北米大西洋岸のバンドウイルカの個体群判別 －形態および生態学的観点から－

ジェームス G. ミード・チャールズ W. ポッター

RECOGNIZING TWO POPULATIONS OF THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) OFF THE ATLANTIC COAST OF NORTH AMERICA

MORPHOLOGIC AND ECOLOGIC CONSIDERATIONS

JAMES G. MEAD[*1] AND CHARLES W. POTTER [*1]

INTRODUCTION

One of the bases for wondering about the existence of two populations of *Tursiops* are the results of the Cetacean and Turtle Assessment Program (CETAP) survey. CETAP was a long term survey funded by the Minerals Management Service and supervised by Dr. Howard Winn at the University of Rhode Island (Winn, 1982). This survey was active from November 1978 to January 1982, a 39 month period. It primarily utilized aerial survey techniques but also employed platform-of-opportunity observers on vessels. The area covered by their surveys extended from Cape Hatteras, North Carolina to Nova Scotia, and from the shore to five nautical miles seaward of the 1,000 fathom contour. A few data points resulting from platform-of-opportunity sightings extended further seaward than this. They made 1025 sightings of *Tursiops* during this period, resulting in the distribution map shown here (Fig. 1).

The major portion of the *Tursiops* sightings extend from Cape Hatteras to the northern limit of the survey area and are clustered around the 1,000 fathom contour, which also correlates with the northward flowing, warm water current, the Gulf Stream.

---

*1 国立自然史博物館 (National Museum of Natural History, Smithsonian Institution, U. S. A.)

Another group of *Tursiops* sightings extends from the coast south of Cape Hatteras to Delaware and is situated in the waters adjacent to the coast. There is a gap between the two groups where the *Tursiops* sightings are relatively rare. This distributional dichotomy formed the first hard data for the existence of a coastal and an offshore population.

Our previous study (Mead and Potter, 1990) showed that the distribution of coastal *Tursiops* is highly seasonal, extending as far north as New Jersey in the summer but restricted to south of Cape Hatteras in the winter. The offshore population does not seem to show such seasonal differences.

This study is part of a on-going project concerned with the life history of the bottlenose dolphin in the northwest Atlantic. We have published the results of 15 years work (Mead and Potter, 1990) in which we speculated on the existence of two or more populations. True (1891) spoke of 12 foot specimens that were taken in the fishery for *Tursiops* at Cape Hatteras. We felt that those may represent a population of larger animals since the model length of coastal *Tursiops* was about 9 feet.

Hersh and Duffield (1990) did a morphometrics study comparing samples of Indian River (Florida) coastal individuals with offshore specimens determined by the presence of two hemoglobin types. They determined a number of characters in both the skull and external measurements where the offshore and coastal appeared to differ. Their sample of offshore animals was sufficiently small(2-4) to preclude statistical verification. They also made the anecdotal observations that the offshore forms tended to be larger and darker than the coastal forms.

We had been unable to differentiate the two populations in our mixed sample of stranded animals. It was only when we obtained access to 15 specimens that had been taken offshore in fisheries operations that we managed to isolate the morphometric factors that allowed separation of individual specimens.

MATERIALS AND METHODS

The collection of *Tursiops* in the United States National Museum consists of 1030 specimens. Most of these are from the northwestern Atlantic. The specimens with which we were involved make up the following samples:

Historic

Fort Macon, direct coastal fishery, prior to 1871...............= 45

Cape Hatteras, direct coastal fishery, True, Nov. 1884..... = 60
Cape Hatteras, direct coastal fishery, Kellogg, Feb. 1928.. = 168

Marine Mammal Program

Strandings from 1972 - 1987.. =170
1987 disease mortality (1 June 87 - 1 May 88)................ =239
Strandings since 1 May 88... = 62
Incidentally caught offshore animals, 1972 - present....... = 15

The historic sample consists almost entirely of skulls and no other biological data. The specimens collected by the Marine Mammal Program since 1972 consist of skulls, skeletons, stomach contents, parasites, tissue samples, photographs and external measurements.

The skull measurements were taken according to Perrin (1975). We paid particular attention to the measurements that had been found useful in differentiating populations in the studies by Ross (1977) and Walker (1981).

MORPHOLOGIC DIFFERENTIATION

Skull morphology

We had felt that the degree of morphologic differentiation between the populations was probably comparable to the degree of random variance within a population and was therefore going to be difficult to detect. We had a sample of 15 known offshore animals which were taken incidentally in a gill-net fishery, but the much larger sample of stranded animals contained a mixture of the populations making it extremely difficult to interpret.

While handling the skulls of the incidentally taken offshore specimens in the collection, Potter noticed subjective morphological differences between the incidentally taken specimens and the rest of the collection. These differences were in the shape of the bones surrounding the internal nares (pterygoid and palatines).

Figure 2 is a view of the ventral side of a typical coastal *Tursiops* (USNM 550928). The area of interest extends anteriorly from the internal nares. The configuration of the bones surrounding the internal nares is relatively slender. The pterygoids are not markedly expanded in reference to the width of the nares. Figure 3 is a view of the ventral side of a typical offshore *Tursiops* (USNM 571442), showing the expanded pterygoids.

We went through the stranded animals and separated them into two groups on this basis. We then measured the skulls and subjected them to statistical analysis which revealed that the relative diameter of the internal nares, compared to either condylobasal lenghth or zygomatic width, was greater in the offshore specimens. The method of taking the three basic measurements, condylobasal length, zygomatic width and internal nares width is shown in Figure 4.

If the parameters condylobasal length or zygomatic width are inserted in the following equations:

$$\mathbf{NW = 0.129\ CBL + 0.84}$$

or

$$\mathbf{NW = 0.202\ ZW + 1.85}$$

[where NW = Internal Nares Width, CBL = Condylobasal Length and ZW = Zygomatic Width]

and if the measured internal nares width is greater than that predicted by the equations, then the specimen is from the offshore population. This allows separation of all specimens and is even more pronounced in young animals. Figure 5 shows a plot of internal nares width against condylobasal length for coastal red and offshore specimens. The populations can be separated by a line that represents $NW = 0.129\ CBL + 0.84$.

Variance in skull Morphometrics

In comparing the samples of the offshore and coastal population, it immediately became obvious that the offshore population formed a coherent sample with relatively little variance. On the other hand, the coastal population seems to still be a mixed sample from more than one population. The coastal environment is more complex than the offshore environment, having room for more than one population to evolve. The stranded sample is mixed and we do not have a means of obtaining a sample that we presume is from a single coastal population. In the future we are hoping to obtain specimens of photo-identified coastal animals on which we have information about their normal distribution.

Overall size

We determined the modal length of the specimens in both populations. The offshore population has its mode at 290 cm total length, the coastal population has a broad mode that extends from 250 to 260 cm. Thus the old idea, based on anecdotal information that the offshore population was physically larger, is borne out. That population is approximately 15% larger than the coastal population. The relative frequencies of total length in the coastal and offshore population is shown in Figure 6. The modal lengths of the skulls of the two populations also differ, with the coastal population having a pronounced mode at 47 cm, while the offshore population has its mode at 51 cm (Fig. 7).

Physiological demands in the populations

Hersh and Duffield (1990) hypothesized that the offshore forms dove deeper than the coastal forms and that that was the reason for the differing structures of the hemoglobin. Our finding of relatively greater nareal diameter in offshore specimens would correlate with an increased respiratory function.

ECOLOGIC DIFFERENTIATION

We then went back and investigated the stomach contents and parasites in the two populations.

Food habits

The offshore specimens for which we have stomach contents, fed on pelagic squid and fish, mainly deep water species of the family Myctophidae. The sample is small [N=18] but consistent.

The coastal sample [N=117] is much larger and consists of specimens having mainly four species of near-shore sciaenid fishes in their stomachs [trout or weakfish, *Cynoscion* cf. *C. regalis;* croaker, *Micropogonias undulatus;* spot, *Leistomus xanthurus;* white perch, *Bairdiella chrysura*]. Squids are very rarely found (N=20) in the stomachs of coastal animals and, when they are, it is squids of the coastal genus *Loligo*.

The stomach contents indicate substantially different food habits, which is to be expected because of the different habitats in which the populations live and prey available to them.

Parasites

The offshore *Tursiops* are infected with the cestode parasites *Phyllobothrium*, Monorhygma and the nematode *Crassicauda*. The parasites have life histories that make them useful as biological tags (Walker, Hochberg and Hacker, 1984). *Phyllobothrium* and *Monorhygma* are the intermediate stages of tapeworms (cestodes) that are encysted in the blubber in the case of *Phyllobothrium*, or just deep to the peritoneum in the case of *Monorhygma*. They are large: *Phyllobothrium* cysts are abouto 1 cm in diameter, and *Monorhygma* cysts are abouto 2.4 cm in diameter. They also tend to be numerous in animals that are infected.

Once an individual is infected with them, the parasites last the life of the host. That is, the cestodes depend upon the host species being eaten by a predatory or scavenging species in which the parasite will develop its final form.

The nematode (*Crassicauda*) is a long term inhabitant of the mammary, where it sheds its eggs into the milk (Geraci, Dailey and St. Aubin, 1978) or it can be an equally long term ectopic parasite in the accessory air sinuses of the skull (Perrin and Powers, 1980). It is in the latter role, as an ectopic parasite in the accessory air sinuses, that it has been useful to us in our study of *Tursiops*.

Figure 8 shows typical *Crassicauda* lesions in the orbital sinus of a skull of a offshore specimen (USNM 571442). The area of the lesion is about 1.5 cm in diameter. *Crassicauda* lesions consist of a circular area that has many small interlocking spherical scars that represent individual coils of the body of the worm. Figure 9 shows another view of *Crassicauda* lesions, this time in the anterior portion pterydoid bone in an offshore specimen (USNM 571442).

These bony lesions are very characteristic and unmistakable. They are found in a great majority of the offshore specimens (74% of 38 specimens examined) and a minority (1.6% of 183 specimens examined) of the coastal specimens. *Crassicauda* occurred in 21 coastal specimens in sites other than the accessory air sinuses of the skull, mainly in the mammry glands and superficial fascia of the abdomen.

The coastal specimens have none of the three parasite species that infect offshore populations but do have chronic pancreatitis and are infected with the sessile trematode *Braunina*. The pancreatitis is correlated with heavy infestations of a trematode (cf. *Campula*) in the hepatopancreatic ducts. This disease is characterized by extreme fibrosis of the pancreas, which is permanent.

LATITUDINAL DISTRIBUTION OF STRANDINGS OF OFFSHORE POPULATION

The offshore form occurs in approximately 20 percent of the Tursiops strandings in states south of New Jersey to North Carolina. In New Jersey it occurs in approximately 50 percent of the strandings, in New York 75 percent, and in states from Massachusetts north it constitutes 100 percent of the strandings. *Tursiops* that strand north of Cape Hatteras in the winter are likely to be offshore animals. We have confirmed that the offshore form occurs as far south as Florida but do not have quantitative data on its occurrence. One of us (CWP) examined a sample of skulls of animals that Hersh and Duffield had used in their 1990 study. All of the animals fit into either of our definitions of the offshore or coastal populations.

This observed distribution of stranding correlates well with the CETAP observational data on distribution of sightings and our hypothesis that the CETAP sightings along the 1,000 fathom contour are a different population (offshore) from the CETAP coastal sightings.

TAXONOMY

We examined the type of *Tursiops truncatus* (Montagu, 1821) in the British Museum (specimen number 353A) and found that specimen to agree with our offshore population. There are two nominal taxa that are applicable to the coastal population, *Tursiops erebennus* (Cope, 1865), based on a specimen that stranded in the Delaware River, and *Tursiops subridens* True 1884, based on specimens that were stranded in the Chesapeake Bay.

1987 *TURSIOPS* MORTALITY

Tursiops mortality began to increase during the late summer along the east coast of the United States. This increased mortality extended from New Jersey to Florida and lasted until May 1988. During that time period at least 742 animals were found dead. Initially the mortality was attributed to ingestion of the red tide organism, *Ptychodiscus brevis* (Geraci, 1989). Subsequent work has show that the mortality was due to a morbillivirus (Duignan, P.J. and Geraci, J.R., 1993; Lipscomb, T.P., 1993).

Preliminary (Scott, Burn and Hansen, 1988) assessments were that this mortality was limited to the coastal population. Our sample confirms this. We looked at the ratio of coastal/offshore specimens in our sample of stranded animals and came up with the following observations:

	Offshore	Coastal	Ratio Offshore/Coastal
Before 1897 05 31	21	99	0.2121
1987 06 01- 1988 04 30	1	146	0.0068
After 1988 05 01	6	22	0.2727

In the specimens that had stranded up to May 31, 1987 (pre-mortality) there were 21 offshore versus 99 coastal specimens for a ratio of 0.21. During the period of increased mortality (June 1, 1987 to 30 April 1988) there was one offshore versus 146 coastal specimens for a ratio of 0.0068. Following the period of increased mortality (May 1, 1988 to present - post mortality) there were 6 offshore versus 22 coastal specimens for a ratio of 0.27. Chi squared tests indicate that the difference between the pre-1987 mortality ratio and the 1987 mortality ratio are statistically significant but that the difference between the pre- and post 1987 mortality ratios are not statistically significant.

That calls into question the decision by the National Marine Fisheries Service that the coastal population was decimated by the mortality. If that were the situation, we should expect a lesser contribution to the stranding sample by the coastal population after the mortality because there were relatively fewer coastal animals. That is not supported by the stranding data.

CONCLUSIONS

We have been able to differentiate two populations of *Tursiops* along the Atlantic coast of the United States. These differ in their distribution, overall size, skull morphology, food habits and parasite burden. Based on the sample currently available to us, there is no overlap in skull morphology, suggesting that there is no interbreeding between the two populations. The coastal sample exhibits enough variance in skull morphology to be derived from more than one coastal population. In the furure we hope to be able to examine photo-identified coastal animals to attempt to better define the coastal populations.

REFERENCES

Duignan, P. J. and Geraci, J. R. 1993. Epizootology of marine mammal morbilloviruses in the western North Atlantic. Abstract, Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, Texas, 11 -15 November, 1993.

Geraci, J. R. 1989. Clinical investigation of the 1987-88 mass mortality of bottlense dolphins along the U. S. central and south Atlantic coast. Final report to the National Marine Fisheries Service and U. S. Navy, Office of Naval Research and Marine Mammal Commission, April, 1989, ii + 63 pp.

Geraci, J. R. , Dailey, M. D. and D. J. St. Aubin 1978. Parasitic mastitis in the Atlantic white-sided dolphin, *Lagenorhynchus actus*, as a probable factor in herd productivity. Journal of the Fisheries Research Board of Canada 35:1350- 1355.

Hersh, S. L. and Duffield, D. A. 1990. Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. Chapter

6, *in* Leatherwood, S. and Reeves, R. R. (eds) The Bottlenose dolphin, Academic Press, New York, pp. xviii + 653 pp.

Lipscomb, T. P. 1993. Some answers to questions about morbillovirus. Strandings, Newsletter of the Southeast U. S. Marine Mammal Stranding Network, Volume 2, Number 3, Fall/Winter 1993, pp. 4, 5.

Mead, J. G. and Potter, C. W. 1990. Natural history of bottlenose dolphins along the central Atlantic coast of the United States. pp. 165-195 *in* Leatherwood, S. and Reeves, R. R. (eds) The bottlenose dolphin. Academic Press, New York, xviii + 653 pp.

Perrin, W. F. 1975. Variation of spotted and spinner porpoise (Genus *Stenella*) in the eastern Pacific and Hawaii. Bulletin of the Scripps Institution of Oceanography, Volume 21, vi + 206 pp.

Perrin, W. F. and Powers, J. E. 1980. Role of a nematode in natural mortality of spotted dolphins. J. Wildlife Management 44(4):960-963.

Ross, G. J. B. 1977. The taxonomy of bottlenosed dolphins *Tursiops* species in South African waters, with notes on their biology. Annals Cape Provincial Museums, (Natural History) 11(9):135-194.

Scott, G. P. , Burn, D. M. and Hansen, L. J. 1988. The dolphin dieoff: long term affects and recovery of the population. Presented at "Oceans 88", Baltimore, 5 ms. pp.

True, F. W. 1891. Observations of the life history of the bottlenose porpoise. United States National Museum, Proceedings, 13(1890):197-203.

Walker, W. A. 1981. Geographic variation in morphology and biology of bottlenose dolphins (*Tursiops*) in the eastern north Pacific. NOAA/NMFS Administrative Report no. LJ-81-00003c, 21 pp., 9 tables , 6 figs., 6 tables in appendix.

Walker, Hochberg and Hacker 1984. The potential use of the parasites *Crassicauda* (Nemotoda) and *Nasitrema* (Platyhelminthes) as biological tags and their role in the natural mortality of common dolphins, *Delphinus delphis*, in the eastern North Pacific. National Marine Fisheries Service, Administrative Report LJ- 84-08C, iii + 31 pp.

Winn, H. E. (ed.) 1982. A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U. S. outer continental shelf. Final Report of the Cetacean and Turtle Assessment Program, University of Rhode Island, prepared for the Bureau of Land Management, U. S. Department of the Interior under contract AA551-CT8-48. pp.[x] +450 + 114 pp., overlays.

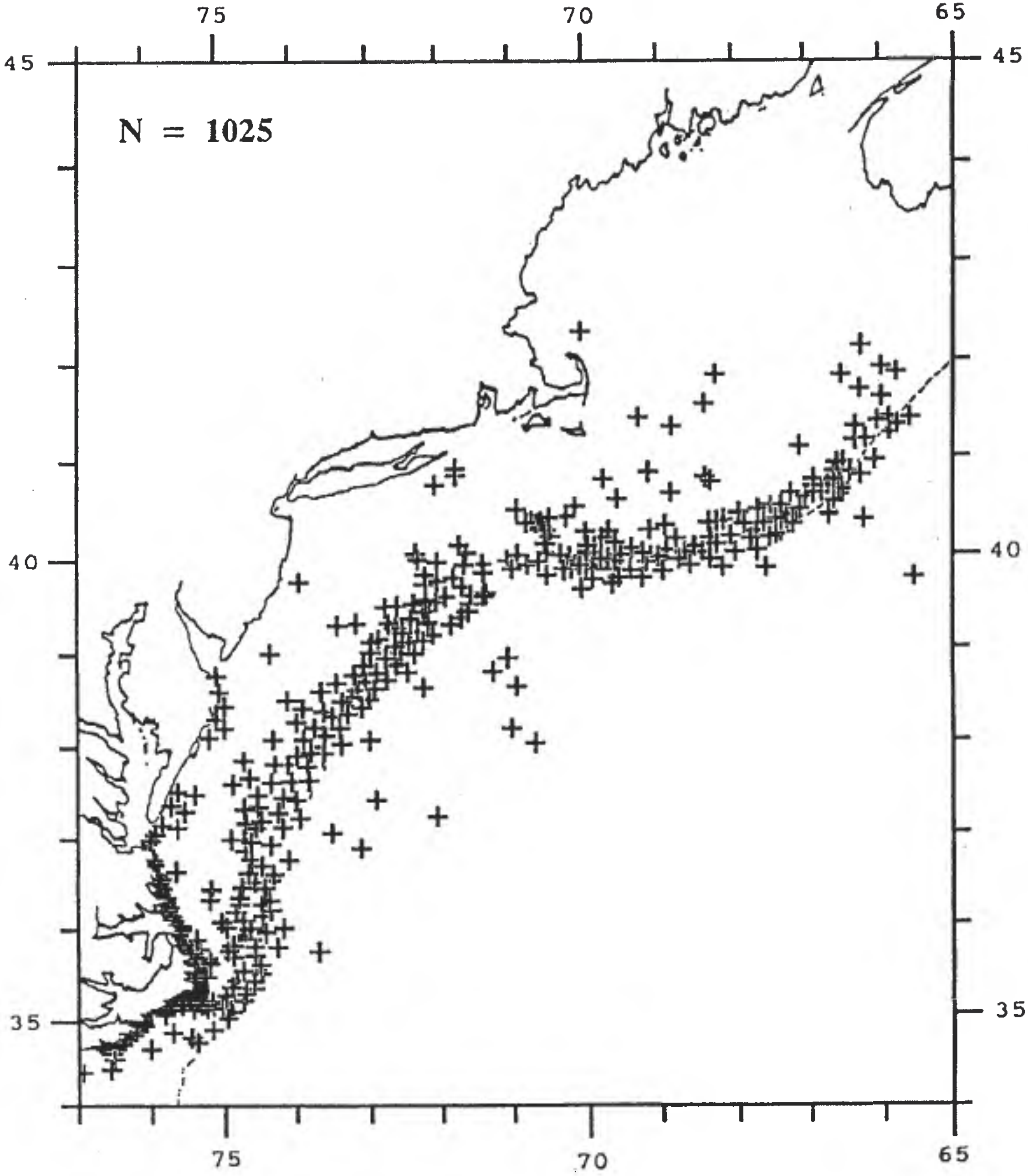

Fig. 1. Distribution of *Tursiops* off the Atlantic coast of the United States (data from CETAP, 1 November 1978 through 28 January 1982).

Fig. 2. Ventral view of coastal *Tursiops* (USNM 550928) showing the region around the internal nares.

Fig. 3. Ventral view of skull of an offshore *Tursiops* (USNM 571442) showing the region around the internal nares.

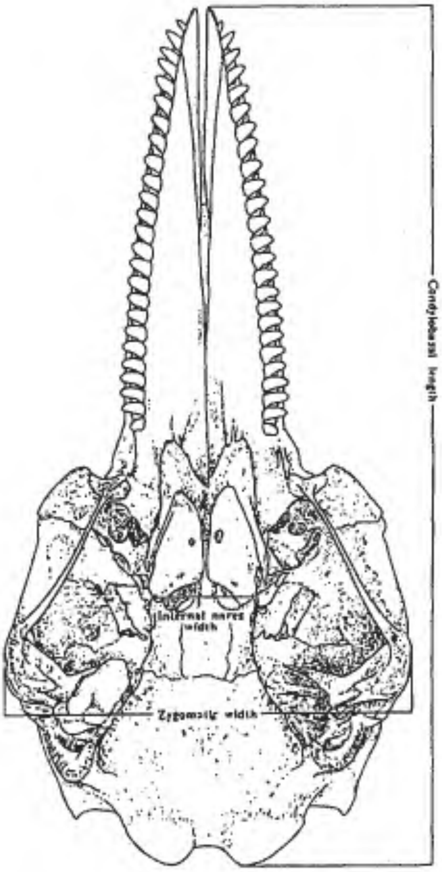

Fig. 4. Method of taking skull measurements (condylobasal length, zygomatic width, internal nares width) illustrated on a coastal specimen (USNM 550403).

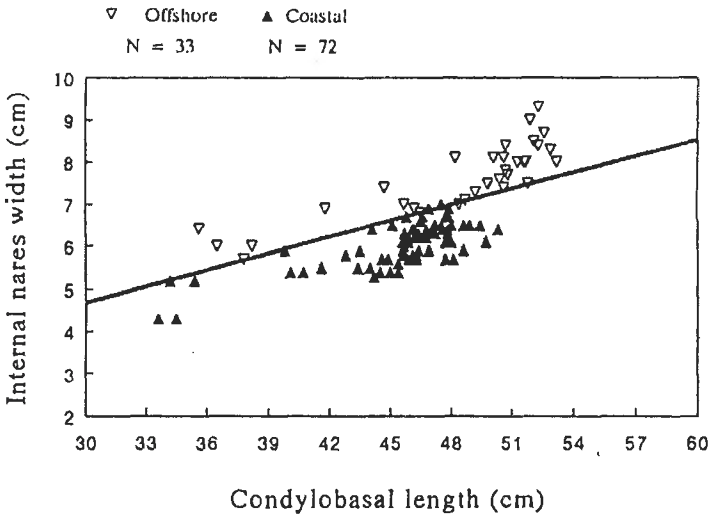

Fig. 5. Plot of internal nares width against condylobasal width showing the separation of offshore and coastal speciments.

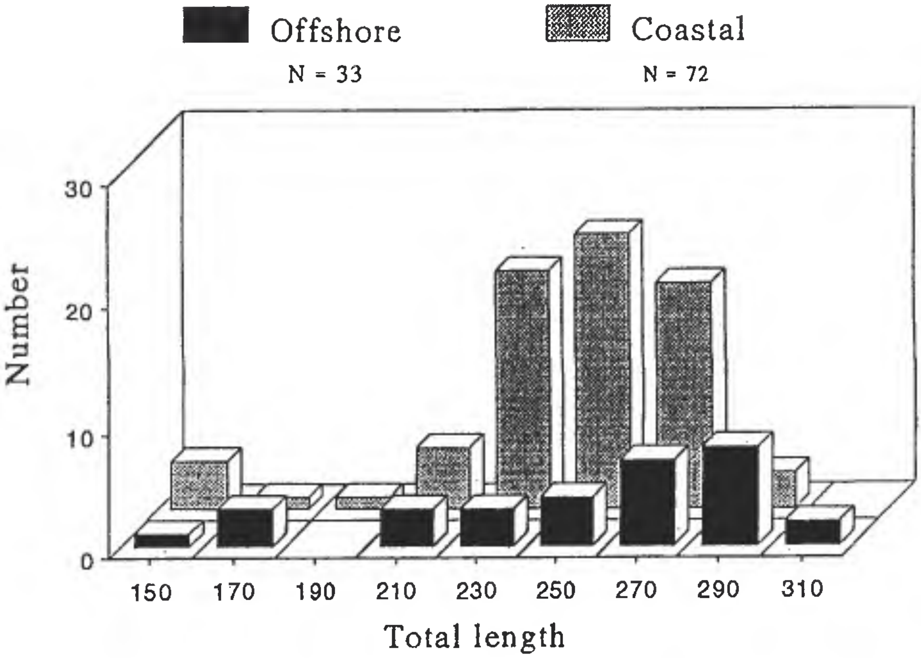

Fig. 6. Relative frequencies of total length in the offshore and coastal populations.

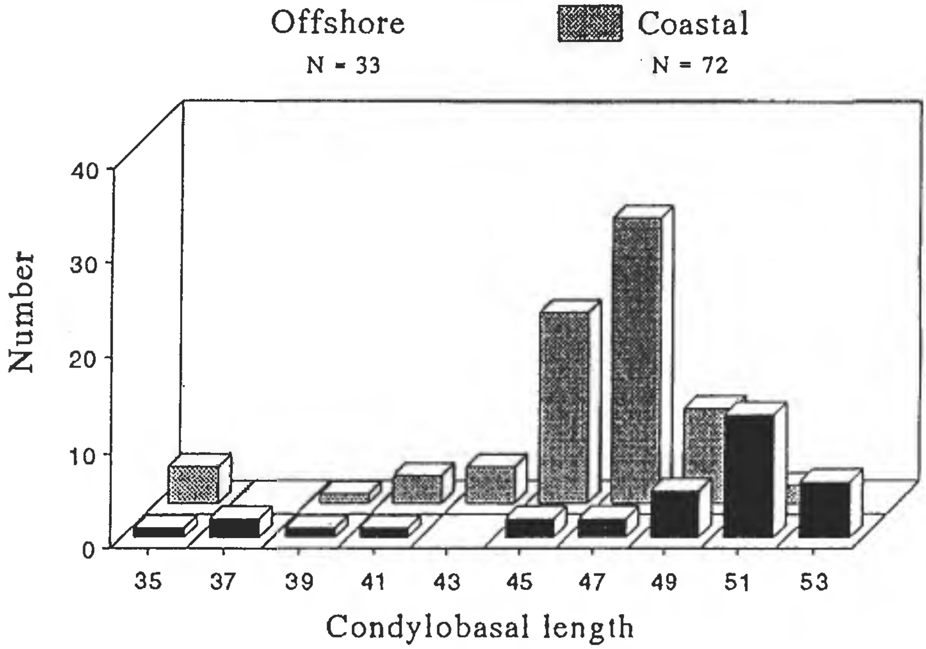

Fig. 7. Relative frequencies of condylobasal length in the offshore and coastal populations.

Fig. 8. *Crassicauda* lesions in the orbital sinus of an offshore specimens (USNM 571442).

Fig. 9. *Crassicauda* lesions in the anterior portion of the pterygoid bone in an offshore specimen (USNM 571442).