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SOME OBSERVATIONS ON ARKSHELL CLAMS, *NOETIA PONDEROSA* AND *ANADARA OVALIS*, AND IMPLICATIONS FOR FISHERIES MANAGEMENT

by

Kay A. McGraw[1] and Michael Castagna[2],

I. INTRODUCTION

Two species of arkshell or "blood" clams, *Noetia ponderosa* (ponderous ark) and *Anadara ovalis* (blood ark), have been harvested by watermen on the Eastern shore in Virginia (Figure 1) since 1991. These are sold to markets in Washington D.C., New York City, Los Angeles and Chicago. Long considered a useless incidental catch in the harvest of clams and oysters, the arkshell clams now constitute a rapidly growing fishery with potential for future development. There is little information on the life history of these species in Virginia waters. The intensive harvesting of blood clams and paucity of data on important factors such as distribution, densities, growth rates, and size-age relationships present a problem for management of the fishery.

At this time no official data on landings or exploitation rates are available (Knur, 1992) but some estimates from watermen and Virginia Institute of Marine Science (VIMS) biologists are in the range of 6,000 - 10,000 clams harvested per day from the Seaside lagoons on the Eastern Shore of Virginia. Most of the blood clams harvested are *N. ponderosa*; however, some *A. ovalis* are also included. Virginia state fishery regulations concerning the harvest of arkshell clams are currently the same as for *Mercenaria mercenaria* (hard shell clams), which prohibit dredging from April 1 through

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December 1. Harvest by mechanical tongs, however, is not currently regulated by a season, and harvesting by that method continues year-round. Clam fishermen requested a variance to permit dredging the arkshell clams during the normally closed season (Terry 1991), but the Virginia Marine Resources Commission (VMRC) denied the request until more information is gathered on which to base management practices and regulations.

The regional sales of blood clams is not available, but two seafood dealers in Washington, D.C., offered some rough estimates for their stores. One sells 3,000 - 5,000 clams per week at a price of \$ 2.50 - \$ 3.00 per dozen (V. Pruitt 1993). Another company sells about 2,000 per week from about November through March and charges \$ 3.00 - \$ 4.00 per dozen (S.K. Martin 1993). Watermen report receiving from \$ 0.07 to \$ 0.25 per whole clam, depending on the size and demand; one reportedly received \$0.50 per clam sold directly from his boat.

The blood clams are sold primarily as an ethnic food. Both species have a somewhat bitter taste and contain hemoglobin in blood cells, which gives the flesh a red color (Yonge and Thompson 1976; Abbott 1968). These attributes may explain why they are not usually eaten in the U.S.; however, various ark species constitute significant fisheries in other parts of the world. For example, Japan annually imports 23,000 metric tons (MT) of blood clams from Korea, in addition to domestic landings of about 90,000 MT (DuPaul 1992). Species of *Anadara* are harvested and/or cultured for food in India, Thailand, Malaysia, and Taiwan (Narasimham 1988, 1969; Ismail 1986; Bae 1986; Sahavacharin et al. 1988; Wong and Lim 1985; Ting 1981). Prior to 1950 there were also substantial harvests of *Arca noae* (up to 685 tons per year) from the Adriatic Sea (Hrs-Brenko 1980).

The ponderous ark (*N. ponderosa*) is ubiquitous along the Eastern Shore, in mud-sand substrates, but juveniles are often found in shell debris or "shell hash", where they attach by a prominent byssus to whole shells and pieces of shell. Because they have no prominent siphons, as most clams do, they are found at the substrate surface, making them very accessible for harvest. *Anadara ovalis* occurs both in shell and muddy substrates, but, according to several watermen, densities around the Eastern Shore seem to be far less than *Noetia*. More intensive harvesting of arkshell clams of both species presents a problem for management of the fishery because the market size for *N. ponderosa* may include animals over six years of age. The slow growth rate, coupled with insufficient recruitment, could eventually lead to over-harvest of the resource if present practices persist.

II. GOALS AND OBJECTIVES.

The primary purpose of this study is to provide some basic information on blood clams for management of the fishery. We focused on age-size relationships and growth rates of clams. Some data were also collected on densities of blood clams and size-frequency distributions in fisheries and non-fisheries samples, as well as some morphometric data.

III. METHODS AND MATERIALS.

A. **Shell aging.** A shell aging technique (acetate peel) was used on different sizes of clams to determine age more precisely and to estimate the maximum longevity of the clams. The acetate peel technique has long been used by paleontologists (Rigby and Clark 1965), but has proven effective in age determination for several species of bivalves

(Ropes and O'Brien 1979; Ropes 1984, 1987; Kennish et al 1980; Richardson 1987, 1988). Shell microgrowth patterns have been discussed in detail by several authors, including Panella and MacClintock (1968), Rhoads and Panella (1970), and Lutz and Rhoads (1980). Age and size data can be applied to size distribution data through back-calculation procedures to create age frequency distributions, thus providing a better understanding of the population structure.

The acetate peel method was used successfully to obtain age-size data for about 25 clams ranging in size from 12 mm to 60 mm in height, 20 of which were Noetia and five were *Anadara*. All *Anadara* were from the growth study and were approximately 19 - 25 mm in height. Preparation and examination of acetate peels was labor intensive; therefore, only a few were processed to obtain a very general range of ages for certain sizes.

B. Growth study. In October 1992, small blood clams of both species were collected from a raft behind Revel Island. The clams attached to the raft in late July or early August, according to the watermen who owned it, so the clams were about 2-3 months old when we collected them and began the growth study. A hundred of the larger *Anadara* were measured, marked, placed in mesh bags, and placed in trays about .5 m above the bottom in about 4 meters of waters at two different locations (50 numbered clams at each station). Approximately 500 additional, randomly selected, *Anadara* were also placed at each location. Measurements of subsamples of the unnumbered groups were also taken before the clams were placed in trays. Growth was checked in February and June 1993. Two locations were used in case of tray loss, and not necessarily to follow growth at different locations.

Approximately 600 *Noetia* were also placed in trays at each of the two locations after subsamples of each group were measured. The clams were too small to be numbered, so subsamples of 50 from each group were used to assess growth.

In August 1993 a random sample of *Anadara* was collected from the raft behind Revel Island and measured for a comparison with clams held in trays. There were no *Noetia* found on the raft, and therefore no comparable data are available for that species.

C. Fisheries sample. Several hundred blood clams were obtained from a local supplier in February 1993 and were measured in order to obtain size-frequency data for clams sold in the retail markets.

D. Non-fisheries samples. Non-fisheries samples were collected for the study by a local waterman in June 1993. Tongs were selected as a sampling device because of the ease in sampling and because more discreet samples can be obtained with tongs as compared to a dredge. All material in the tongs was brought aboard, sorted, and estimates of volume were recorded. All clams found in the samples were counted and measured. Estimates of catch-per-unit-effort were made from the samples.

IV. RESULTS

A. Shell aging. Preliminary results showed that the blood clam shells contained more than one growth period per year. Previous studies on other species indicate that 2 or more growth lines per year is the norm for Virginia waters, and we confirmed that in our findings. Figure 2 shows a typical acetate peel from a clam approximately 60 mm in height. Distinct winter bands can be seen, alternating with one or more spring and summer bands, indicating cessation of growth due to water temperature or other factors. This clam was estimated to be about 6 years old, based on the assumption of seasonal growth bands. We used smaller clams of known age from the growth experiment to verify that the clams form more than one annulus per year. Since the average size of market clams (mostly *Noetia*) is about 55 - 60 mm in height, the implication is that clams of that size are at least 6 years old; others that we examined had many more lines, indicating ages from 12 to perhaps 20 years for some in that size group.

Noetia grows very slowly after attaining a size of about 50 mm in height. Some general observations indicate that the whole wet weight (including shell) of larger, older clams (i.e., 50 - 60 mm in ht. and over 12 years old) is more than 100 grams (111 - 157 g, whole wet weight), whereas that of younger clams of similar size is less (85 - 95 g.). Another interesting observation is that the older, larger, and heavier clams contained no gametes, as did the younger clams. Perhaps the older clams reproduce less often. Our sample was too small to draw any definite conclusions regarding weight and age; however, larger sample sizes will provide a better understanding of the relationship between age and size.

We derived a growth curve using the shell aging data for *Noetia* (Figure 3 and Table 1) and included the data point 1 yr. = 10 mm, based on the tray experiments (see section on growth study and Table 2). The equation which best fits the data ($r^2 = 0.90$) is $Y = 11.378 + 17.378(\log X)$. A growth rate of about 1 mm per year after about age 13 (approximately 56 mm) is probably a reasonable estimate. More data are needed to refine the growth model, but the equation given is a workable one for the present.

B. Growth study. A summary of the growth study is found in Table 2. Some larger *Anadara* were purposely chosen for numbering so that we could follow growth of clams on an individual basis. Smaller, unnumbered, *Anadara* were subsampled. The numbered *Anadara* in the two groups averaged 20.3 (± 1.4) mm and 19.6 (± 1.1) mm in height at the beginning of the study in October 1992 (i.e, about 2-3 months old). There was no statistical difference in average sizes. By June 1993, the *Anadara* averaged 1.7 mm in total growth for Group 1 and 2.1 mm for Group 2, for totals of 22.0 mm and 21.7 mm, respectively.

The subsamples of the unnumbered *Anadara* from the two locations averaged about 14.5 (± 3.3) mm (height) at the beginning of the study and 16.6 (± 3.4) and 17.1 (± 3.1) mm, respectively, in June, 1993. The maximum mean growth increment for *Anadara* was 2.7 mm (Group 2) from October 1992 to June 1993.

In October 1992, average height for the two groups of *Noetia* subsampled were 6.2 (± 1.2) mm and 6.4 (±1.5) mm, respectively (Table 2). By June 1993 (i.e, clams were about 10 - 11 months old), average heights were 8.5 (±1.5) and 9.5 (±1.4) mm, with total average growth increments (height) of 2.3 mm and 3.1 mm, respectively. There appeared to be a difference in the timing of growth in *Noetia*, compared to *Anadara*. During the winter months (from October to February) *Anadara* grew very little, if at all, and most growth took place between February and June. In contrast, *Noetia* averaged increments of almost 2 mm from October to February, and less from February to June. Using data from the tray growth study, we estimate the size of *Anadara* at yr 1 (± .083) at about 18 mm and of *Noetia* to be about 10 mm.

The 1-yr class *Anadara* taken in August 1993 from the raft at Revel Island Bay averaged 10 mm in height. This is considerably smaller than those in the tray experiment. The rafts were used for live storage of hard clams and oysters. That hugh biomass with its associated competition for food and oxygen may have caused slower growth. Also the high temperature and lowered dissolved oxygen concentration found on a surface float such as the raft would have contributed to a lower growth rate.

C. **Fisheries sample.** Results of the fisheries sample are presented in Figure 4 and Table 3. Clams ranged in size from 15 mm (height) to 68 mm; the mean ht. was 55.7 ($\pm$ 6.7) mm. Approximately 71% of the clams were 51 - 60 mm in height. A regression analysis of height on length (Figure 5) showed a high degree of correlation (r^2 = 0.94, p = 0.03). Morphometric data such as these will be useful in future studies for predicting length when only the parameter of height is recorded.

D. **Non-fisheries sample.** Tonged samples were obtained from Parting Creek in June 1993 by a local waterman. Results are presented in Figure 6 and Table 4. Approximately 0.1 cubic meters (c.m.) of material was sorted from 8 tonged samples, resulting in about 0.075 cubic meters of shell debris and mud, and 0.025 cubic meters of clams. There were 234 *Noetia*, 13 *Mercenaria*, and 3 *Anadara* in the combined samples. The *Anadara* measured 26.8, 29.8, and 32.4 mm in height. Approximately 60% of the *Noetia* caught were below 45 mm in height (Table 4). Few were over 55 mm, and the waterman reported that the area had been fished for clams previously with dredges. The paucity of larger clams substantiated the efficiency of the dredges and/or intensity of fishing in the area. A comparison of this sample with the fisheries sample (Figure 4) shows that most of the clams taken for market are over 55 mm and that over-fishing may be occurring in the Parting Creek area, and, perhaps, other areas as well.

Among the *Noetia* taken in the non-fisheries sample, 50 (21%) were attached to empty clam shells, usually to the inner, concave surface. These ranged from 14 - 40 mm in height (mean height = 29 mm). None of the larger clams (i.e., >40 mm in height) were attached. The attachment may afford some degree of protection from predation for the smaller clams.

SUMMARY

The blood clams being harvested in the fishery are predominantly *Noetia ponderosa*, which is more abundant along the Eastern Shore than *Anadara ovalis*, but which also grows more slowly. Most of the clams are being harvested by dredges, which are probably more efficient than tongs, in terms of time and labor, but may be causing an undetermined amount of mortality. One waterman, who uses only tongs, reported that he had fished in several areas where dredging had occurred and found numerous dead, market-sized clams. He said the clams were grouped in aggregations or reefs on the bottom and attributed the mortalities to dredges. Lack of time and funding prevented obtaining any data to substantiate his allegations. However, the length-frequency data from fisheries and non-fisheries samples indicate that over-fishing is occurring, at least in one location.

The relatively slow growth rate of *Noetia*, documented in growth experiments, as well as the shell aging study, suggest that some management of the fishery should be considered. For example, gear could be limited, dredging eliminated, and perhaps some areas could be closed/opened on a rotating basis. Another option is to locate areas with substantial amounts of *Anadara*, and promote the harvest of this faster growing species in place of, or in addition to, *Noetia*.

Seasonal restrictions on blood clams would probably be less appealing, since people involved in the fishery might lose their credibility in the markets they have established if they are unable to supply clams on a regular basis. Some consideration could also be given to catch limits, but there are insufficient data at this time for determining what those limits should be.

Both *Anadara* and *Noetia* have been successfully spawned and reared at the Wachapreague Laboratory. It may be possible to grow juveniles of both species in trays or on the bottom (in leased areas) for future harvest. The choice of species for aquaculture would probably be *Anadara*, since it grows faster and tends to have more meat in proportion to shell mass than *Noetia*.

In lieu of more data, perhaps the best course of action is to allow blood clam harvesting with tongs only, and require that any blood clams caught incidentally with dredges while harvesting hard clams must be thrown overboard.

ACKNOWLEDGEMENTS

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List of Figures and Tables

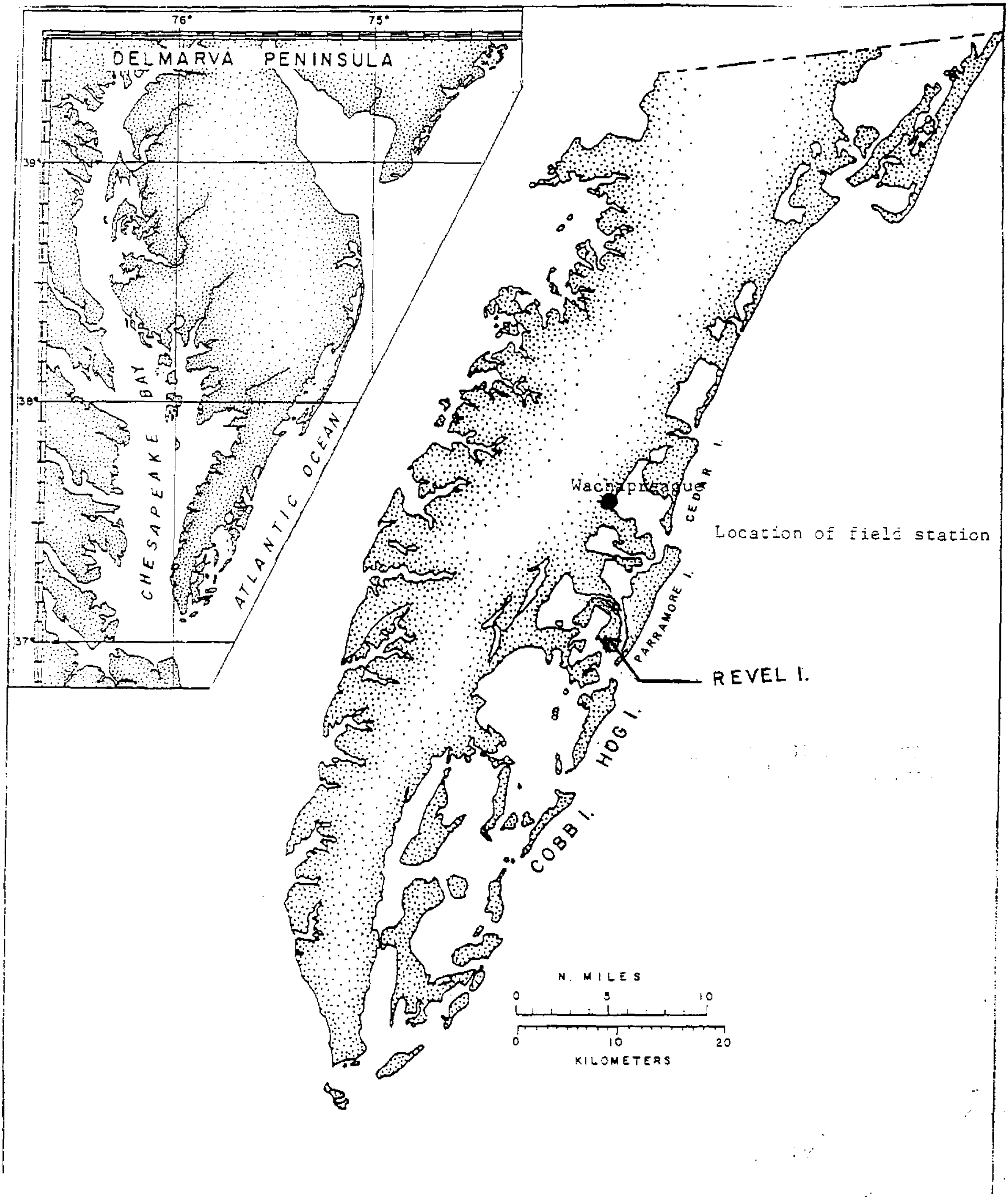

Figure 1. Map of Tidewater (Eastern Shore) Virginia showing location of VIMS field station.

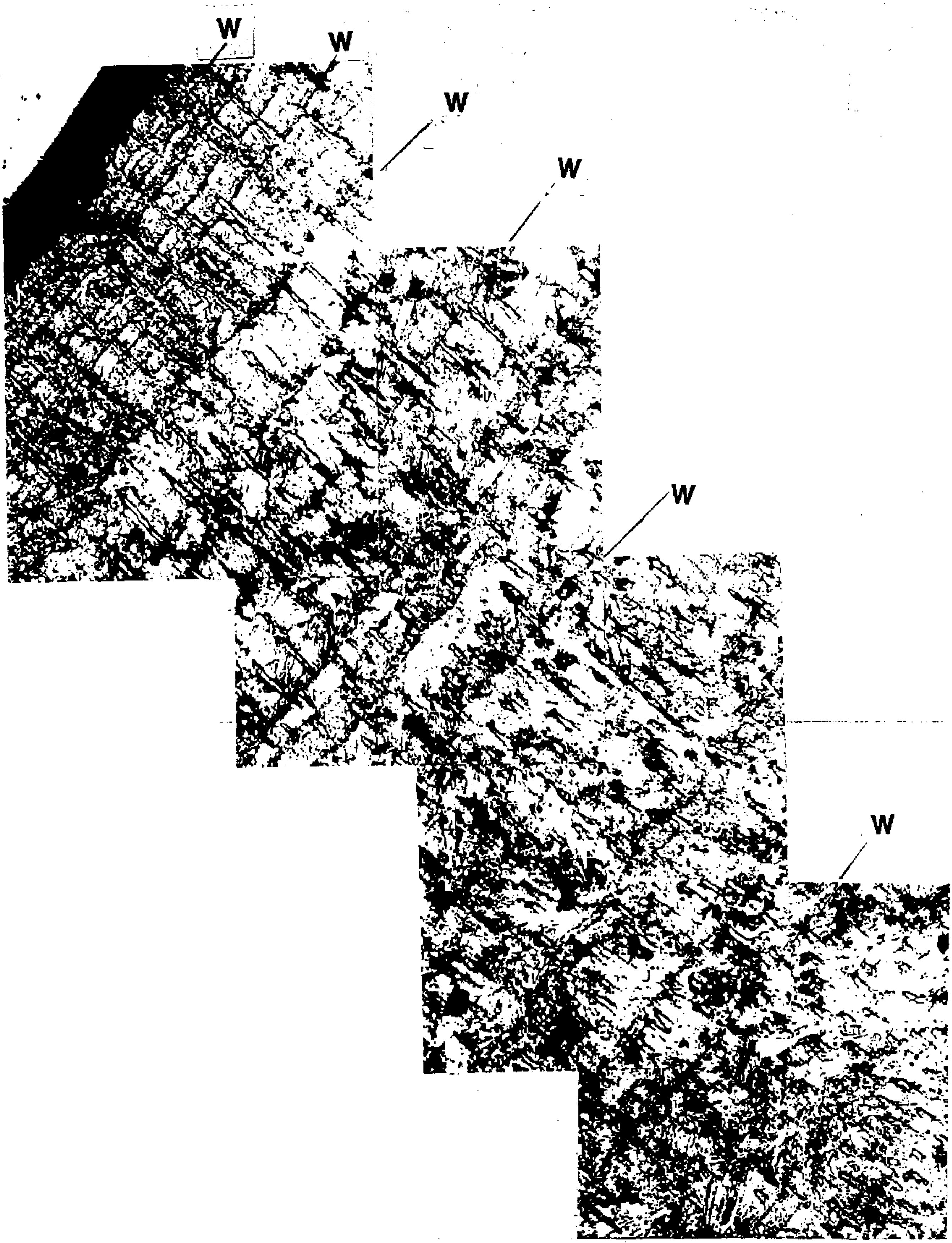

Figure 2. Acetate peel of *Noetia ponderosa* (height = 58.5 mm, length = 71.1 mm; magnification = 160X). "W" indicates winter bands, showing clam is approximately 6 years old.

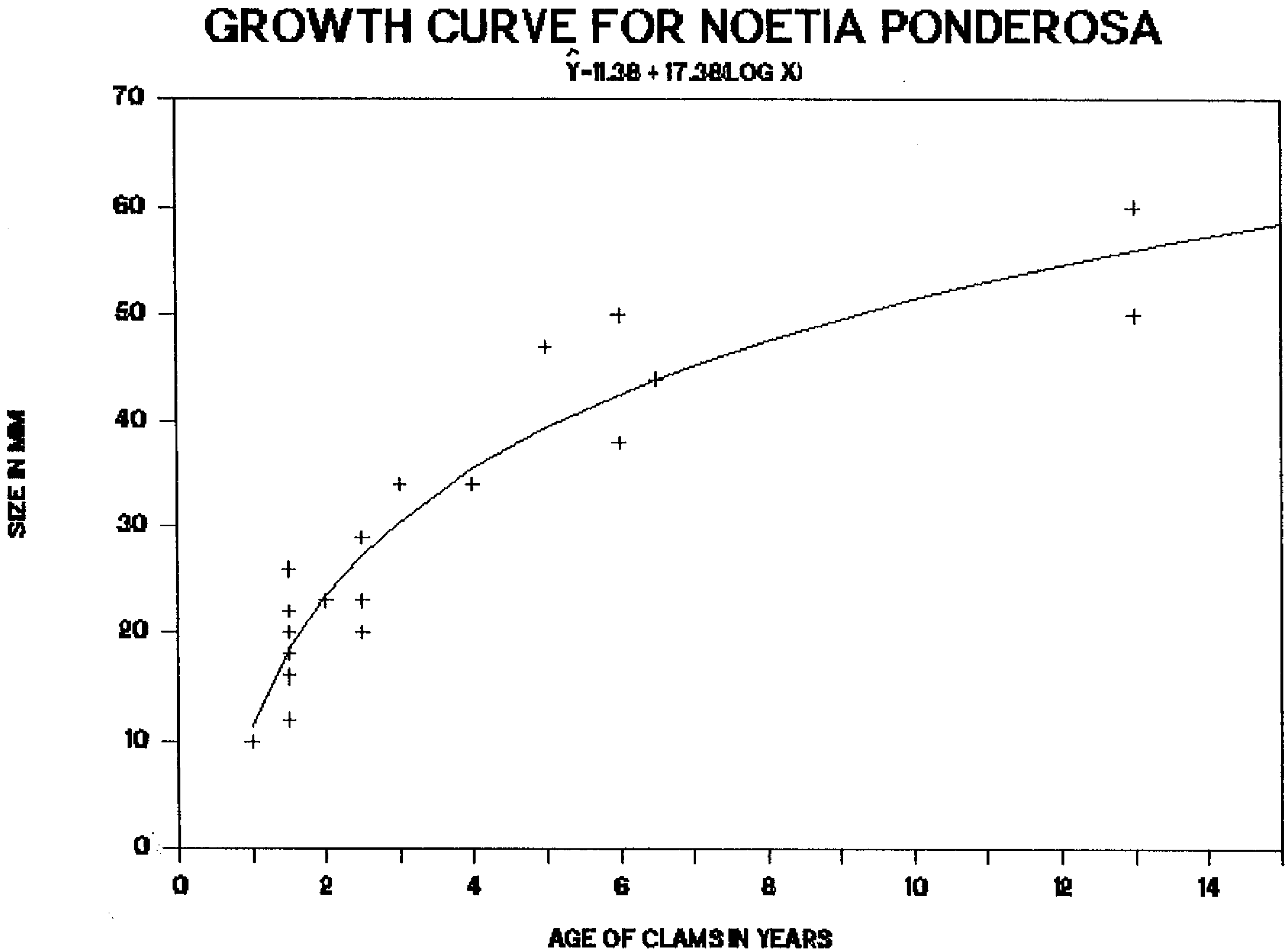

Figure 3. Growth curve for *Noetia ponderosa* (age 0 - 15 yrs) computed from age-height data.

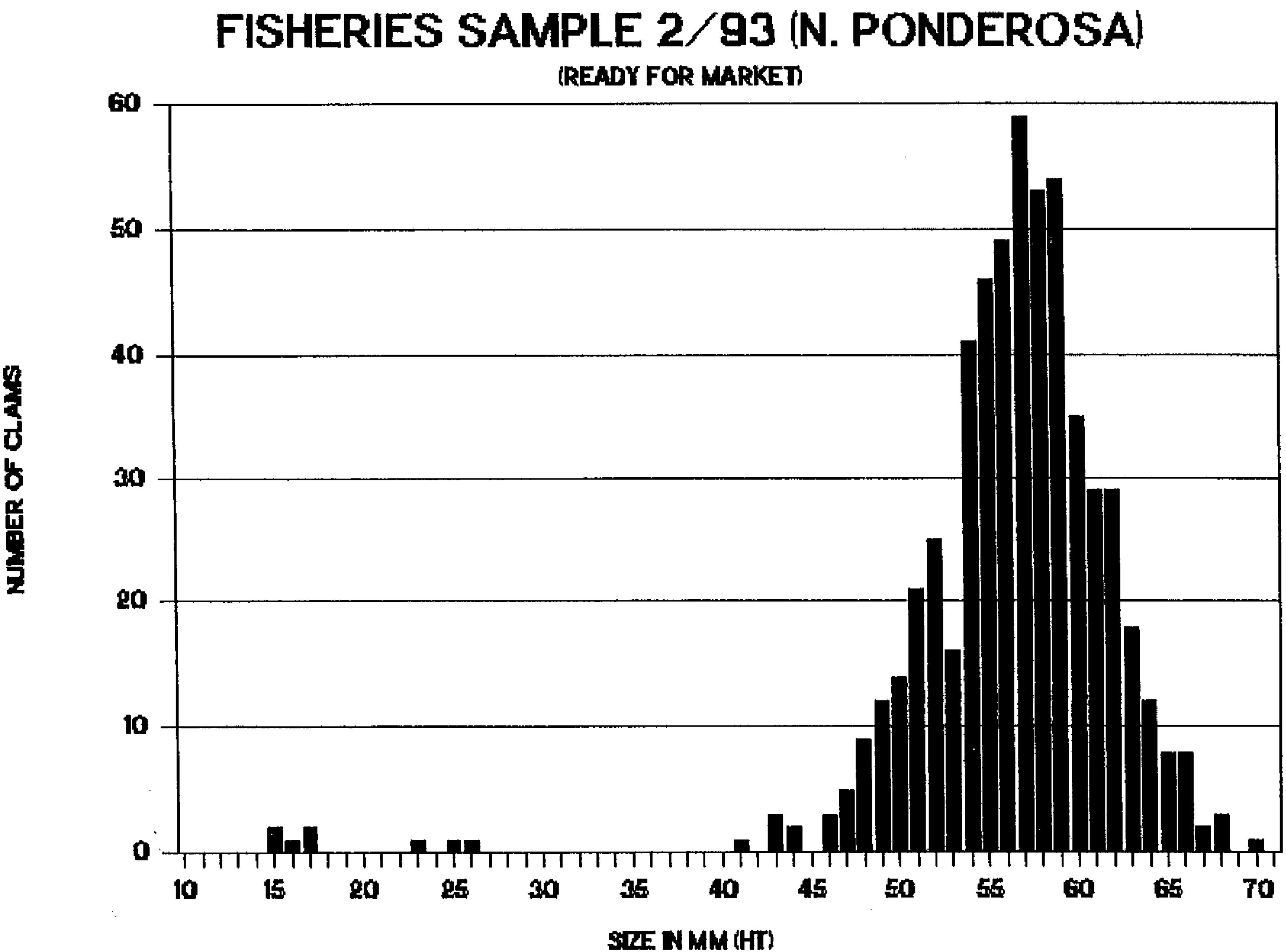

Figure 4. Graph of size frequency data from fisheries (market) sample.

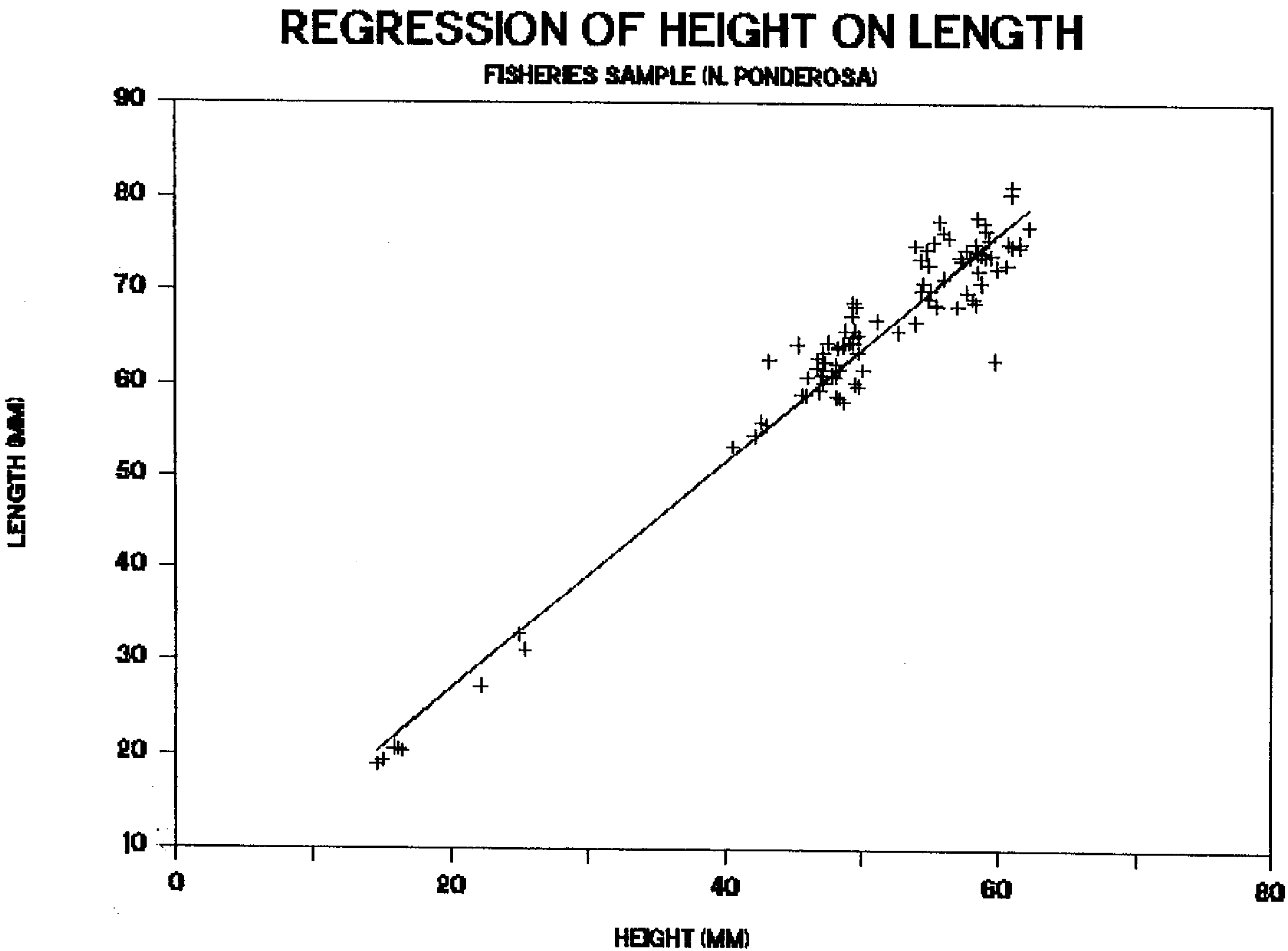

Figure 5. Regression of height on length of *Noetia ponderosa* from fisheries sample.

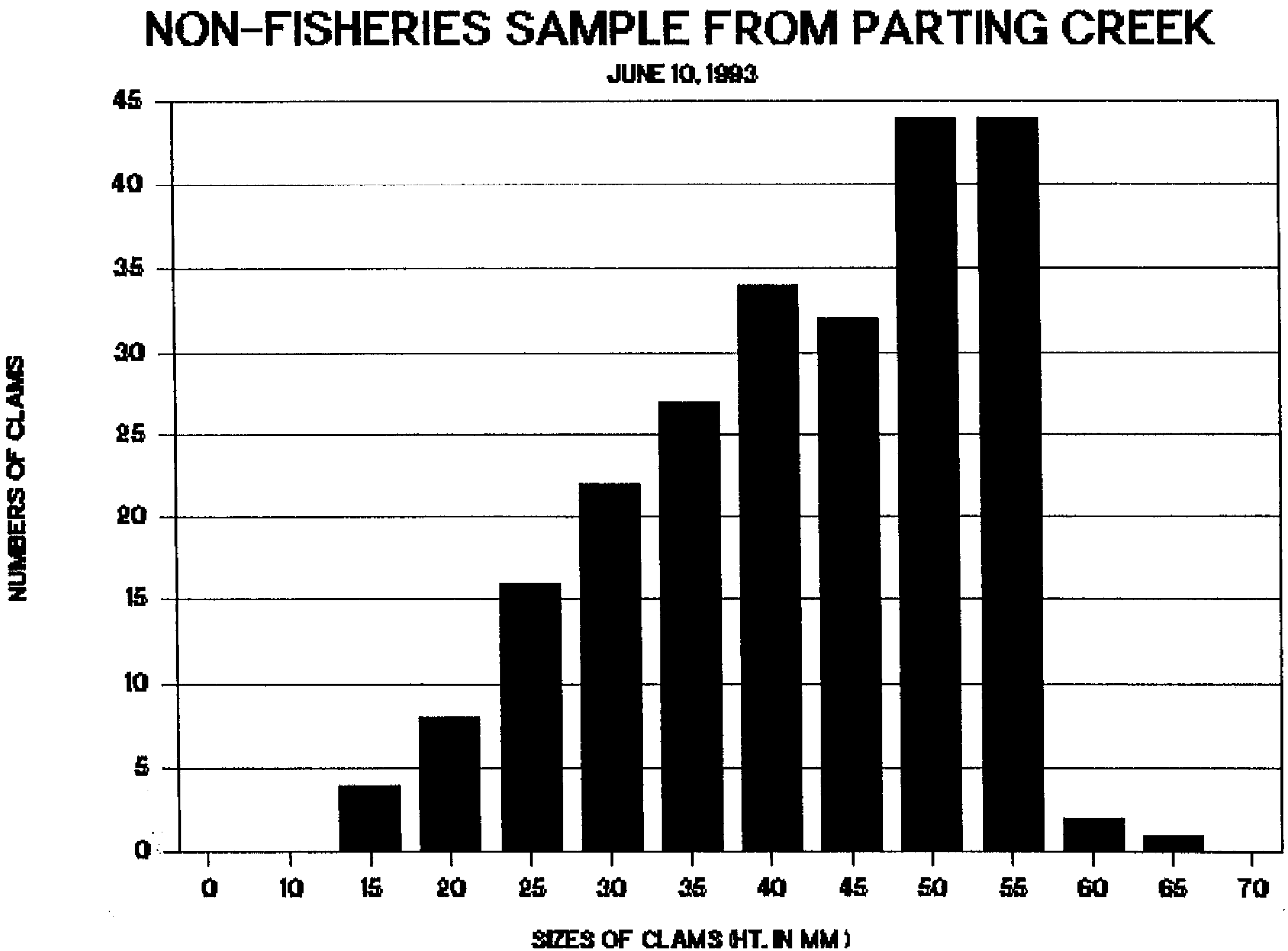

Figure 6. Graph showing size-frequencies of *Noetia ponderosa* (ht in mm) from non-fisheries (Parting Creek) sample. Note abrupt depletion at 60 mm size.

Table 1. Age - height data for *Noetia ponderosa* used to compute growth curve.

HEIGHT (in mm)	ESTIMATED AGE*
10	1.0
12	1.5
16	1.5
18	1.5
20	1.5
20	2.5
22	1.5
23	2.5
23	2.0
26	1.5
29	2.5
34	3.0
34	4.0
38	6.0
44	6.5
47	5.0
50	13.0
50	6.0
54	13.5
60	13.0

* Estimated age based on shell aging technique

Table 2. Growth data for *Noetia ponderosa and Anadara ovalis*, 1992-1993*

Species	Oct. 1992	Feb. 1993	June 1993	Total mean growth
	MEAN HEIGHT (MM) (± S.D.)			
A. ovalis (numbered)				
Sta. 1	20.3 (1.4) n=50	20.3 (1.4) n=47	22.0 (1.8) n=26	1.7
Sta. 2	19.6 (1.1) n=50	19.8 (1.3) n=41	21.7 (1.4) n=38	2.1
A. ovalis (subsample of all sizes)				
Sta. 1	14.5 (3.3) n=50	14.2 (3.2) n=30	16.6 (3.4) n=50	2.1
Sta. 2	14.4 (3.4) n=50	14.4 (3.5) n=30	17.1 (3.1) n=50	2.7
N. ponderosa (subsample of all sizes)				
Sta. 1	6.2 (1.2) n=50	8.1 (1.7) n=50	8.5 (1.5) n=50	2.3
Sta. 2	6.4 (1.5) n=50	8.3 (1.4) n=50	9.5 (1.4) n=50	3.1

A. ovalis (approx. 1 yr. old) from raft behind Revel Island 8/20/93: Mean = 10.7 (4.4)
(n = 82)

* Blood clams were obtained from a raft in an oceanside lagoon in Oct. 1992, and are believed to have recruited on the raft in July 1992. Larger *Anadara ovalis* were numbered and measured and placed in two different locations for a growth study. A subsample of additional (smaller) *Anadara* and *Noetia* were measured and also placed in trays at the two locations. Subsequent measurements were taken in Feb. and June 1993. The growth study is still in progress.

Table 3. Size frequencies (height in mm) of *Noetia ponderosa* from fisheries sample taken in February 1993.

SIZE	# OF CLAMS	% OF TOTAL
0 - 10	0	0.0
10 - 15	2	0.4
16 - 20	3	0.5
21 - 25	2	0.4
26 - 30	1	0.2
31 - 35	1	0.2
36 - 40	0	0.0
41 - 45	6	1.1
46 - 50	43	7.5
51 - 55	149	26.3
56 - 60	250	44.2
61 - 65	96	17.0
66 - 70	14	2.4
> 70	0	0.0
TOTAL =	567	100.0
MEAN =	55.7 mm (± 6.7)	

Table 4. Size frequencies (height in mm) of *Noetia ponderosa* from non-fisheries sample taken in Parting Creek, Virginia, June 1993.

SIZE	# OF CLAMS	% OF TOTAL
0 - 10	0	0.0
10 - 15	4	1.7
16 - 20	8	3.4
21 - 25	16	6.8
26 - 30	22	9.4
31 - 35	27	11.5
36 - 40	34	14.5
41 - 45	32	13.7
46 - 50	44	18.8
51 - 55	44	18.8
56 - 60	2	0.9
61 - 65	1	0.4
66 - 70	0	0.0
TOTAL =	234	100.0
MEAN =	39.6 mm ($\pm$ 10.7)	