describes the body length, age, sex, reproductive status, stomach content weight, and number of food items for each specimen. Chou et al. (1993) estimated their ages and examined reproductive statuses. In total, there were seven juveniles (two *L. borealis* and five *D. delphis*) and two adults (both *D. delphis*, one male and one female). The female *D. delphis* (No. 9) was pregnant, with a 1 cm-long embryo. Because main stomach contents included very few items, usually weighed less than 20 g (except one at 40 g) and constituted less than 7% of the complete diet remains, we combined the contents from the forestomach and main stomach for analysis.

The stomach content weights of the two *L. borealis* were 740 and 990 g. Stomach content weights of four *D. delphis* were less than 80 g, while those of the other three *D. delphis* ranged from 1,170 to 1,420 g. *D. delphis* specimen No. 1 contained only a milky substance in its stomach and intestines, indicating it was still nursing and was therefore excluded from the detailed diet analysis. Similar to Walker and Jones (1991), identification and enumeration of prey relied almost exclusively on fish otoliths and cephalopod beaks because of rapid digestion. Most of the otoliths and squid beaks found were isolated and comprised 96% and 91% of total items, respectively. Fish were the major food items and comprised of 89% and 94% of the total number of items in the diet contents of *L. borealis* and *D. delphis*, respectively.

Table 2 lists the number and species of fish found in each stomach. There were at least thirty-three fish species belonging to twelve families in the diet list. Myctophidae was the major group of fish prey in terms of both consumption quantity (89% for *L. borealis* and 95% for *D. delphis*) and occurrence (100% for both). At least seventeen species of myctophids were found. Only one to three species were found from each of the remaining eleven fish families, and these fishes contributed less than 11% to fish diet contents. The most commonly occurring fish species was *Ceratoscopelas warmingi*, followed by *Diaphus theta, Diaphus* sp., and *Bathylagus* sp. Quantitatively, *Lampanyctus jordani* and *Ceratoscopelas warmingi* were the most dominant in the fish diet of *L. borealis*, while *C. warmingi, Lampanyctus jordani*, and *Diaphus gigas* were dominant in the diet of *D. delphis*. In other words, these two dolphin species seem to share similar major fish food types as prey.

Regarding the diet list for each dolphin species studied, 351 fish preys (range: 255 – 96, $n$ = 2) belonging to at least twelve species and four families were found in stomach contents of *L. borealis*; and 2,057 fishes (range: 0 – 1,405, $n$ = 6) belonging to at least thirty-two species and twelve families were found in those of *D. delphis*. Regarding food diversity, the minimum number of fish prey species were seven and eleven for the two immature *L. borealis*. Diets varied much more for *D. delphis*, i.e., two to nine fish prey species for the four juveniles and twelve to thirty-two for the two adults; the diet of No. 6 (an adult male) was especially diverse. All fish species (except *Melamphaes* sp.) on the list of stomach contents of *L. borealis* were shared by *D. delphis*. Most whole fish were less than 10 cm in total length, while a few were between 16 and 30 cm in total length.

Squid items only constituted a small proportion of the stomach contents of *L. borealis* (11%) and *D. delphis* (6%) (Table 1). In total, we found at least 185 squids, which belong to thirteen species and eight families (Table 3). The most commonly occurring species were *Abraliopsis felis* and *Onychoteuthis borealijaponica*, while the most quantitatively dominant species were *Onychoteuthis borealijaponica, Abraliopsis felis*, and *Gonatopsis borealis*. Unlike fish otoliths, squid beaks do not seem to be a universally occurring diet item. Out of eight dolphin stomachs, three (Nos. 3, 4 and 9) contained no beak remains. Regarding squid consumption by each dolphin species, the numbers of squid species found in the stomachs of *L. borealis* and *D. delphis* were nine and eleven, respectively. There were six squid species in common between the diet lists of both species, while four and three unique species occurred in *L. borealis* and *D. delphis*, respectively.

**Discussion**—The numerical method (Hyslop 1980) is the most common way to analyze cetacean stomach contents. Data are collected that indicate the numbers of individuals in each food group, and the relative abundance of different food groups is described. However, there are some limitations to this

**Table 2.** Fish species and minimum estimated number of fish prey found in the stomachs of *Lissodelphis borealis* and *Delphinus delphis*

| | Dolphin No. | | | | | | | | Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | L-2 | L-5 | D-3 | D-4 | D-7 | D-8 | D-9 | D-6 | L | D |
| Alepocephalidae | | | | | | | | | | |
| m.l. alepocephalid | | | | | | | | 0.5 | | 0.5 |
| Argentinidae | | | | | | | | | | |
| *Microstoma* sp. | | | | | | | | 2.5 | | 2.5 |
| *Nansenia* sp. | | | | | | 1 | | 1 | | 2 |
| Bathylagidae | | | | | | | | | | |
| *Bathylagus* sp. | 34 | 0.5 | | | | 1 | 1 | 23 | 34.5 | 25 |
| Unid. bathylagids | 2 | | | 3.5 | | | | 39.5 | 2 | 43 |
| Chauliodontidae | | | | | | | | | | |
| *Chauliodus* sp. | | | | | | | | 1.5 | | 1.5 |
| Gonostomatidae | | | | | | | | | | |
| *Ichthyococcus* sp. | | | 0.5 | | | | | 1 | | 1.5 |
| *Gonostoma* sp. | | | | | | | | 2.5 | | 2.5 |
| Melamphidae | | | | | | | | | | |
| *Melamphaes* sp. | 0.5 | | | | | | | | 0.5 | |
| Melanostomatidae | | | | | | | | | | |
| *Tactostoma macropus* | | | | | | | | 3 | | 3 |
| Myctophidae | | | | | | | | | | |
| *Ceratoscopelas warmingi* | 34.5 | 61 | 13 | 52 | 23.5 | 150 | 173.5 | 543.5 | 95.5 | 955.5 |
| *Diaphus gigas* | 1 | | | 3.5 | | 81 | 82 | 67.5 | 1 | 234 |
| *Diaphus parri* | | | | | | | 1 | 199.5 | | 200.5 |
| *Diaphus* sp. | 3.5 | 1 | 8.5 | | | 2 | 1 | 5 | 4.5 | 16.5 |
| *Diaphus theta* | 11.5 | 4 | 2 | | | 4.5 | 3 | 14.5 | 15.5 | 24 |
| *Electrona risso* | | | 2 | | | | | | | 2 |
| *Lampanyctus jordani* | 153 | 15 | | | | | | 262.5 | 168 | 262.5 |
| *Lampanyctus regalis* | | | | | | | | 10.5 | | 10.5 |
| *Lampanyctus* sp. | 2.5 | 6.5 | | 4 | | | | 9 | 9 | 13 |
| *Myctophum asperum* | | | | | | | 0.5 | 32.5 | | 33 |
| *Myctophum* sp. | | | | | | | | 3 | | 3 |
| *Notoscopelas resplendens* | | 8 | | 27 | | 7.5 | 6 | 146 | 8 | 186.5 |
| *Notoscopelas* sp. | | | | | | | | 0.5 | | 0.5 |
| *Protomyctophum* spp. | | | | | | | | 7 | | 7 |
| *Stenobrachius* sp. | 8 | | | | | | | 0.5 | 8 | 0.5 |
| *Symbolophorus* sp. | | | 1 | | | 1 | 1 | 1.5 | | 4.5 |
| Unid. myctophids | 4 | | 25.5 | 4 | 7.5 | 0.5 | 0.5 | 2 | 4 | 40 |
| Paralephidae | | | | | | | | | | |
| *Lestidops ringens* | | | | | | | 1 | 1.5 | | 2.5 |
| *Paralepis atlantica* | | | | | | | | 2.5 | | 2.5 |
| *Paralepsis* sp. | | | | | | | | 19.5 | | 19.5 |
| Percichthydae | | | | | | | | | | |
| *Howella brodei* | | | | | | | | 1 | | 1 |
| Scomberosocidae | | | | | | | | | | |
| *Cololabis saira* | | | | | | | | 1 | | 1 |
| Trachipteridae | | | | | | | | | | |
| *Trachipterus altivelis* | | | | | | | | 0.5 | | 0.5 |
| Unidentified | | | | | | 0.5 | 0.5 | 2.5 | | 3.5 |
| No. species represented | 11 | 7 | 7 | 6 | 2 | 9 | 11 | 31 | 12 | 32 |
| Total estimated no. fish | 254.5 | 96 | 52.5 | 94 | 31 | 249 | 271 | 1,408 | 350.5 | 2,105.5 |

D- = *D. delphis*, L- = *L. borealis*, m.l. = "most like", unid. = unidentified.

method of analysis. For example, the importance of small prey items taken in large numbers may be over-emphasized. Also, results could be biased due to differences in the retention time of various prey body parts. Recchia and Read (1988) stated that squid beaks are more resistant to digestion than otoliths and may remain in the stomach for a longer period due to their angular shape which may catch in stomach folds. They further mentioned that otoliths of different sizes from different prey species could have different digestion rates. In this study squid beaks numerically contributed small portions to the diets of *L. borealis* and *D. delphis*. Although their numerical abundance could have been over-emphasized, they

**Table 3.** Squid species and estimated number of squid in the stomachs of *Lissodelphis borealis* and *Delphinus delphis*

| | Dolphin No. | | | | | | | | Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | L-2 | L-5 | D-3 | D-4 | D-7 | D-8 | D-9 | D-6 | L | D |
| Cranchiidae | | | | | | | | | | |
| *Galiteuthis phyllura* | 3 | | | | 1 | | | 6 | 3 | 7 |
| Eucleoteuthidae | | | | | | | | | | |
| *Eucleoteuthis sluminosa* | | | | | | | | 6 | | 6 |
| Enoploteuthidae | | | | | | | | | | |
| *Abraliopsis felis* | 12 | 3 | | | 7 | 2 | | 13 | 15 | 22 |
| *Abraliopsis* sp. | 1 | | | | | | | | 1 | |
| Unidentified enoploteuthid | 1 | | | | | | | | 1 | |
| Gonatidae | | | | | | | | | | |
| *Gonatus* spp. | 2 | 1 | | | | | | 2 | 3 | 2 |
| *Gonatopsis borealis* | | | | | 1 | | | 34 | | 35 |
| *Berryteuthis anonychus* | 1 | | | | 12 | | | | 1 | 12 |
| Mastigoteuthidae | | | | | | | | | | |
| *Mastigoteuthis* sp. | | | | | | | | 1 | | 1 |
| Octopoteuthidae | | | | | | | | | | |
| *Taningia danae* | 2 | | | | | | | 11 | 2 | 11 |
| Onychoteuthidae | | | | | | | | | | |
| *Onychoteuthis borealijaponica* | 13 | 3 | | | 3 | | | 39 | 16 | 42 |
| Unidentified onychoteuthid | 1 | | | | | | | | 1 | |
| Opisthoteuthidae | | | | | | | | | | |
| *Opishoteuthis* sp. | | | | | | | | 1 | | 1 |
| Unidentified | | | | | | | | 3 | | 3 |
| No. species represented | 9 | 3 | 0 | 0 | 5 | 0 | 0 | 9 | 9 | 10 |
| Total no. squid prey | 36 | 7 | 0 | 0 | 24 | 2 | 0 | 116 | 43 | 142 |

D- = *D. delphis*, L- = *L. borealis*.

do not appear to be important in the diets of these dolphins.

Cetaceans are among the top predators in the ocean food webs. Therefore, the food found in their stomachs could include more than one trophic level. An extensive diet analysis of different trophic levels is necessary to determine whether the contents examined in this study were primarily or secondarily introduced.

With the very limited sample size of this study, conclusive statements regarding the diets of these animals cannot be made. However, there are three implications worth pursuing in future studies. First, *L. borealis* and *D. delphis* in the North Pacific Ocean seem to share a similar diet type. The competition pressure between them might be significant. Next, the adult male *D. delphis* seems to have a very diverse diet. Finally, different reproductive conditions could have different influences on dietary habits. Unfortunately, we only collected one adult male and one pregnant female specimen. The final conclusions will have to wait for more information about the dietary differences among animals of different species, age, and reproductive status.

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# 北太平洋兩種海豚之胃含物研究

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1991年 5 月至 8 月及1992年 9 月至11月間，北太平洋臺灣流刺網漁船蒐集到九隻意外死亡海豚。其胃內含物經稱重、歸類、計數並鑑定至最低可能之分類類別。除一隻眞海豚(*Delphinus delphis*)胃中僅有乳汁外，其它六隻眞海豚及兩隻北露脊海豚(*Lissodelphis borealis*)的胃含物中，魚類爲主要成份，各佔94％及89％，其中又以燈籠魚類(*Myctophid*)最多也最常見，數量上各佔魚類的95％及89％。在胃含物中共發現，12科33種魚類，以角燈魚(*Ceratoscopelas warmingi*)及珍燈魚(*Lampanyctus jordani*)爲優勢種。魷魚類在這些海豚胃含物中所佔比例較低(＜11％)，共發現 8 科13種，以貓多鉤螢火魷(*Abraliposis felis*)及日本爪魷(*Onychoteuthis borealijaponica*)爲優勢種。

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