WAQUOIT BAY
NATIONAL ESTUARINE RESEARCH RESERVE

TECHNICAL REPORT WBNERR-102

1992 Recreational Boating Survey: Practices and Utilization of Waquoit Bay Waters

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Executive Summary

- The boating season lasts about six months.
- An average of 2.9 persons were aboard during a boating trip.
- There were about 1000 boats in the Waquoit Bay recreational boating fleet in 1992.
- Powerboats (outboard and inboard) comprised more than 60 percent of the fleet.
- About 75 percent of the fleet was less than 25 feet long.
- About 30 percent of the boats were 20-25 feet long.
- About 45 percent of the boats were less than 20 feet long.
- Of the boats 20-25 feet long, about 50 percent had a Port-a-Potty-type MSD; 33 percent had no MSD; the remainder had a Type III device.
- Of the boats less than 20 feet long, few had an MSD.
- Five percent of the fleet had Type I and Type II MSDs, the types not allowed by "No-Discharge" regulations.
- About 30 percent of Waquoit Bay boaters were not willing to pay for pumping out.
- 25 percent of the boaters willing to pay for a pump-out would spend more than $6.
- A mobile pump out facility would be most frequently used on weekends (Saturday and Sunday) between 2-6 PM.
- The potential amount of nitrogenous waste discharged into the bay by the recreational fleet was roughly equivalent to that produced by between 18 - 480 people or 10 - 270 households.
- There is likely to be a minimal tangible reduction in the amount of nutrients entering Waquoit Bay as a result of a "No-Discharge" designation.
- There were about 246 docks in the Falmouth portion and about 128 docks in the Mashpee portion of Waquoit Bay waters in 1992.

Background

Area description and concerns

The estuarine and barrier beach complex consisting of Waquoit Bay and its adjoining waters (Eel, Hamblin, Jehu, Tims and Sage Lot ponds; Childs, Great, Little, Seapit, and Moonakis/Quashnet rivers) (Fig. 1) is the most extensive, largely unaltered estuarine system on the south shore of Cape Cod (WBNERR 1989). Many natural components of the system are specified as Significant Resource Areas in the Massachusetts Coastal Zone Management Program. The protection of these barrier beaches, dunes, salt marshes, shellfish beds, and fish runs, and the preservation of the ecosystems within the associated estuaries and flood plains is a leading state and local concern. As such, most of these waters have been designated as an Area of Critical Environmental Concern (Bliven 1989).

Postwar development of the Waquoit Bay watershed has increased the amount of nutrients (particularly compounds of nitrogen) entering the bay. This has led to changes in the bay ecosystem (Valiela et al. 1992). Understanding the causes and implications of these alterations has been a focus of the research at the Waquoit Bay National Estuarine Research Reserve (WBNERR). For example, scientists of the Land Margin Ecosystem Research Project (funded by NSF, NOAA, and EPA) have established that the bay and surrounding waters are "nitrogen-sensitive". This is because the waters receive an excess of nitrogenous nutrients from their watershed and because tidal flushing in the system is limited. The nutrients act as fertilizers to aquatic plants. The proliferation of seaweeds in Waquoit Bay waters is indicative of excess fertilization. Under certain conditions, excessive plant growth can decrease the amount of dissolved oxygen in the water. The result can be massive fin fish and shellfish kills.

Nutrient sources include septic system discharges which enter the bay via groundwater flow, road runoff, acid rain, dust particles, water droplets in fog, agricultural and lawn fertilizer, and animal waste. Discharges from boat marine sanitation devices (MSDs) are an additional source of nitrogen. Federal law prohibits discharging untreated waste within three miles of the US shore, but discharges from MSDs are allowed. MSD types I and II (Table 1) mix organic waste with disinfectants (e.g. chlorine or formalin) and the mixture is discharged directly overboard. The nutrients in the waste can stimulate the growth of marine plants but because of the chemicals, these discharges can be highly toxic to marine animals.

Furthermore, because MSDs use relatively small amounts of water to operate, the organic matter in boat wastewater is highly concentrated. Introducing concentrated waste into the marine ecosystem may cause environmental stress. A measure of the relative concentration of organic matter is the biological oxygen demand (BOD), the amount of oxygen required to

decompose this matter by aerobic processes. The BOD of boat waste is typically 1700-3500 mg/l, while that of raw municipal sewage is 110-400 mg/l. Treated municipal sewage BOD is 5-100 mg/l (JRB Associates 1981). For an estuary like Waquoit Bay, the oxygen demand from decomposition of discharges from boat MSDs may result in a decrease in dissolved oxygen concentrations in the bay ecosystem.

MSD discharges are also a recognized source of fecal coliform bacteria. The number of these bacteria in our waters is monitored by state health authorities who assess water quality according to a prescribed classification system (Table 2). Water quality degradation from too many bacteria can signal potential health threats. Waterborne diseases caused by septic bacteria and viruses include gastroenteritis, hepatitis, typhoid, and cholera (Milliken and Lee 1990). A large number of boats in an area may result in elevated levels of coliform bacteria (Furfari and Verber 1969, Faust 1982). In such cases, authorities close these areas to fishing and swimming activities. The result is limited access to coastal resources.

A "No-Discharge Zone" designation

In 1992, the Waquoit Bay Intermunicipal Committee was formed. It was comprised of representatives from the Association for the Preservation of Cape Cod (APCC), WBNERR, and the three towns with territory within the Waquoit Bay watershed (Mashpee, Falmouth, and Sandwich). The focus of the committee was to address concerns of common interest regarding the heath of the Waquoit Bay ecosystem and watershed. It was an advisory body intended to provide input for local government management decisions.

An initial concern of the committee was the potential for degradation of Waquoit Bay water quality by the use of MSDs. The committee and local residents were concerned that these discharges may have contributed excess nutrients which have overstimulated plant growth in the bay (a process called eutrophication). There was also concern that malfunctioning MSDs could be fouling the waters with pathogens. To alleviate these concerns, the committee applied to the EPA to designate Waquoit Bay and its contiguous waters as a "No-Discharge Area". Such designation would require that all MSDs used in the bay would be fitted with holding tanks (e.g. Port-a-Potty-type device or Type III MSD). These MSDs either incinerate the organic waste or retain it for pump-out ashore. Pump-out facilities would be located at Edwards Boatyard in East Falmouth and a mobile unit (a specially fitted boat) would be based at Little River Boatyard in Mashpee. Those MSDs (types I and II) which discharge directly overboard when used would be required to have the valves sealed. Enforcement would be provided by the U.S. Coast Guard, Massachusetts Environmental Police, and harbormasters.

WBNERR Recreational Boating Survey

To help assess the implications of this new designation, the Waquoit Bay National Estuarine Research Reserve (WBNERR) conducted a recreational boating survey during the summer and fall of 1992. The survey consisted of two parts: a questionnaire (Appendices A and B) and boat counts.

The questionnaire was designed to answer several important questions, such as: What was a typical boating experience in the Waquoit Bay recreational fleet? How did the boating community perceive the health of the bay? What percentage of boats in the fleet have marine sanitation devices (MSDs) and what was the current distribution of MSD-types? What proportion of the fleet would be affected by the No-Discharge designation? What was the relative size of the potential threat posed by the fleet to the bay waters? Would boat owners be willing to pay to have a holding tank pumped out?

The questionnaire was more than a simple list of questions posed to boaters. It also served to provide recreational boaters with an opportunity for direct input into the system that regulated their activities. Survey results were seen as important input to the development of the new management initiatives under consideration.

Between July 4 and Labor Day 1992, volunteers intercepted 150 recreational boaters at public boat ramps and boat yards (Fig. 1) and asked them to respond to the questionnaire (Appendix A). To reach a broader portion of the fleet, in the Fall of 1992 the questionnaire was mailed to users of boat moorings in Waquoit Bay waters under the purview of the Falmouth Harbormaster.

After the survey had begun, the Town of Mashpee received funding from EPA to purchase a mobile pump-out unit to use on the bay. The Little River Boatyard leased the unit for operations on the bay. To answer questions that arose about the most effective way to deploy the mobile unit, the survey was modified (Appendix B) prior to being mailed to users of moorings in Mashpee waters.

The survey design did not permit detailed statistical interpretation of results (see Appendix C). Therefore, analysis of survey results was generally limited to a graphic compilation of the responses and an evaluation based on comparisons. Results were compiled as percentages of the total number of responses received for each question, where possible.

Boat and dock counts

The number of boats docked or moored on the bay waters was determined in 1992 by either field observation or by examining aerial photographs that were taken September 2, 1992 (a Wednesday). The goals of the counting exercise were (1) to derive an estimate of the size of

the fleet to relate to the questionnaire results and (2) to gain insight about the potential problem associated with the presence of boats painted with antifoulant bottom paints. An estimate of the rate of growth of the fleet was derived from comparisons with counts obtained from aerial photographs taken in 1970 and 1989. The number of docks in 1992 was determined from field counts or from the September 2, 1992 aerial photographs.

Questionnaire responses obtained at boat ramps pertained to the use of trailered boats that occasionally use Waquoit Bay. The total number of these boats in the Waquoit Bay recreational fleet was not determined. An unknown portion of them would have been included in the survey if boats were at a ramp or dock during the count.

Boat and Dock Count Results

During the morning of August 11, 1992, observers travelled by boat and counted 823 boats in the study area (Table 3). On September 3, 1992, 847 boats were photographed on Waquoit Bay and its tributaries (excluding the west "arm" of Eel Pond). Totals of 246 docks in Falmouth waters (including west Eel Pond) and 128 in Mashpee were also counted (Fig. 2). Since some boats were in use during the time the counts were made, and other boats tied to the large number of docks in west Eel Pond (Fig. 2) were not counted, the total number moored or docked in contiguous Waquoit Bay waters was estimated to be about 1000 boats. This was roughly twice the number of boats in the fleet in 1970 (Fig. 3, Table 4).

The fleet may have been larger in 1991. About 110 of the 260 (roughly) moorings at the head of Waquoit Bay were unattended when the bay was photographed in 1992. More moorings may have been occupied the previous year but many boats were damaged by Hurricane Bob in August 1991 and were not in use in 1992.

Questionnaire Results Summary

Owners of about 80 percent of the fleet (673) responded to the questionnaire. Within this number, 15 percent (101) were 26-30 feet long; 29 percent (195) were 16'-20'; 30 percent (202) were 21'-25'; and 16 percent (108) were 15' or less. About 47 percent of the fleet had no MSD installed and 48 percent had some type of holding tank (either Type III MSD or a Port-a-Potty-type unit) (Fig. 4). Only 5 percent of the fleet had the discharging types of MSD (Types I and II) that would be specifically regulated by the No-Discharge designation (Fig. 5).

Other results derived from questionnaire responses (Fig. 6 - Fig. 26) are summarized as follows:

A. Powerboats (outboard and inboard) comprised more than 60 percent of the fleet.

B. Almost one half of the boaters have more than 10 years of boating experience within the

Waquoit Bay region (30 percent have 20+ years).

C. About one half of the boaters use their vessels for 5-6 months per year.

D. Fishing and day sailing are the two most popular boating activities, with weekend cruising a close third.

E. About 25 percent of the fleet is stored on Waquoit Bay during boating season.

F. Decreased water clarity is the most commonly observed change in water quality (of the three choices). Fish kills were noted in only 15 percent of the responses.

G. Type I and Type II MSDs are rare in the fleet (5 percent).

H. Most boats (86 percent) have 2-4 people aboard (average = 2.9).

I. Only 13 percent of the boaters with MSDs use shore waste disposal facilities almost all of the time.

J. In general, boaters are not convinced about the effectiveness of federal MSD regulations.

K. Boaters want pump out stations to be more accessible.

L. About 30 percent of the boaters are not willing to pay for pumping out.

M. Only about 25 percent of the boaters willing to pay for a pump out wanted to spend more than $6.

N. More than 60 percent of the boaters would use a mobile pump out facility, particularly if it is on the bay.

O. A mobile pump out facility would be most frequently used on weekends (Saturday and Sunday) between 2-6 PM.

P. Most boats have a VHF radio that could be used to hail the mobile pumper.

Q. There are three boat ramps providing recreational boating access to Waquoit Bay waters (Fig.

R. The ramps have limited utility to day boaters (i.e. non-residents) because of the confined vehicle/trailer storage areas associated with them.

Implication of "No-Discharge" on Waquoit Bay waters

Pathogens

Although it is illegal to discharge untreated septic wastes within 3 miles of shore, standards adopted by the National Shellfish Sanitation Program (NSSP) for protecting human health in waters used for shellfishing are based on the assumption that such discharges will occur. While coliform levels in Waquoit Bay have remained below the threshold of unsafe limits, it is not uncommon to find increases in fecal coliform bacteria counts in boat mooring areas (Furfari and Verber 1969, Faust 1982). To minimize the potential human health impacts of boating on a body of water, the FDA (U.S. Dept. H.E.W. 1988) has developed the following formula for determining the potential bacterial contribution of boats in a shell fishing area:

$$\text{Fecal coliforms/100 ml} = (N \times F \times E) / V$$

where:

N = number of boats, F = fecal coliforms per person,

E = persons per boat, and V = volume of dilution water available.

A maximum of 14 fecal coliform bacteria per 100 milliliters of water (14 FC/ml) is accepted where shellfishing is allowed. The following worst case assumptions are applied in the NSSP use of this formula (Milliken and Lee 1990): 100 percent boat occupancy rate; 100 percent overboard discharge of sewage; 2 persons per boat (in absence of specific information); 2 billion fecal coliform bacteria per capita per day; thorough tidal mixing; no bacterial die-off or growth; and no other sources of bacteria.

Waquoit Bay covers about 825 acres and averages about 2.7 feet deep (WBNERR Management Plan). According to the NSSP formula, the recommended number of boats for the bay proper is 66. In 1992 the number was about 220. The State of Massachusetts regularly tests the surface waters in the bay system and only the Moonakis River has been found to have unacceptable counts of fecal bacteria. However, in light of the recent growth of the recreational fleet (Fig. 3), it is prudent to be aware of the need to control the discharge of septic wastes. This is particularly true in the mooring area at the head of Waquoit Bay where many large boats are kept and where currents circulate in a circular fashion or "gyre" (S. Gallager, WHOI, pers. commun.). Unfortunately, this circulation pattern tends to retain matter (including fecal coliform bacteria) dumped overboard in the mooring area.

The transient-boat anchorage area near the breachway is better flushed than the mooring area at the head of the bay. Although most models for determining the allowable number of boats in a mooring area consider volume of dilution waters, not flushing rate, Milliken and Lee (1990) noted that increased water flows will decrease the scope of influence of the environmental impact of boats. Presumably, locating the anchorage in the southern portion of the bay has minimized the potential environmental threat from that aspect of recreational boating in the bay.

Designating the bay as a No-Discharge Area provides a useful regulatory tool. A prohibition against the discharge of septic waste (treated or otherwise) will help protect the health-standard qualities of bay waters for shellfishing and swimming. Perhaps more importantly, public awareness about water quality issues will be enhanced by the publicity associated with the designation and with the operation of a clearly marked mobile pump-out boat. Public awareness and response are critical to preserving the health of our coastal resources. In the long term, behavior modification by users of our coastal areas remains an essential for the protection of our coastal waters.

Nutrients

The potential for discharge of total nitrogen by the 1992 recreational boaters can be estimated from the results of the survey. According to the survey, the fleet of about 1000 boats had an average of 2.9 people aboard during each boating trip. Waquoit Bay LMER project researchers (Valiela et al. 1992) estimated a production of 10.6 pounds (4.8 kg) of total nitrogen per capita during one year. Boating impact calculations are based on one half of this value because the typical boating season lasted no more than six months. Although the questionnaire did not investigate the frequency of boat use, if we assume that boat use patterns are reflected in responses to the question regarding pump-out facility use (Fig. 24), then the integrated range of typical boat use on a given day is about 25 - 33 percent of the total fleet. Using this as an "occupancy rate", then the total nitrogen within potential MSD discharges was about 3850 - 5100 pounds (1750 - 2325 kg). This is equivalent to the annual septic discharge of about 350 - 480 shoreside residents or 195 - 270 households in the Waquoit Bay watershed (at an average of 1.8 people per household; I. Valiela, pers. com.). This calculation is grounded on assumptions describing the unlikely worst case scenario whereby all people using the boats will use some type of MSD and will discharge their wastes illegally into the bay. It is improbable that the worst case occurs but this estimate provides an upper limit to the potential contribution of nitrogen from the fleet.

The least amount of nitrogenous wastes we can expect from the fleet would come from that portion (5 percent) with MSDs that discharge overboard. At a 25 percent occupancy rate, the lower limit of the potential contribution of nitrogen would be equivalent to the waste of 18 people or about 10 households. The actual amount of nitrogen discharged by the fleet into the bay is likely to be nearer the lower end of the range of estimates. Accordingly, a realistic estimate of the potential threat posed to the Waquoit Bay ecosystem by the nutrients discharged from the recreational boating fleet is probably equivalent to that of a small housing development.

Conclusion

It is interesting to consider the ultimate fate of the wastes from boat MSDs. Wastes removed from holding tanks by the pump-out facilities will presumably be transported to a regional waste treatment facility. Because none of these occur within the Waquoit Bay watershed, nutrients in this disposed waste would be removed from the bay ecosystem. However, about one half of the fleet consists of small boats with Port-a-Potty-type devices (or buckets). Many of these units will be transported ashore for disposal, perhaps in a septic system. If the septic system is within the Waquoit Bay watershed, some of the nitrogen will end up in the bay anyway - via groundwater.

In these cases, the greatest benefit of the No-Discharge Area designation would be the reduction in the potential for the introduction of human pathogens to the Waquoit Bay ecosystem. While it is important to minimize all sources of excess nutrients entering the bay, the "No-Discharge" designation is likely to have a minimal tangible effect on bay eutrophication. Eliminating discharges from boats is a step in the right direction but will not "solve" the eutrophication problem.

Implication of the No-Discharge designation to the fleet

Only five percent of the fleet have the MSD type that is directly affected by designating Waquoit Bay and adjoining waters as a No-Discharge Area. Most of the larger boats in the fleet already have the proper type of MSD to meet mandated requirements. The large number of smaller boats without an installed MSD (e.g. boats less than 20 feet) could meet program requirements with an appropriate portable device.

It remains unclear whether boating practices on Waquoit Bay waters would be affected. The survey design did not discern whether boaters were violating existing regulations prohibiting untreated septic discharges within the 3-mile coastal zone. If this does occur (and we assume that it does), it is unclear that a new prohibition would affect this behavior.

Enforcement to ensure compliance with the No-Discharge regulation will not be trivial. Boating regulations, including the No-Discharge rule, will be enforced by local authorities. Harbormasters will be challenged to ensure that all boaters in small open boats will be complying with the regulations. Compliance is likely to be more successful if accessible shoreside facilities (e.g. boater "rest stations") are provided. In addition, operators of the mobile pump out unit should be encouraged to use a vessel with an MSD that would be available for free use by the boating public.

Growth potential of the fleet

Given the small amount of parking space near the boat launching ramps, there appears to be a limited potential for growth within the non-resident "day tripping" sector of the recreational boating community. There have been discussions about enlarging the parking area near Edwards Boatyard but questions about subsequent responsibilities for maintenance, etc. have delayed decisions. Even with enlarged parking lots, this sector of boating activity on these waters is likely to remain small.

Growth potential for the remainder of the recreational fleet also seems to be limited. Moorings readily accessible to the boat ramps (i.e. those requiring the shortest row in a dinghy) are the most popular. For example, moorings in the Childs River are fully reserved and vacancies

are rarely available. In comparison, vacancies do occur periodically within the mooring area at the head of Waquoit Bay (although there is a waiting list of several years). However, these waters are relatively exposed and boats are vulnerable during major storms, such Hurricane Bob (August 1991).

Acknowledgements

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Table 1. Marine sanitation devices (MSD) as classified according US Coast Guard regulations. Boats longer than 65 feet must use Type II or III. Boats less than 65 feet can use any of them. It is illegal to dispose of untreated septic waste within three miles of shore. Discharge of even treated waste is prohibited in all waters within No-Discharge Areas.

Type I:

Chops up waste and disinfects it with chemicals to 1000 fecal coliform bacteria per 100 milliliters of water; no visible floating solids in discharge.

Type II:

Similar to Type I but the fecal coliform bacteria count level is 200 per 100 milliliters of water; suspended solids in discharge are no greater than 150 milligrams per liter.

Type III:

Holding tank fitted with piping to discharge waste overboard when more than three miles off shore or into a fixed or floating pump-out facility.

Bucket or "Port-a-Potty"

No treatment. Waste brought ashore and disposed of in a septic system or sewage treatment plant.

Table 2. Massachusetts water quality classification scheme and associated uses allowed according to safe public health standards.

Grade	Specification
SA	Fecal coliform bacteria count less than 14 per 100 milliliters of water; clean water, all uses permitted.
SB	Fecal coliform bacteria count between 14 and 199 per 100 milliliters of water; shellfish beds closed to harvesting shellfish due to potential health hazard.
SC	Fecal coliform bacteria count greater than 199 per 100 milliliters of water; area closed to swimming.

Table 3. A total of 823 boats within several size categories observed moored or docked in four general areas of Waquoit Bay waters during the morning of August 11, 1992.

Area	Open boats 16' - 23'	Cabin boats less than 23'	Cabin boats over 23'	Totals
Waquoit Bay	72	21	67	160
Seapit River	12	10	12	34
Childs River	75	23	140	238
adjoining waters	155	60	176	391

Table 4. A total of 847 moored or docked boats appeared in a series of aerial photographs of Waquoit Bay and its tributaries (excluding the west "arm" of Eel Pond) taken during the morning of September 3, 1992.

Waquoit Bay	222	Seapit River	27
east Eel Pond	149	Childs River	177
Jehu Pond	36	Great River	94
Hamblin Pond	36	Little River	87
Sage Lot Pond	0	Moonakis River	19

Table 5. Boats counts obtained from aerial photographs taken of waters in the Waquoit Bay area during 1970 and 1989.

	Summer 1970	August 1989
Waquoit Bay	55	238
Seapit River	7	15
Childs River	101	110
Eel River	52	61
Jehu Pond	0	5+
Great River	16	67
Little River	3	28
Hamblin Pond	30	15
Total	264	539

Appendices

Appendix A.

The following list of questions comprised the original questionnaire used in the WBNERR Boating Survey. The questionnaire was distributed to boaters in Falmouth, either as part of an intercept survey conducted at the two boat ramps or by a direct mailing to addresses of registered mooring holders as provided by the Falmouth Harbormaster.

1. What type of boat do you own?

a.	Sailboat with no engine.	d.	Powerboat with inboard engine.
b.	Sailboat with inboard engine.	e.	Powerboat with outboard engine.
c.	Sailboat with outboard engine.	f.	Other.

2. Approximately how many years, including this year, have you been boating on Waquoit Bay?

a.	1 year	d	4 years	g.	7 years	j.	10-15 years
b.	2 years	e.	5 years	h.	8 years	k.	15-20 years
c.	3 years	f.	6 years	i.	9 years	l.	20+ YEARS

3. How long is your boat?

a.	Under 15 feet	c.	20-25 feet	e.	31-35 feet
b.	16-20 feet	d.	26-30 feet	f.	over 36 feet

4. How long is your boating season (months per year you use your boat)?

a.	1 month	c.	3 months	d.	5-6 months	g	9-11 months
b.	2 months	d.	4 months	e.	7-8 months	h	year round

5. How many people are usually aboard?

a.	1 person	c.	3 people	e.	5 people
b.	2 people	d.	4 people	f.	6 or more

6. What type of activities do you participate in when boating on Waquoit Bay?

a	Fishing	d.	Waterskiing	g.	Weekend cruising
b.	Day sailing	e	Racing	h.	Extended cruising
c.	Entertaining	f.	Other		

7. Where is your boat stored during the boating season?

a.	Waquoit Bay	e.	SeaPit River	i.	Quashnet River
b.	Eel Pond	f.	Great River	J.	Jehu Pond
c.	Childs River	g.	Little River	k.	Hamblin Pond
d.	On a trailer	h.	Boat rack storage	l.	Other

8. Have you noticed any changes in the following water characteristics since you have been boating on Waquoit Bay?

a.	Trash	b	Water visibility	c.	Fish kills
d.	Other observations?				

9. Do you have a marine sanitation device (MSD) on board?

a. Yes b. No

9a. If "Yes", it is a:

a. Type I (Type I and II use on-board treatment and discharge processes)
b. Type II
c. Type III (holding tank system)
d. Port-a-Potty-type portable head

9b. If "Yes", what percentage of the time do you use shore waste disposal facilities?

a	0-10%	c	25-50%	e.	75-90%
b.	10-25%	d.	50-75%	f.	90-100%

10. Do you feel that the federal government regulations covering marine sanitation devices are effective in reducing water pollution?

a. Yes b. No c. Not sure

11. If you have an MSD aboard, would you use pump out stations more often if they were:

a.	more accessible?	d.	less expensive?
b	easier to use?	e.	knew the reason for them?
c.	not sure?	f.	already use pump out stations all the time.

12. Would you be willing to pay for a pump out for your boat?

a. Yes b No.

12a. If "Yes", up to how much would you be willing to pay per boat?

a.	$2	c.	$6	e.	$10	g.	$14	i.	$18
b	$4	d.	$8	f.	$12	h.	$16	j.	$20

13. Comments.

Appendix B: Additional questions added to original questionnaire.

The following list of questions was appended to those in Appendix A to comprise a modified questionnaire for the second phase of the WBNERR Boating Survey. This longer questionnaire was mailed to addresses in Mashpee identified as registered mooring holders by the town harbormaster. These questions were added to the survey to learn about public perceptions regarding the new mobile MSD pump-out facility that was installed at the Little River Boatyard. The following text constituted a preface to the appended questions:

> "Plans are being made for a new mobile pump-out vessel to be berthed at the Little River Boatyard. It will travel around the bay to the various mooring areas and the anchorage once a day. It is scheduled to start-up in the Summer of 1993 with a pump-out fee of $5.00. The new facility will operate in addition to the pump-out at Edwards Boatyard on Waquoit Bay. The following questions pertain to this new facility."

14. Would you be likely to use the mobile pump-out facility?

a. Yes b. No

15. If so, would you be more apt to use it when it is berthed at Little River Boatyard or when it is visiting moored and anchored vessels on the bay?

a. At the boatyard b. On the bay

16. What hours of the day would you be most likely to use it?

a	6-8 AM	c.	10-12 AM	e	2-4 PM
b.	8-10 AM	d.	12-2 PM	f.	4-6 PM

17. What days of the week would you be most likely to use it?

a	Mon	c.	Wed	e.	Fri	g.	Sun
b.	Tues	d.	Thur	f.	Sat		

18. It is suggested that boats hail the pump-out vessel by radio. Do you have a radio?

a. Yes. b. No.

19. If so, what kind?

a. CB b. VHF c Not applicable

Appendix C: Comments on boating survey design.

To facilitate the conduct of future boating surveys, suggestions are provided regarding the design of the 1992 WBNERR Recreational Boating Survey questionnaires (Appendices A and B). Although the survey design did not include provisions for statistical analysis of the results, the questionnaires were quite successful. They were simple to comprehend and complete, yet subtly inclusive. Response to the mailings was excellent.

However, questionnaire response was quite variable. Many forms had multiple responses, others were partially completed. As a result, sample sizes for the responses to various questions differed. Several other limitations became apparent during the evaluation of the survey results, such as:

- there were errors (e.g. no size category for boats 15-16 feet long);
- there was no measure of frequency of boating trips;
- boaters were not asked if they carried a bucket to serve as an MSD;
- the scope in the choice of responses for some questions was limited (e.g. three options for noticed changes in water characteristics);
- there was no provision to identify owners of more than one boat;
- there was no identification of boat storage type (dock or mooring);
- there was no provision to separate boating activity that was confined within the bay versus a passage through the bay to activities beyond;
- although this type of information was included in the plans for the design of the survey, there were no identifications of vessel horsepower or type of bottom paint; and
- the 2 mailings (parts A and B) complicated rigorous data analysis.

It is recommended that future survey designs include a plan for analysis that will yield the answers sought. Examination of the plan will reveal whether appropriate questions have been included in the questionnaire.

Appendix D: Summaries of responses to the questionnaire. See Fig. 6 to Fig. 26.

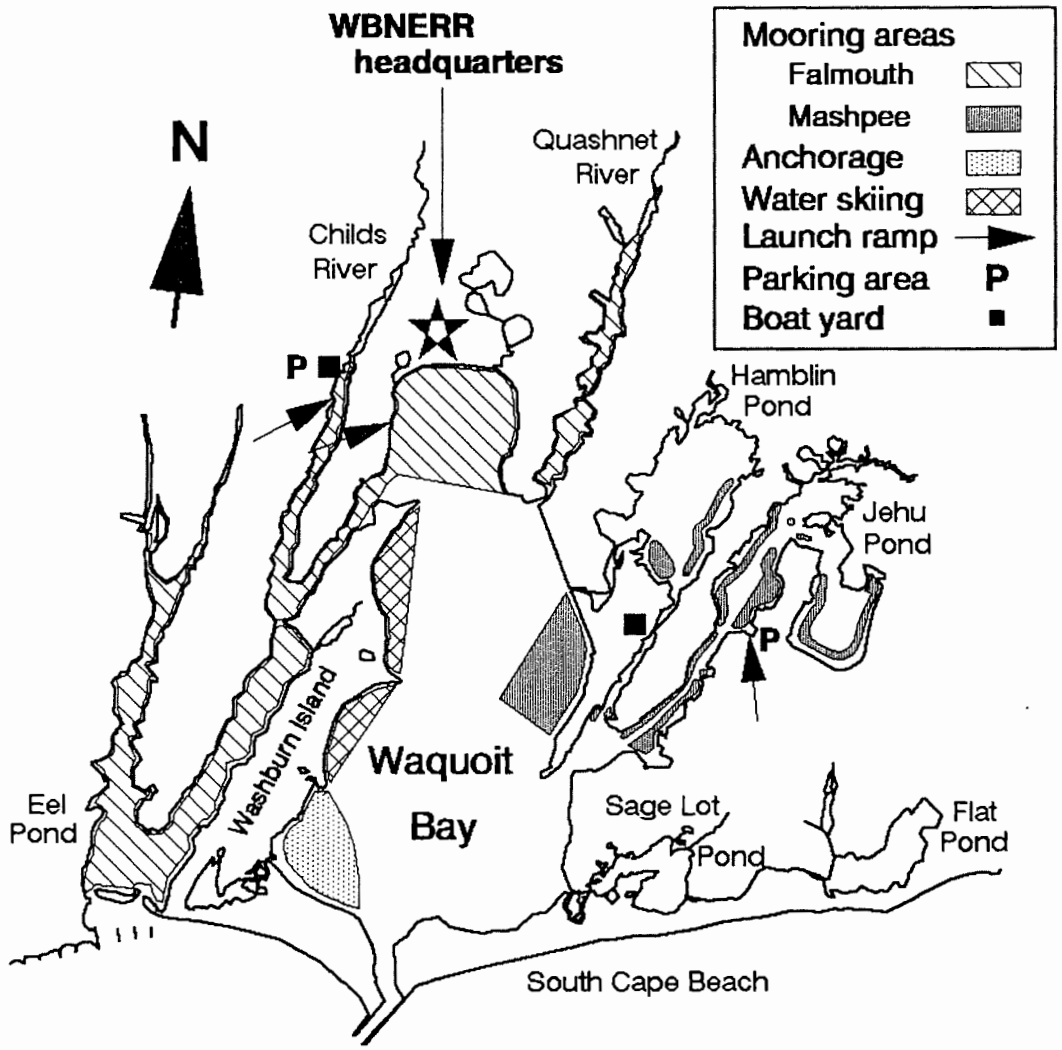

Fig. 1. Location of mooring areas, the anchorage for transient boats, where waterskiing (i.e. high speed operation) is allowed, public launch ramps and parking areas, and boat yards in the Waquoit Bay estuarine system.

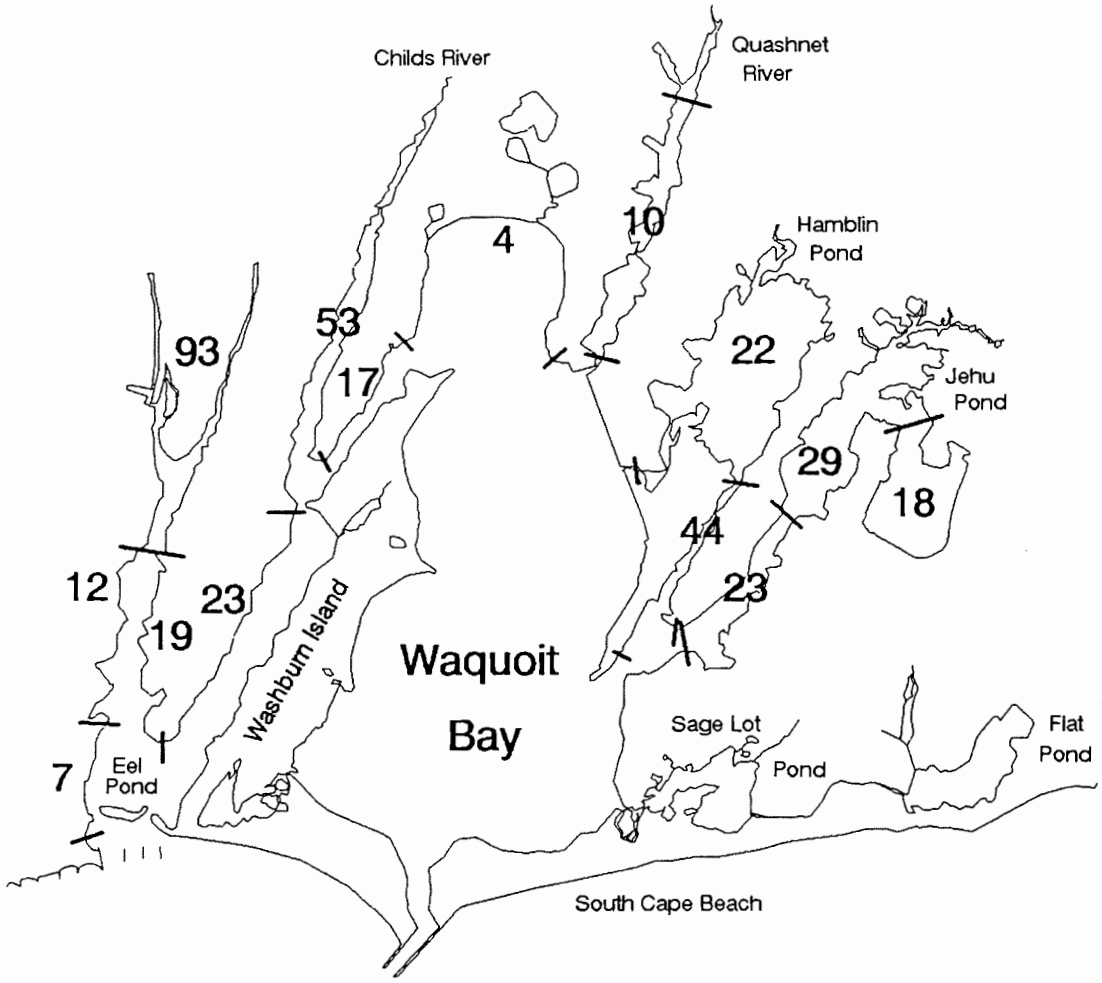

Fig. 2. Numbers of docks occurring along the shore of the Waquoit Bay system. Numbers represent the amount of docks occurring along the segments of shoreline indicated by the slash marks.

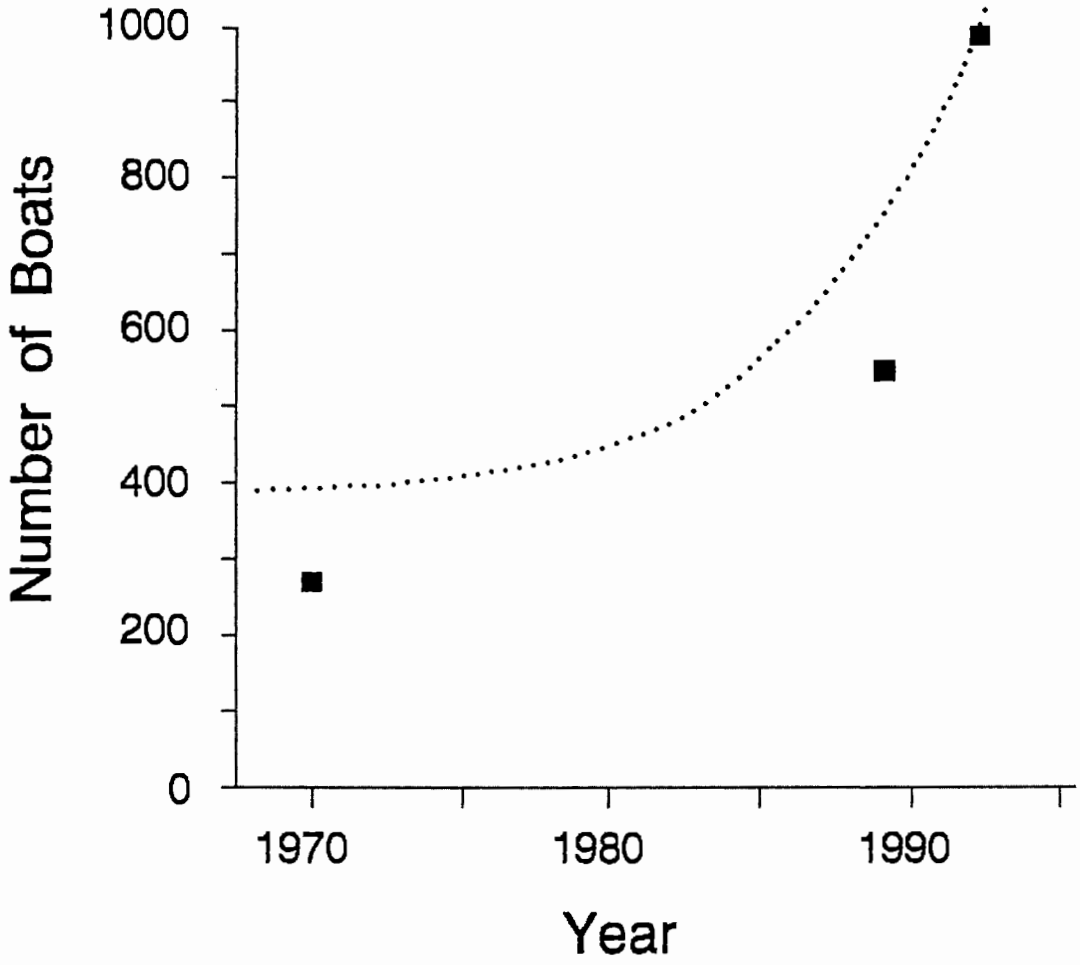

Fig. 3. The approximate change in the number of boats in the Waquoit Bay recreational fleet between 1970 and 1992, as derived from examination of aerial photographs. The line was adjusted at the points for 1970 and 1989 data to account for boats in use. Datum for 1992 includes the adjustment.

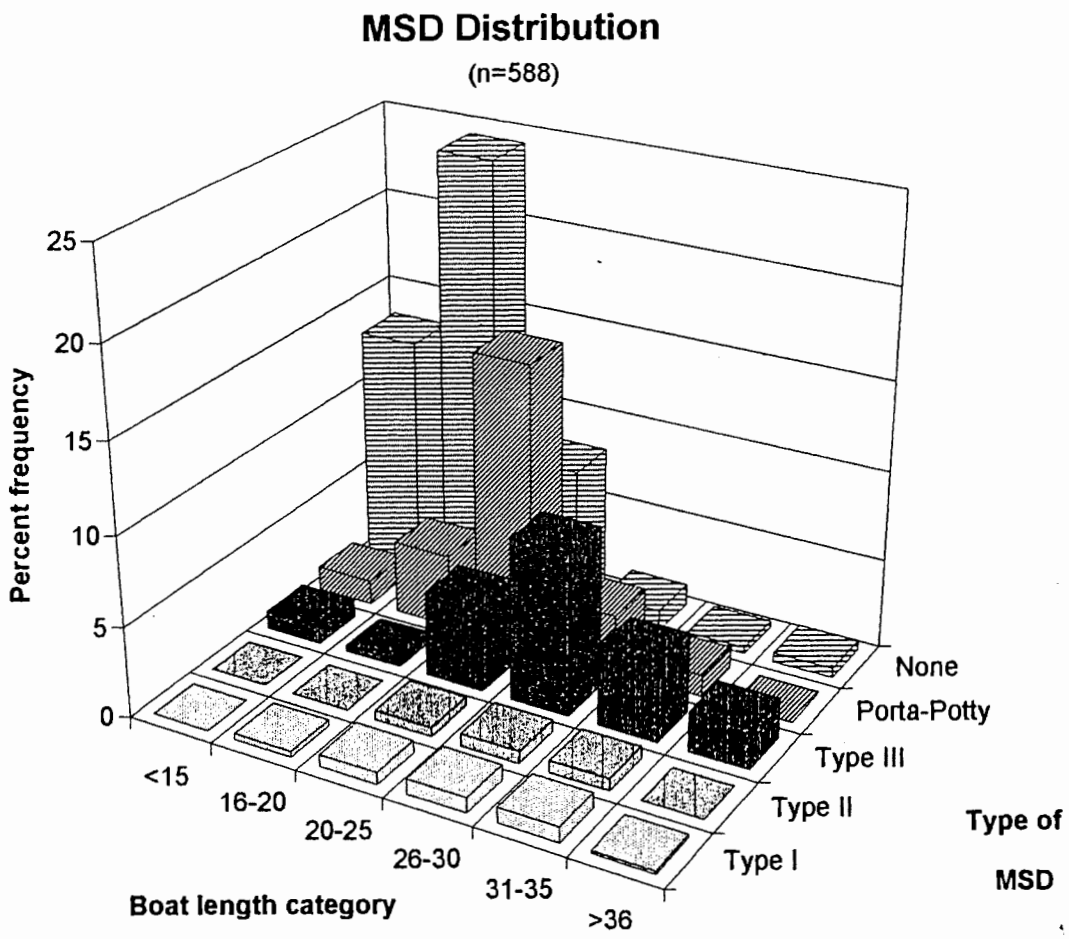

Fig. 4. Distribution of the types of marine sanitation devices (MSD) in use in different boat length categories of the Waquoit Bay recreational fleet.

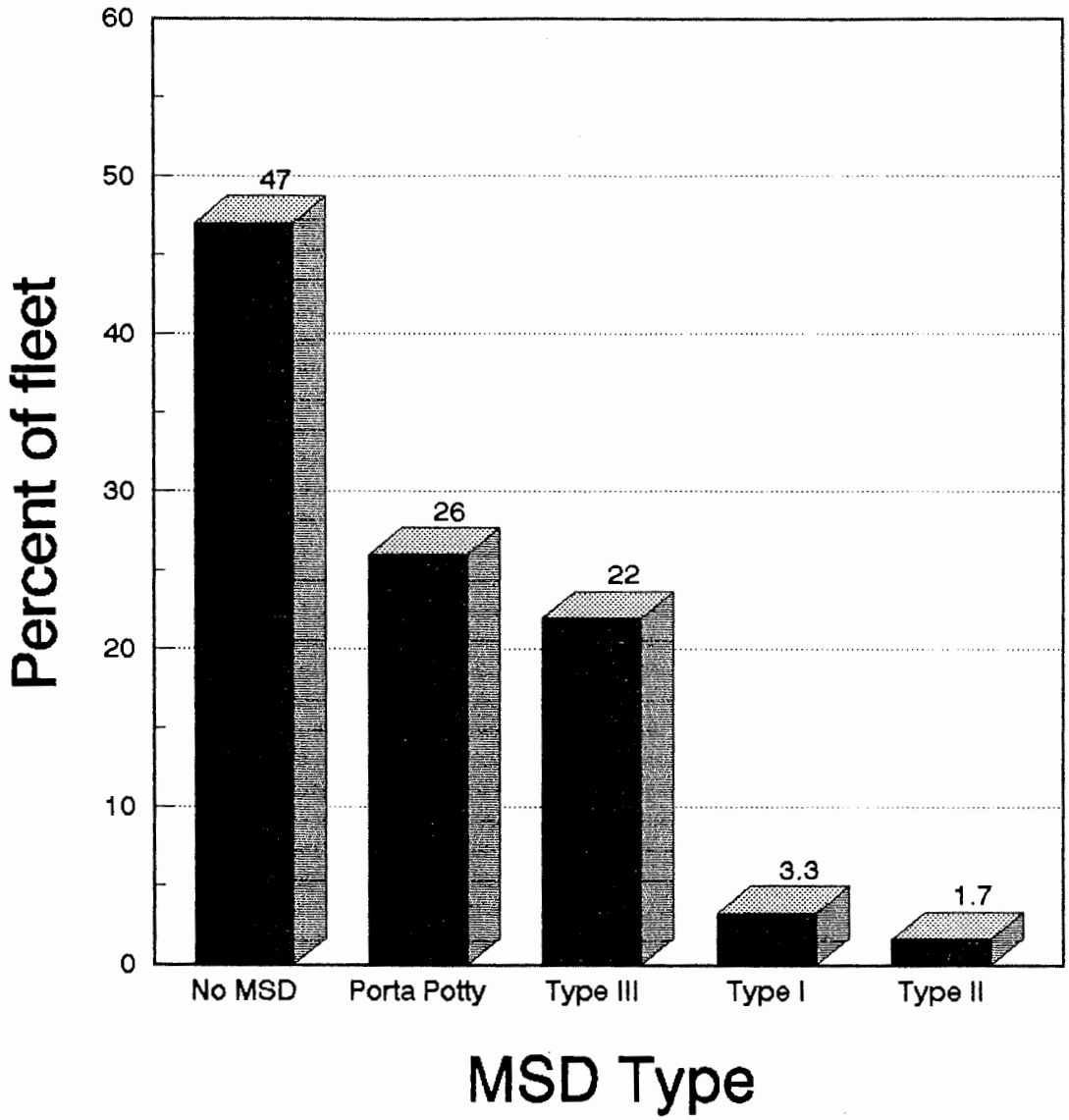

Fig. 5. The relative use of different types of marine sanitation devices (MSD) within the Waquoit Bay recreational fleet.

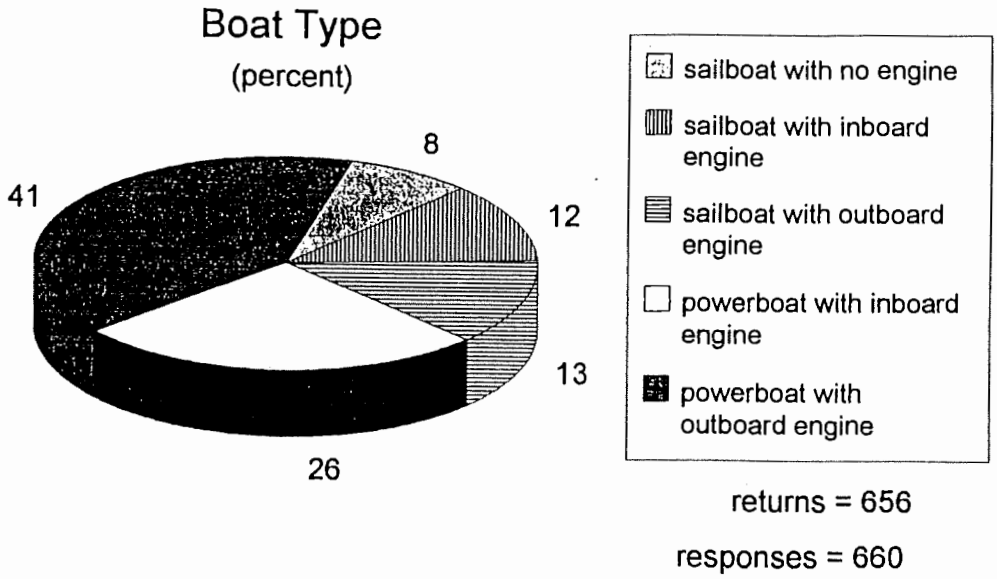

Fig. 6. Response to question 1: What type of boat do you own?

a.	Sailboat with no engine.	d.	Powerboat with inboard engine.
b.	Sailboat with inboard engine.	e.	Powerboat with outboard engine.
c.	Sailboat with outboard engine.	f.	Other.

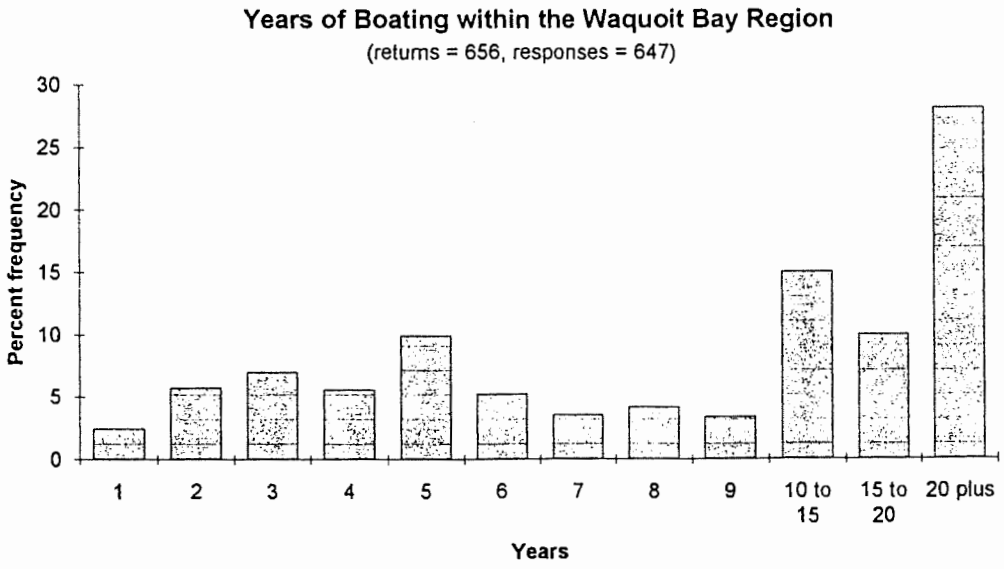

Fig. 7. Response to question 2: Approximately how many years, including this year, have you been boating on Waquoit Bay?

a.	1 year	d.	4 years	g.	7 years	j.	10-15 years
b.	2 years	e.	5 years	h.	8 years	k.	15-20 years
c.	3 years	f.	6 years	i.	9 years	l.	20+ YEARS

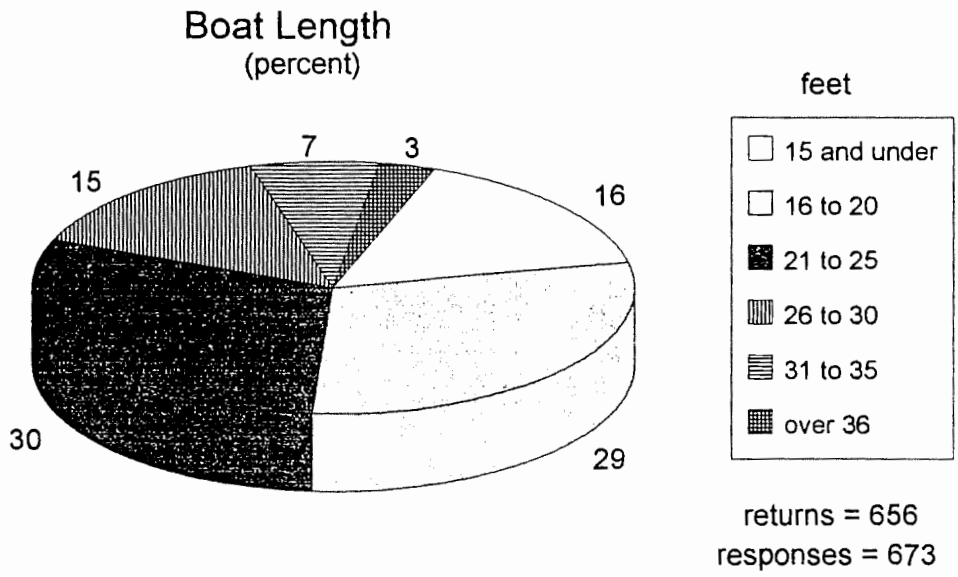

Fig. 8. Response to question 3: How long is your boat?

a.	Under 15 feet	c.	20-25 feet	e.	31-35 feet
b.	16-20 feet	d.	26-30 feet	f.	over 36 feet

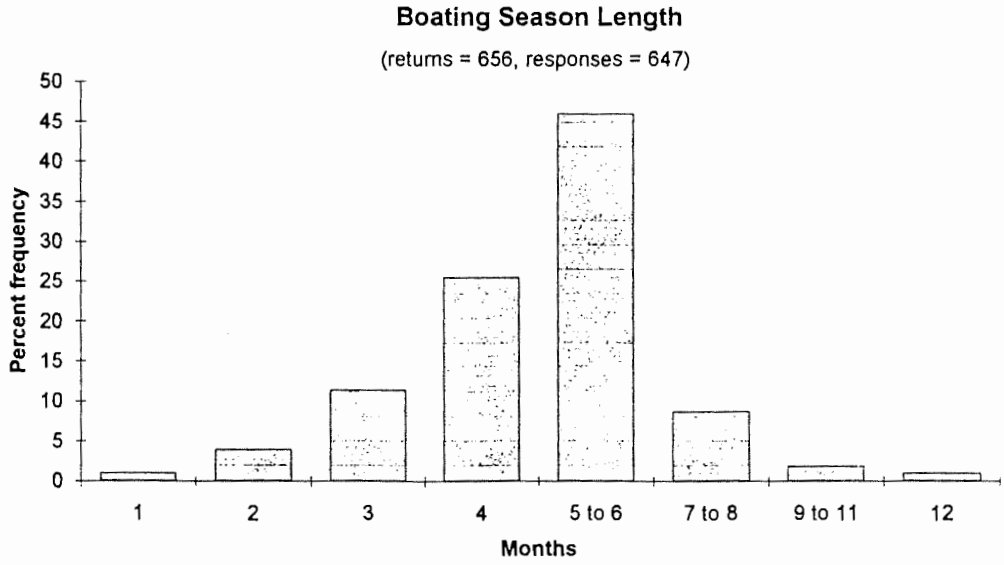

Fig. 9. Response to question 4: How long is your boating season (months per year you use your boat)?

a.	1 month	c.	3 months	d.	5-6 months	g.	9-11 months
b.	2 months	d.	4 months	e.	7-8 months	h.	year round

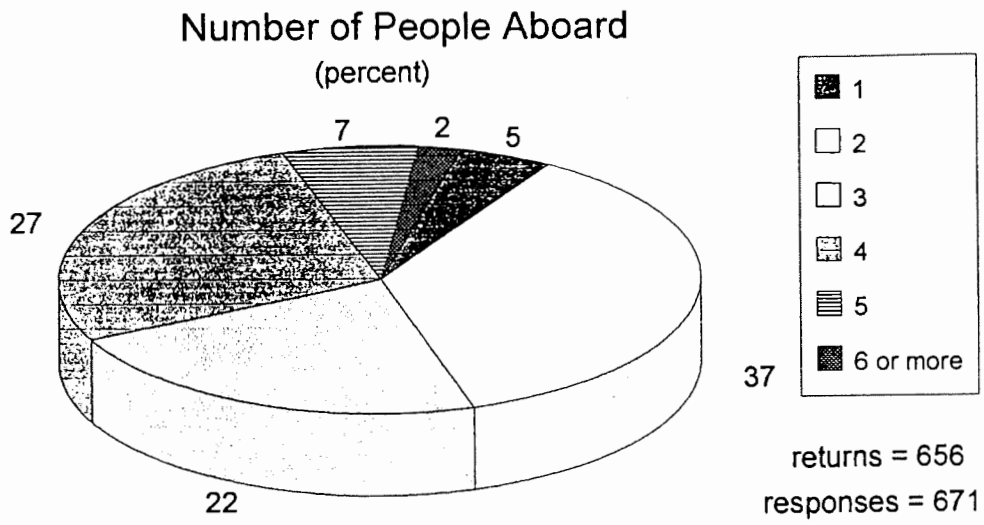

Fig. 10. Response to question 5: How many people are usually aboard?

a.	1 person	c.	3 people	e.	5 people
b.	2 people	d.	4 people	f.	6 or more

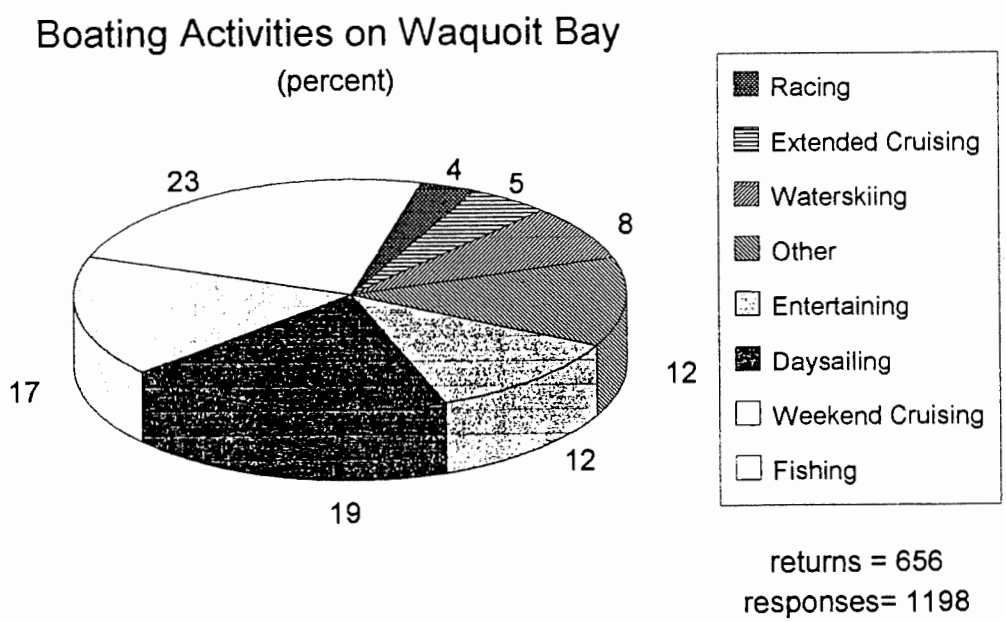

Fig. 11. Response to question 6: What type of activities do you participate in when boating on Waquoit Bay?

a.	Fishing	d.	Waterskiing	g.	Weekend cruising
b.	Day sailing	e.	Racing	h.	Extended cruising
c.	Entertaining	f.	Other		

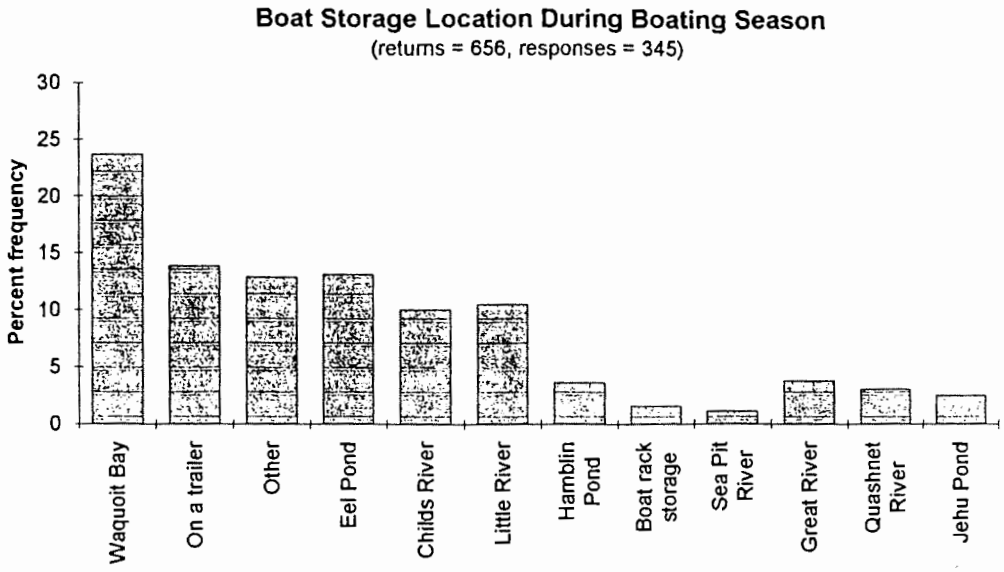

Fig. 12. Response to question 7: Where is your boat stored during the boating season?

a.	Waquoit Bay	e.	SeaPit River	i.	Quashnet River
b.	Eel Pond	f.	Great River	J.	Jehu Pond
c.	Childs River	g.	Little River	k.	Hamblin Pond
d.	On a trailer	h.	Boat rack storage	l.	Other

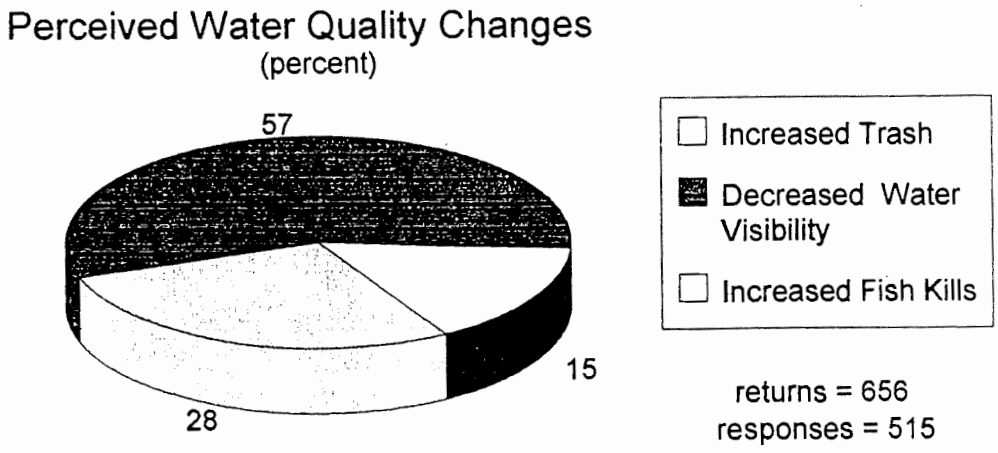

Fig. 13. Response to question 8: Have you noticed any changes in the following water characteristics since you have been boating on Waquoit Bay?

a.	Trash	b.	Water visibility	c.	Fish kills
d.	Other observations?				

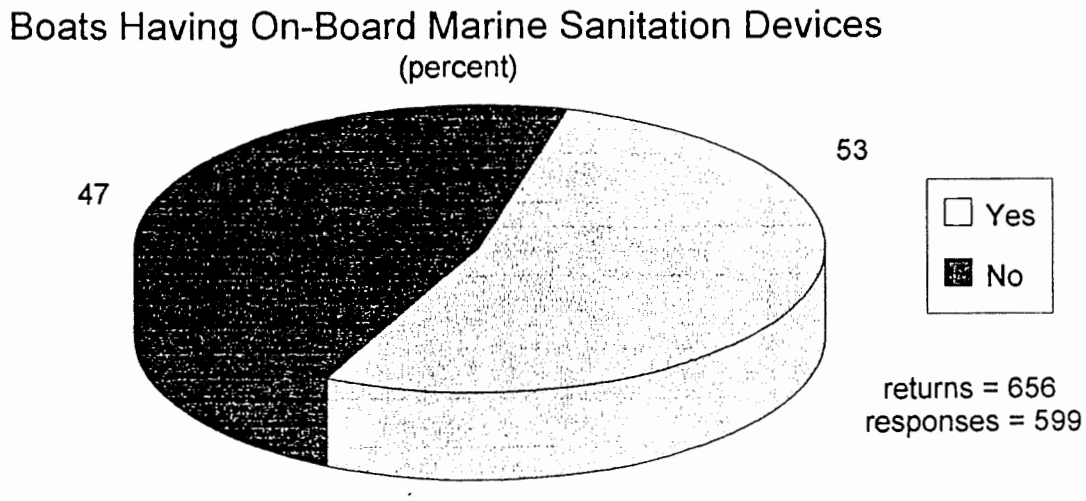

Fig. 14. Response to question 9: Do you have a marine sanitation device (MSD) on board? a. Yes b. No

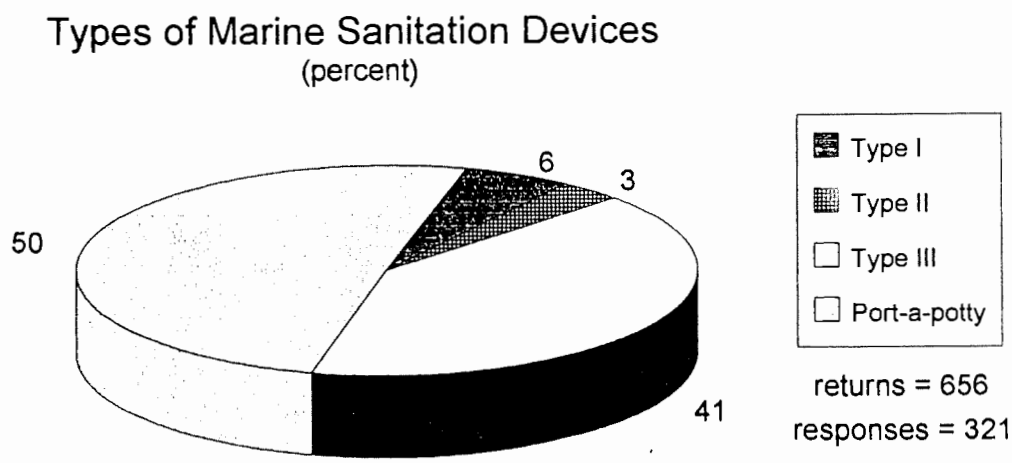

Fig. 15. Response to question 9a: If "Yes", it is a:

a. Type I (Type I and II use on-board treatment and discharge processes)
b. Type II
c. Type III (holding tank system)
d. Porta-Potty-type portable head

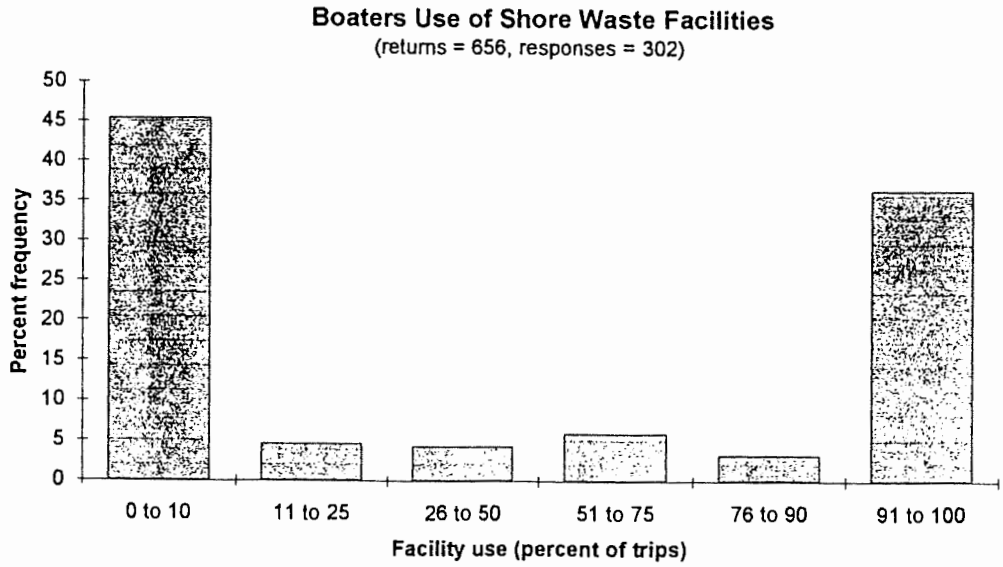

Fig. 16. Response to question 9b: If "Yes", what percentage of the time do you use shore waste disposal facilities?

a.	0-10%	c.	25-50%	e.	75-90%
b.	10-25%	d.	50-75%	f.	90-100%

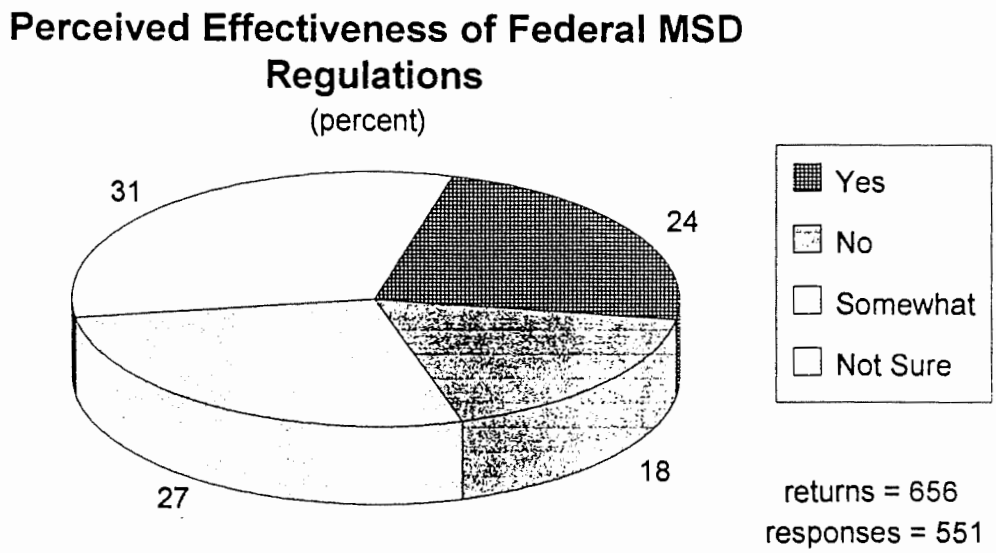

Fig. 17. Response to question 10: Do you feel that the federal government regulations covering marine sanitation devices are effective in reducing water pollution?

a. Yes b. No c. Not sure

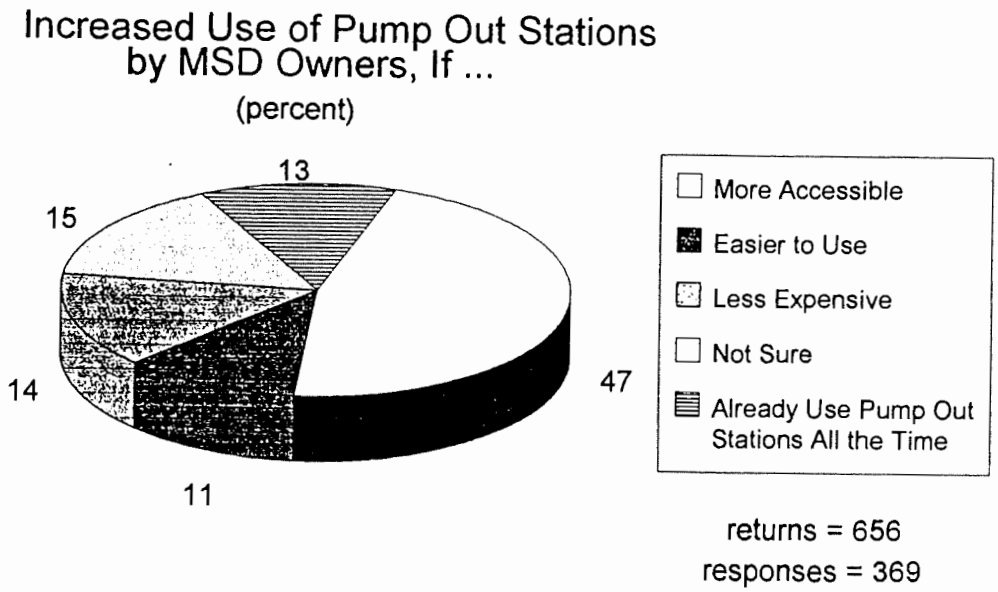

Fig. 18. Response to question 11: If you have an MSD aboard, would you use pump out stations more often if they were:

a. more accessible?
b. easier to use?
c. not sure?
d. less expensive?
e. knew the reason for them?
f. already use pump out stations all the time.

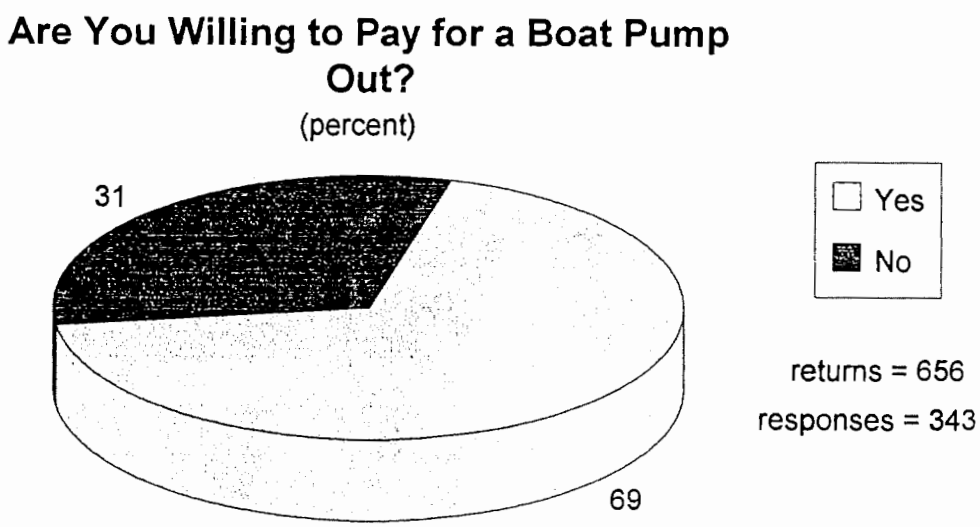

Fig. 19. Response to question 12: Would you be willing to pay for a pump out for your boat? a. Yes b. No.

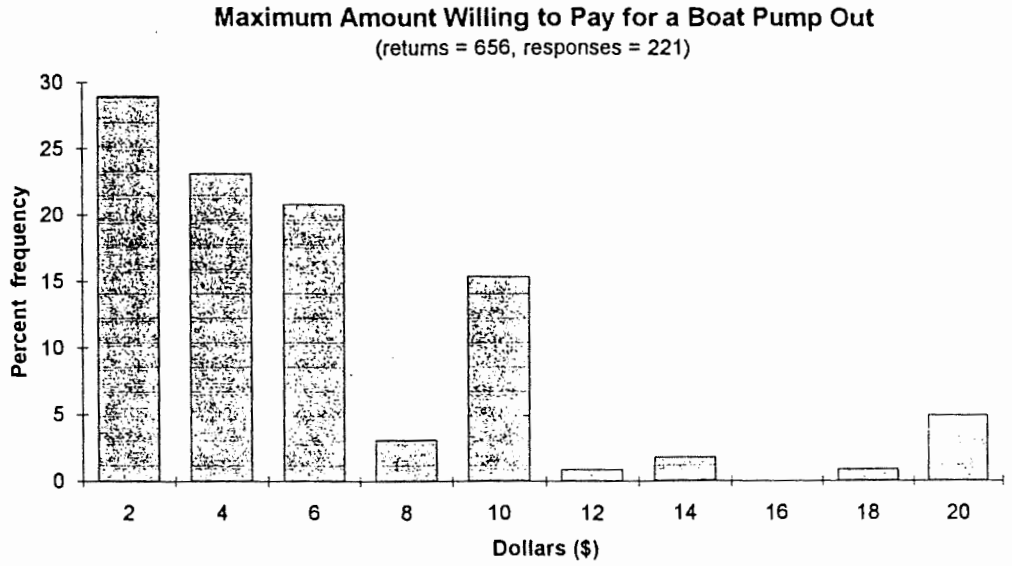

Fig. 20. Response to question 12a: If "Yes", up to how much would you be willing to pay per boat?

a.	$2	c.	$6	e.	$10	g.	$14	i.	$18
b.	$4	d.	$8	f.	$12	h.	$16	j.	$20

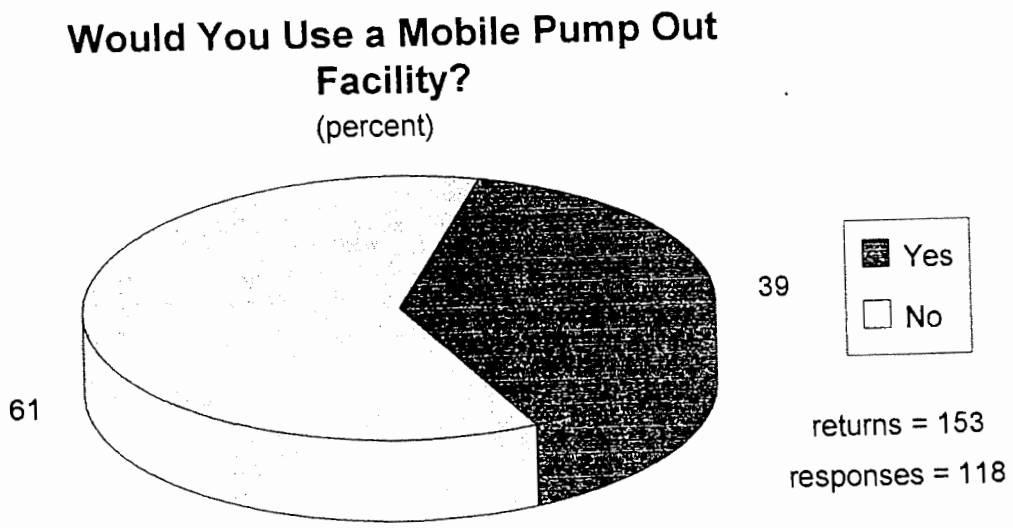

Fig. 21. Response to question 14: Would you be likely to use the mobile pump-out facility?

a. Yes b. No

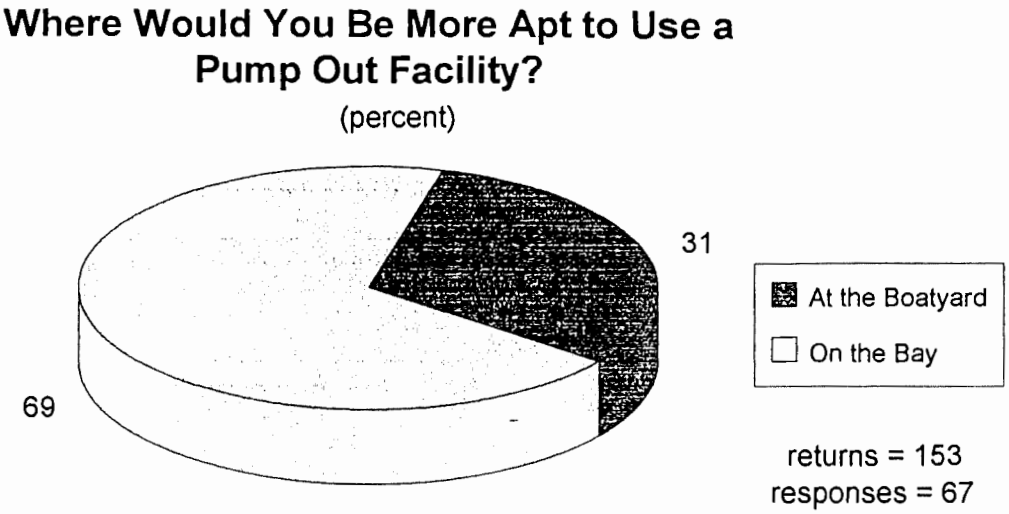

Fig. 22. Response to question 15: If so, would you be more apt to use it when it is berthed at Little River Boatyard or when it is visiting moored and anchored vessels on the bay?

a. At the boatyard b. On the bay

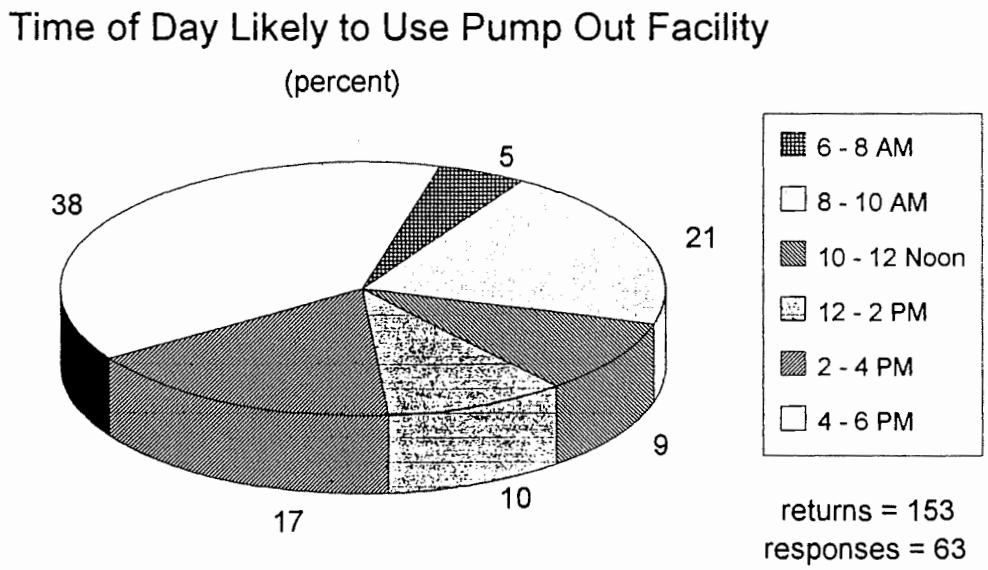

Fig. 23. Response to question 16: What hours of the day would you be most likely to use it?

a.	6-8 AM	c.	10-12 AM	e.	2-4 PM
b.	8-10 AM	d.	12-2 PM	f.	4-6 PM

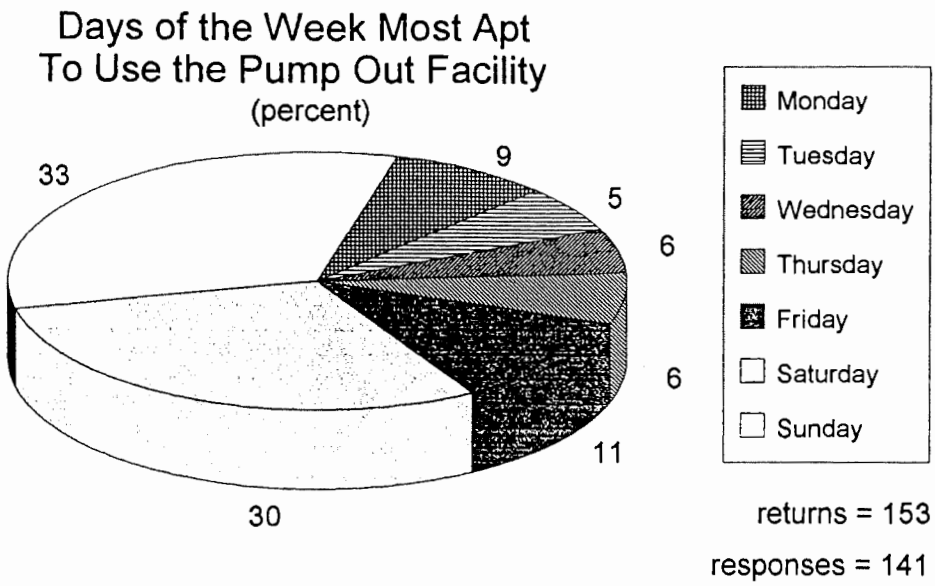

Fig. 24. Response to question 17: What days of the week would you be most likely to use it?

a.	Mon	c.	Wed	e.	Fri	g.	Sun
b.	Tues	d.	Thur	f.	Sat		

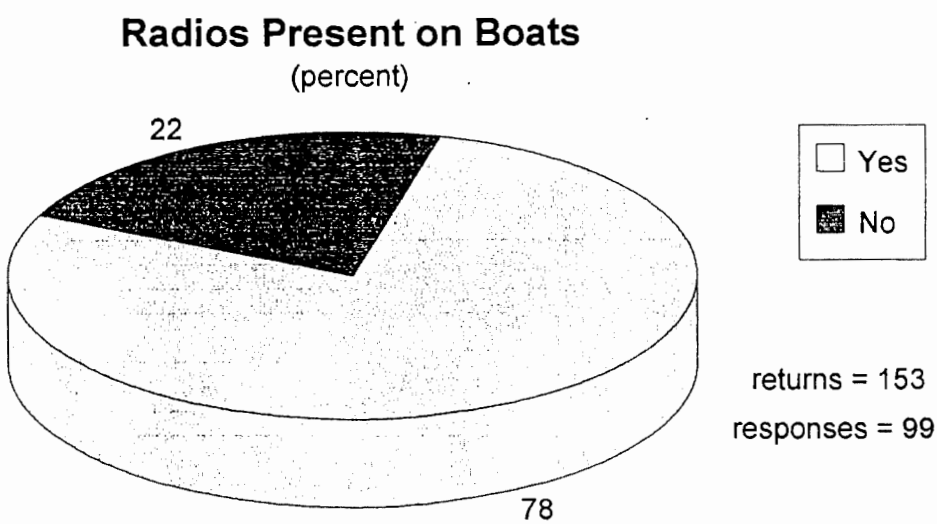

Fig. 25. Response to question 18: It is suggested that boats hail the pump-out vessel by radio. Do you have a radio?

a. Yes. b. No.

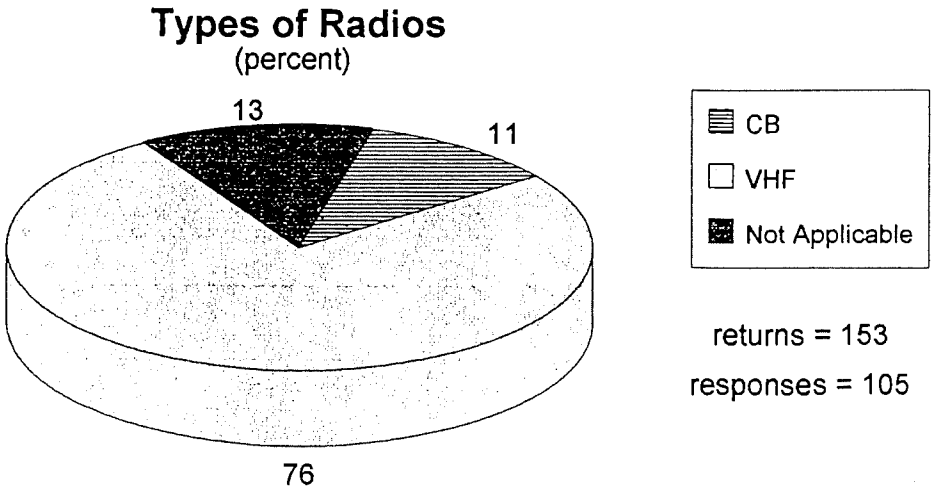

Fig. 26. Response to question 19: If so, what kind?
a. CB b. VHF c. Not applicable