

## Progress Report for Year 2000

"Aspects of the ecology of the red squid *Ommastrephes bartramii*, a potential target for a major Hawaiian fishery"

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### Introduction:

The HOKUSEI MARU 2000 cruise was directed primarily at obtaining additional material of *Ommastrephes bartramii* and their prey for stable isotope analyses and gathering material of another ommastrephid squid, *Sthenoteuthis oualaniensis*, for comparative trophic analyses. The latter involved obtaining stomach contents of the squid, and tissue samples from the squid and its prey for stable isotope analyses. A secondary goal was to continue efforts to define the distribution of adult and paralarval *O. bartramii* that would enable identifying the region over which they spawn. The cruise plan was to take the ship straight north to the subtropical front where catches of *O. bartramii* typically are greatest then to steam south to examine trophic changes in *S. oualaniensis* as one approaches the Hilo region on the windward coast of the big island. This latter region is noted for the high abundance of this squid and for a suspected island-related affect on their diet. Plankton tows and midwater trawl were taken at each station.

While the cruise track reflected the initial cruise plan (Fig. 1), two factors strongly affected the outcome of the cruise. First the subtropical front was unusually far north and catches there were not as high as in previous years. Second as we approached the more southerly latitudes to study *S. oualaniensis*, the moon-phase was approaching full which resulted in disappointing catches of this squid. The most unusual aspect of the cruise was the capture of large numbers of *O. bartramii* paralarvae far south of the region that we had assumed to be their normal range of occurrence.

### Paralarvae:

Catches of paralarvae (Fig. 2) were absent from the single station taken north of the subtropical front. This result is consistent with that of previous cruises. Paralarvae were also absent from the nearest station to the south of the front. The front, however, was found to be further north than during previous cruises judging from the position of the 19° C sea-surface isotherm. Prior cruises had sporadic and usually low catches south of about 23° N lat.; previous peak catches centered around sea-surface temperatures of 22°C. The HOKUSEI MARU 2000 cruise sampled much further south than previously and surprisingly found abundant paralarvae at approximately 20° N lat. Sea-surface temperatures (SST) there were an unusually cool 23.4 - 23.9°C which lies with the SST of previous paralarval captures. These southern catches were among the highest we have made during any cruise (catch rates to nearly 7 paralarvae/25m<sup>2</sup> of the sea surface). Due to the small size of the paralarvae (approx. 1.5 mm mean ML), and the trawling conditions, large numbers of ommastrephid paralarvae were damaged and unidentifiable to species. If these unidentified paralarvae are *O. bartramii*, as is almost certainly the case, the maximum catch rate would be 18 paralarvae/25m<sup>2</sup> (the catch rate for identified paralarvae at this station was 6.33). We plan on examining these southern stations again on the 2001 cruise to determine if this occurrence is as unusual as it presently seems.

### *O. bartramii* catches:

Only 12 specimens (11 males and 1 female) were captured during the cruise and they were all taken at the two most northern stations. As in the past, the distribution of adult captures, especially females, did not reflect the distribution of their paralarvae. Although few specimens were caught they do not appear to show any different trends in size (Fig. 3 and 4)

### *S. oualaniensis* catches:

A total of 47 specimens (8 males and 39 females) were captured during the cruise. Captures were made at nearly every station except that north of the subtropical front and one of the southern stations. While catches were substantially better than for *O. bartramii*, they were far less than we would expect to catch under optimal conditions. The presence of a full moon in the middle of the southern stations where catches should have been greatest, apparently was the cause of the low catches. As in previous years, large females taken north of about 22° N. lat. had not matured at this northern extreme of their habitat. The numbers caught are insufficient to demonstrate an island effect on their diet. We hope to re-examine this problem during the 1991 cruise.

### Feeding:

Final processing of stomach contents of *O. bartramii* and *S. oualaniensis* including identification of contents for the 1999 and 2000 cruises has not been completed but we expect this to be finished during the fall. Processing of the stomach contents is a labor-intensive process and emphasis during the past year has been directed toward obtaining stable-isotope data. The stomach-content data, as indicated in last year's report, are showing some distinct trends and completion of the feeding study should prove worthwhile.

### Stable Isotope Analyses:

Samples of mantle muscle were obtained from each individual squid caught. Paralarvae catches were high on this cruise and individuals were collected when present. Two 15L samples of water were filtered at each station to obtain a representative baseline isotopic signal of POM for that station. Three plankton tows were taken per station and "clean" samples, e.g. those not exhibiting shipboard contamination were kept. Representative prey items were taken from each midwater trawl. Attempts were made to obtain at least 5 individuals per major prey species of myctophid when present. Other representative prey from different families of fish were collected also. In addition to mantle muscle, the gladii, eye lenses, and blood were collected. When possible these tissues were collected on the first ten individuals caught, if less than ten squid were caught these tissues were taken from all squid at that station. Given the size of the squids, and consequently the size of the blood volume and major blood vessels in the animal, blood was only attainable from *O. bartramii* and larger *S. oualaniensis*; specimens of ML > 180 mm.

Analyses that have been conducted so far are listed by category in Table 1. below. All squid samples analyzed have been from the mantle muscle. Although sample preparation is relatively simple the amount of samples analyzed to date are limited by instrument access and time per

sample run. Roughly 22 samples (excluding blanks and standards) can be run in a standard work day from 8am to 6 pm. The instrument used in these analyses services many researchers within SOEST and also several throughout the University and the mainland U.S.. Reserving time to run the analyses for this project has been challenging.

Table 1. Number of stable isotope analyses run to date, by category and year.

Category	1998	1999	2000
Filters	-	9	-
Zooplankton	-	9	-
<i>O. bartramii</i> (adult)	-	14	9
<i>S. oualaniensis</i> (adult)	20	19	25
<i>O. bartramii</i> (paralarvae)	-	8	13
<i>S. oualaniensis</i> (paralarvae)	-	1	5
<i>O. bartramii</i> (juvenile)	-	3	

Future endeavors include analyzing major myctophic prey species, and different tissues from the squids to compare tissues with fast metabolic (and therefore isotopic) turnover rates such as blood, with tissues that change slowly or not at all after deposition such as eye lenses and the gladius. More muscle samples will be analyzed to investigate possible interannual isotopic differences as well as geographic variation. These analyses are scheduled to be preformed prior to the year 2001 cruise.

Isotopic data analyzed thus far show that in the red squid and the purple squid  $\delta^{15}\text{N}$  varies as a function of mantle length (Figs. 5 and 6). An increase of  $\delta^{15}\text{N}$  with mantle length occurs in the purple squid, starting off low in the paralarvae and then increasing up to the maximum size of purple squid caught. The red squid shows a similar trend up to mantle lengths of males around 35cm and then seems to remain constant or even decrease slightly with large sized females around 55cm. The  $\delta^{15}\text{N}$  of the purple squid varies significantly with size and with year caught when fitted to a General Linear Model (Minitab v. 13,  $p < 0.005$  in all cases). A linear model does not seem appropriate for the red squid data and more in depth statistical methods are being sought (Fig. 6). Three anomalous data points for the purple squid data occur at a station occupied on the night of 2/12/99 (Fig.5). Out of the six total points for that station, half seem to follow the trend of the regression line for that year, while the other half are much more enriched in  $\delta^{15}\text{N}$  than any other purple squids of that size from any year. Replicates were run for each of the anomalous data points and yielded similar results. A closer examination of the parameters present at that station is in progress.

Stable isotope analyses indicate that adults of the red squid are at least one trophic level above the purple squid (Table 2.). The female red squid have a  $\delta^{15}\text{N}$  which is about 4.36‰ greater than the purple squid while the male red squids are roughly 5.48‰ greater. The juveniles of the red squid have  $\delta^{15}\text{N}$  signatures which are very similar to adult purple squid of similar size (Table 1., Figure 4.). This may indicate that as the red squid is growing it spends a portion of its life feeding at the same trophic level as the purple squid until its greater size is realized and it can take advantage of higher trophic levels which are not utilized by the purple squid.

Table 2. The average  $\delta^{15}\text{N}$  for four categories of squid.

Category of squid	$\delta^{15}\text{N}$ (‰)
Red squid (male)	13.45
Red squid (female)	12.33
Purple squid (female)	7.97
Red squid (juvenile)	7.66
Red squid (paralarvae)	6.40

### General Project Synopsis:

This project examines the general ecology of the red squid *Ommastrephes bartramii* in the central North Pacific near the Hawaiian Archipelago. Our interests in the red squid are based on (1) its considerable potential for a Hawaii-based commercial fishery and (2) its importance in the ecology of the broadbill swordfish, which is a major commercial fishery in Hawaii. This project involves strong cooperative aspects with the National Marine Fisheries Service (NMFS) in Honolulu and Hokkaido University in Japan.

At present we are trying to obtain data on latitudinal and other environmental trends in feeding, reproductive condition, and abundance. Our data, although limited, suggest that adult squid are most abundant in the vicinity of the subtropical front. Females, unlike males, are difficult to capture south of the front. We suspect this is due to a nighttime habitat that is deeper in the south than near the front and this makes females less vulnerable to our sampling gear.

Paralarvae are caught predominantly south of the front, with a maximum in abundance near SST of 22° C, but their distribution is patchy and widely scattered there. Apparently the spawning grounds of this squid constitute a broad area south of the subtropical front. In the Hawaiian region, the red squid feed predominantly on midwater fishes and other squids. There is some indication that supplemental feeding occurs during the daytime in deep water and that food is more abundant near the subtropical front. Our evidence suggests that the red squid is a multiple spawner and that spawning is fueled by feeding on the spawning grounds.

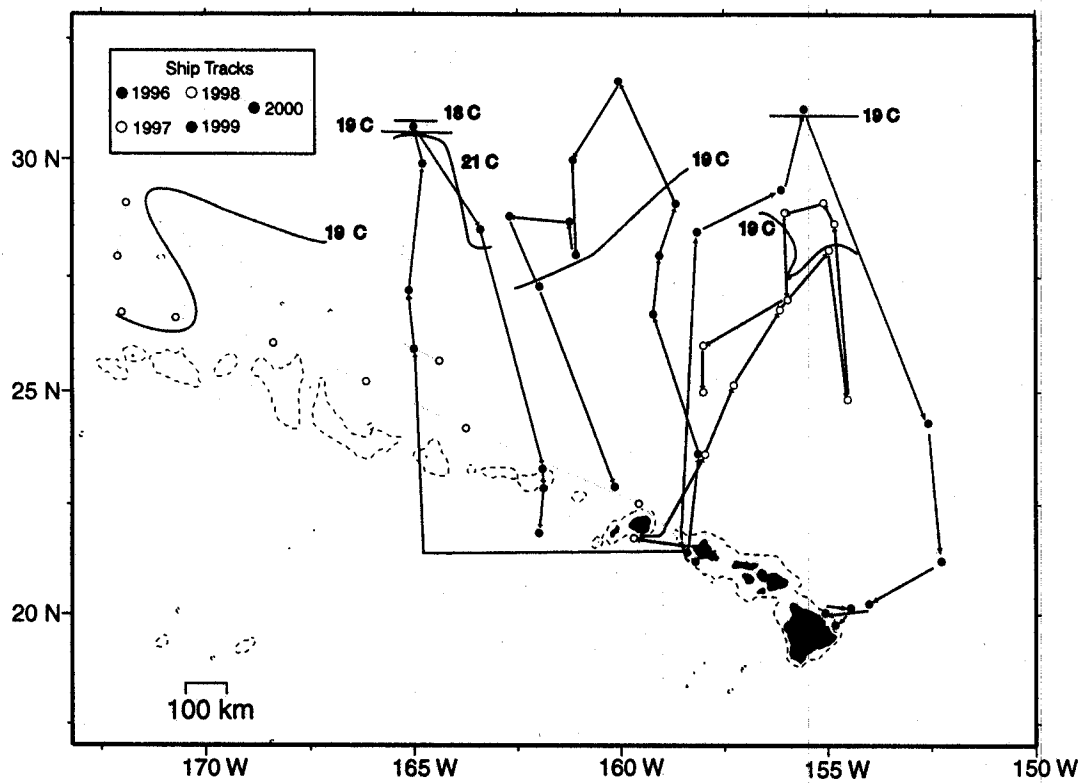


Figure 1. Plot showing cruise tracks for all five years.

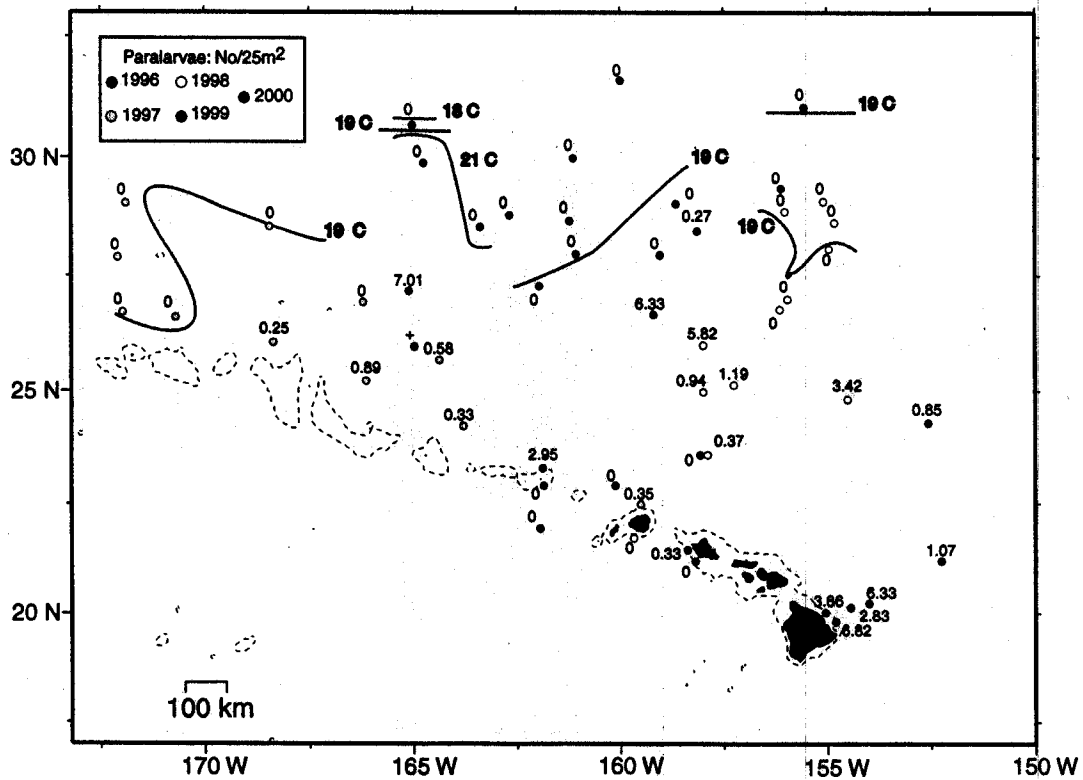


Figure 2.- Paralarvae catch for each station for all 5 cruises, catch reported as paralarvae per 25m<sup>2</sup>.

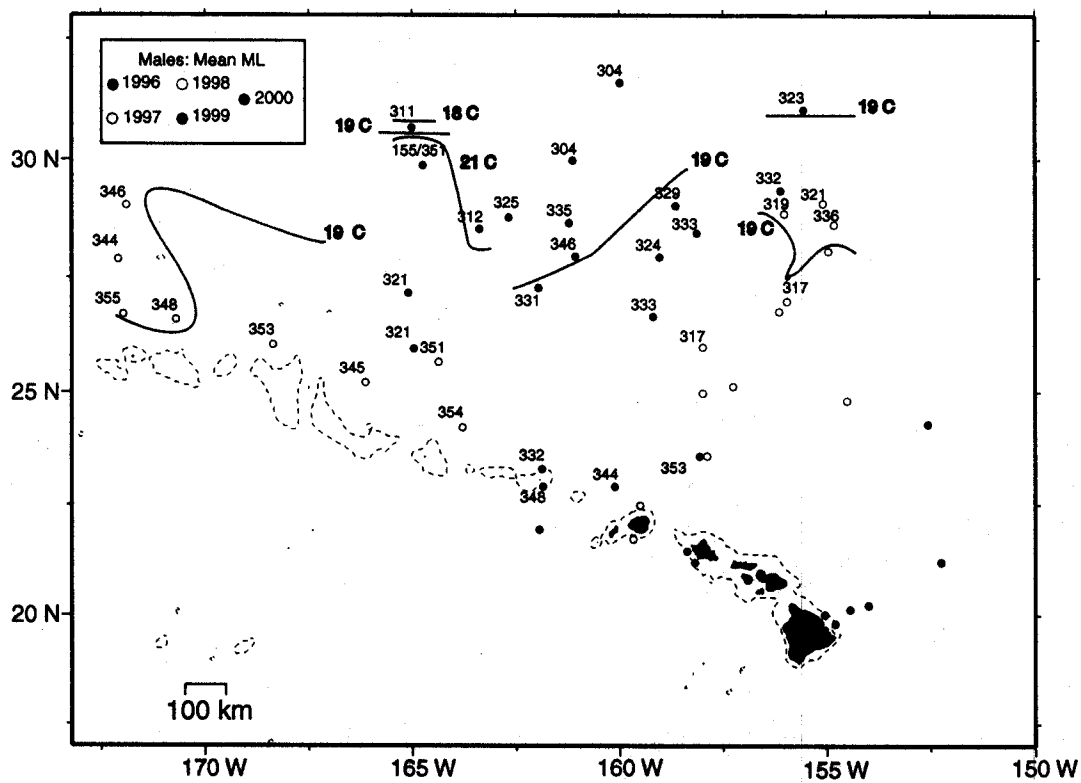


Figure 3.- Map of mean mantle length for male *O. bartramii* caught on all five cruises.

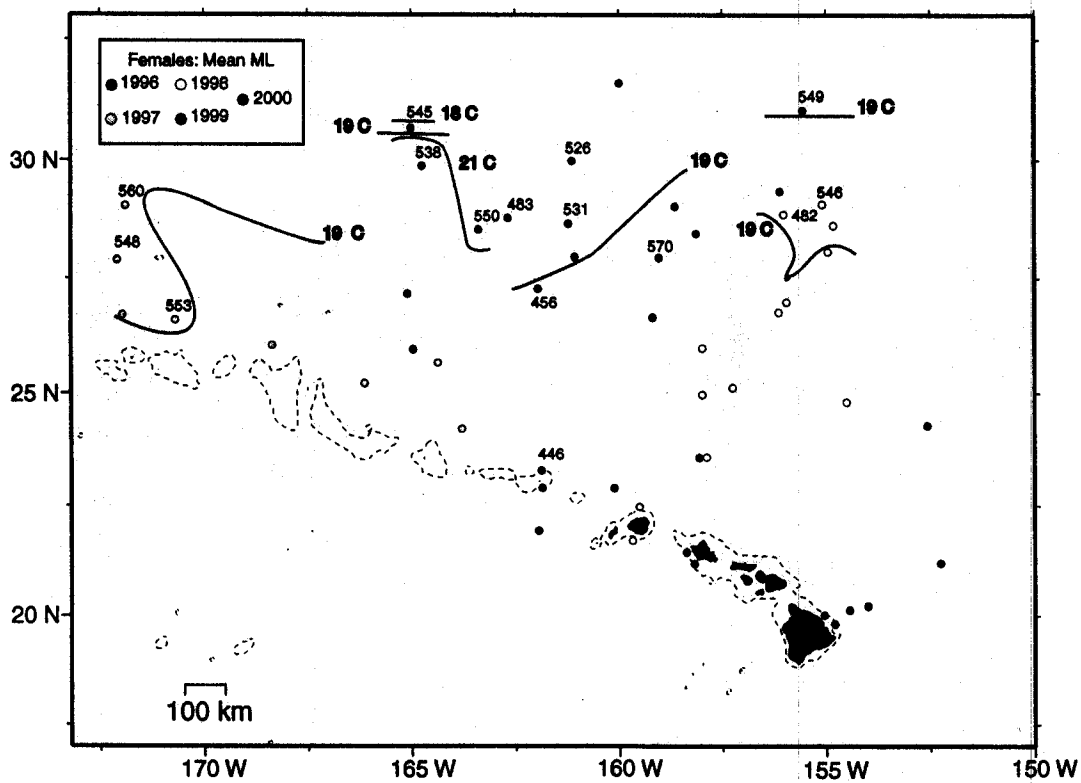


Figure 4.- Map showing mean mantle length for female *O. bartramii* for stations during all five years.

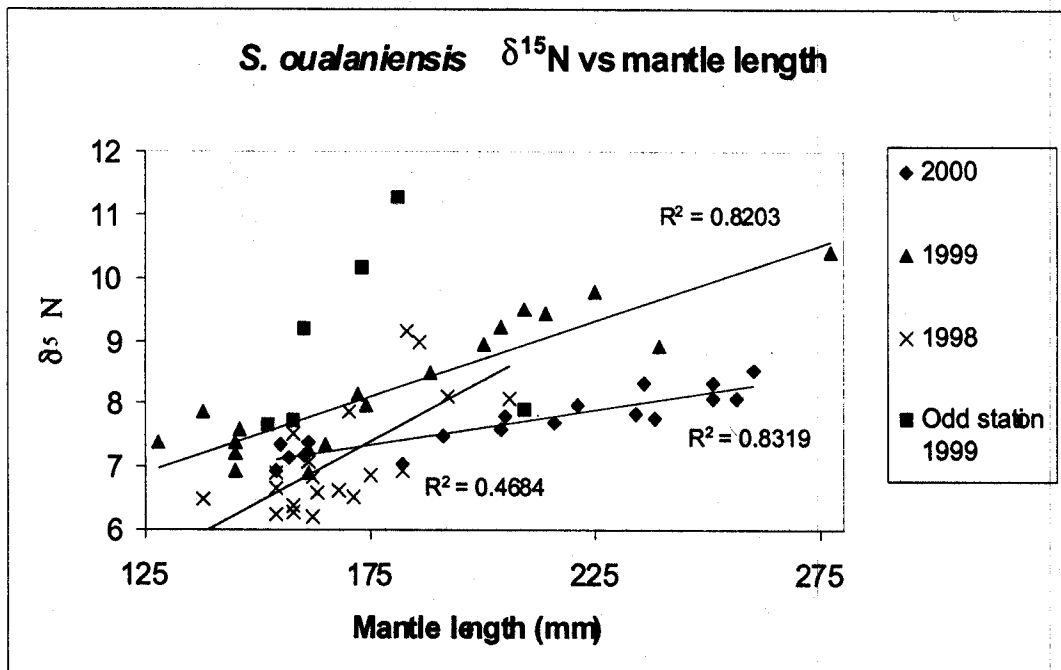


Figure 5- Plot showing the relationship of  $\delta^{15}\text{N}$  to mantle length for *S. oualaniensis* caught during successive years.

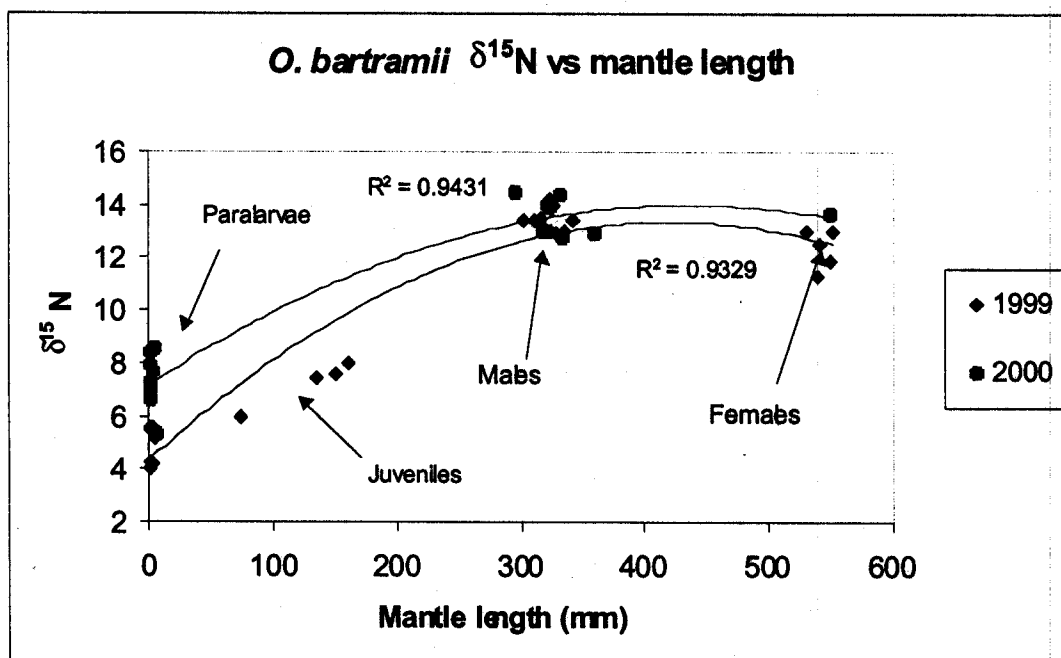


Figure 6- Plot showing the relationship of  $\delta^{15}\text{N}$  to mantle length for different years, sexes, and life history stages of *O. bartramii*.