

AN EVALUATION OF MOORING BUOYS IN THE  
FLORIDA KEYS NATIONAL MARINE SANCTUARY

Final Report  
to  
Looe Key National Marine Sanctuary  
DNR Contract No. C-8013

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## INTRODUCTION

This study documents and evaluates boat use relative to the location of mooring buoys within the Florida Keys National Marine Sanctuary (FKNMS) in comparison to observations of boat use. Mooring buoys are semi-permanent anchoring devices boaters can use instead of anchoring on coral reefs. Mooring buoys effectively prevent anchor damage and can be used to control access to coral reefs. Access to coral reefs is currently unrestricted yet managers are responsible for both the preservation and accommodation of these marine environments for public's use. Mooring buoys are an on-site management tool for balancing these two contradictory responsibilities. Mooring buoys were originally placed along the reef tract by various organizations (Appendix 1) in an effort to promote safe access and to limit anchor damage to the reef. Additionally, carefully placed mooring buoys can effectively limit access to threatened areas or promote access to different areas.

Specifically, this report recommends placing mooring buoys at 14 new locations, eliminating mooring buoys at 1 location, increasing mooring buoys at 5 locations, and decreasing mooring buoys at 10 locations. Boat size and activity is also characterized at five reefs (Sand Key, Western Sambo, Looe Key, Big Munson patch reefs, and Sombrero Key) in the middle and lower Keys. For each of these five reefs, hourly boat counts from throughout the day are reported. Finally, a comparison of boating activity at a marked (Big Munson patch reef) and an unmarked (Cook Island patch reef)

reef is included to examine the effect daymarkers have on boating activity.

The recommendations for mooring buoy use promulgated in this report are based solely on boating activity observed between June 1, 1992 and March 6, 1993. The mooring buoy placement recommendations in this report do not consider resource protection issues such as the number of divers a reef can accommodate without being significantly degraded or the creation of preserve areas currently under consideration by the Florida Keys National Marine Sanctuary (FKNMS). The only criterion considered for recommending mooring buoy placement was to accommodate at least 90% of current boating activities. The figure of 90% was selected so that all boats would have access to the reef except on the busiest days and to illustrate how mooring buoys can function as a management tool.

#### METHODS

Data for this project were collected in two phases. First, aerial surveys were used to count and classify boats. The aerial surveys provided as close to an instantaneous boat count as was possible for such a large area. Second, surface surveys were used to make hourly boat counts at selected reefs for extended time periods. The surface surveys provided detailed observations of boating patterns for specific reefs. These two data-collection methods complement each other by ensuring wide spatial coverage and detailed daily records of boat activity.

Thirty-six aerial surveys were completed between June 1, 1992 and March 6, 1993. One additional flight was discontinued because

of foul weather. Flight days were selected randomly within four temporal categories (summer weekends, winter weekends, summer weekdays, and winter weekdays) and on holidays. The percentage of flights in each category, based on the total number of days in each category, ranged from 6.9% on winter weekdays to 11.4% on summer weekends. A total of six flights were made on holidays and during special events - specifically on July 4, on the beginning days of lobster season, and on Labor Day. Each aerial survey was considered one observation.

Flights originated at the Marathon airport after 1000 ET (eastern time) and were completed by 1500 ET. Consequently, the upper key's reefs were surveyed between 1000 ET and 1130 ET, and the lower key's reefs were surveyed between 1330 ET and 1500 ET. The entire FKNMS east of the Marquesas Keys was surveyed at an altitude of 500 ft, except for a small area north of Marathon and the restricted air space near Key West, Boca Chica, and Cudjoe Key. Generally, boats within three miles of the flight path could be counted and classified depending on the amount of haze. The flight path was altered as necessary to ensure that all boats could be seen well enough to be classified by activity, length, and type.

Surface surveys were accomplished with the aid of volunteers and as time and weather permitted. Because the surface-survey days and times were not randomly selected, there will be limited statistical consideration of the surface-survey data. However, the additional data collected by the volunteers at selected sites allows more accurate descriptions of daily boating patterns. Six sites were

selected for the surface surveys: Sand Key, Western Sambo, Looe Key, Big Munson patch reef, Sombrero Key, and Molasses Reef. Surface-survey observations ranged from 3 to 10 hours, and boat counts were made at hourly intervals. Each hourly boat count was referred to as one observation, regardless of the number of days or surveys represented. No surveys were made at night.

For both the aerial and surface surveys, boats were classified by activity (moving, diving, fishing, or anchored), length (<30 ft or >30 ft), and type (motor or sail). Each boat was assigned to one activity category, even though some boats were engaged in multiple activities. Activity classifications were assigned based on potential resource damage. That is, diving was recorded preferentially over all other categories, and fishing was recorded preferentially over moving or anchored. A boat was classified as diving if a dive flag was visible, divers or snorklers were visible, or a swim line was deployed. A boat was classified as fishing if a chum slick was visible or fishing poles were in use, regardless of whether the boat was anchored or moving. Boats were classified as anchored if no diving or fishing activity was observed.

Boat location observations were recorded on a lap-top data-collection atlas that was created using the Florida Marine Research Institute - Marine Resources Geographic Information System (MRGIS). Sampling was accomplished by subdividing the FKNMS into 1-minute-square cells using a latitude' and longitude' based grid coordinate system. Each cell is approximately one square mile at this

latitude. Boats within a distinct cell were counted and classified in accordance with the previously described methodology.

Mooring buoy locations were determined by contacting the organizations maintaining those buoys and by direct observations. Mooring buoy locations were determined only within the 1-minute MRGIS cells. Exact latitude and longitude coordinates for each mooring buoy were not determined.

Two charts depicting current and suggested mooring buoy locations was produced from the aerial- and surface-survey data. Four additional charts will depict small- and large-boat use during<sup>both</sup> the first month of lobster season and the remainder of the year. Histograms depicting the frequency of specific activities at the six surface-survey sites and the size of the vessels involved in those activities will be presented. We will also present boat frequencies at each reef and use those boat frequencies to make recommendations on the number of mooring buoys required at each reef.

The mooring buoy recommendations for each reef were calculated to accommodate at least 90% of the boats observed at that reef during the aerial surveys. For example, at Sand Key (Figure 12), we observed 193 boats during the 36 aerial surveys. The maximum numbers of boats observed at Sand Key were 19 on July 4 and 12 boats on both July 25 and October 11. If 11 mooring buoys were deployed at Sand Key, 8 boats on July 4 and 1 boat on each of the other days would not have had a mooring buoy available. The percentage of boats unable to use mooring buoys can be calculated

by

$$\% \text{ boats unable to use buoys} = \frac{\sum \left( \begin{array}{l} \# \text{ of boats in a group} \\ \text{if greater than } \# \text{ of buoys} - \text{suggested} \end{array} \right)}{\text{total } \# \text{ of boats observed}}$$

or for Sand Key:

$$5.2\% = \frac{(19 - 11) + (12 - 11) + (12 - 11)}{193}$$

Finally, a t-test (Cody and Smith, 1991) will identify the difference in boating activity between a marked patch reef (Big Munson) and an unmarked patch reef (Cook Island). The boat counts from these two sites were  $\log_{10} + 1$  transformed to meet the assumption of homogeneity of variance.

## RESULTS

Most mooring buoys are located along the reef tract in the upper and lower keys (Chart 1 and Table 1). Mooring buoy placement in the middle keys has been poorly funded and only three of the four envisioned sites currently have mooring buoys (Florida Keys Marine Sanctuary, Inc., 1991). Additionally, only 20 of the 43 previously deployed mooring buoys in the middle keys remain due to buoy maintenance and replacement. Cottrell Key, northwest of Key West, is the only mooring buoy site not in the Atlantic. Nine of the 15 permitted mooring buoys are currently in place at Cottrell Key. No mooring buoys are currently within John Pennekamp Coral Reef State Park (JPCRSP) although several mooring buoys are scheduled for deployment as part of an impact study.

Hourly boat counts taken at the six surface-survey reefs readily demonstrated daily boating patterns (Figure 1). Because

observations at Sand Key, Western Sambo, and Big Munson have been limited, the boating patterns at these locations are preliminary and do not accurately reflect daily activity. However, Looe Key and Sombrero Key have bimodal activity peaks separated by a small drop in boat number between 1200 ET and 1300 ET. The slight increase in activity at 1700 ET at Sombrero Key is anomalous and a result of only two boat counts, one of which was July 4, being made between 1700 ET and 1800 ET. Although peak boat number differs for the two sites, Looe Key and Sombrero Key both exhibit a gradual increase in boat number until 1200 ET, a sustained-peak boat use until 1400 or 1500 ET, and a gradual decline thereafter. These figures confirm that the aerial surveys in the lower keys were made at peak boat-use times. The aerial surveys in the upper keys were made between 10~~x~~00 and 11~~x~~30<sup>ET</sup>, and may have occurred before peak boat use.

Extrapolating the Looe Key and Sombrero Key surface-survey data to the upper keys indicates that aerial-survey data collected before 12~~x~~00 ET underestimates peak boat use by 9.6% at Looe Key and 32.5% at Sombrero Key (Figure 1). The underestimation for these two sites is 21%, suggesting that observed boat use recorded during the aerial surveys may be 21% below the maximum boat use in the upper keys. However, the surface-survey data from Molasses Reef indicates maximum boat use occurs at three distinct times (Figure 1). Because boat use is extremely variable throughout the day at Molasses, no sampling bias is associated with the timing of the aerial surveys in the upper keys. Nevertheless, dive shops

generally report greater boating activity in the afternoon at reefs in the upper keys.

Boats using the lower keys surface-survey sites were classified separately during both the surface surveys and the aerial surveys (Figures 2 - 11). The frequencies of dive, fishing, and anchored boats are reported separately and combined for each site in histogram format. The total boat histograms derived from the surface-surveys and aerial-surveys are quite similar, confirming that both methods accurately reflect boat use even though the variation in the surface-surveys is within each day and the variation in the aerial-surveys is between days. There were more fishing and anchored boats reported in the surface-survey histograms than in the aerial-survey histograms because priority was given to looking for dive boats during the aerial surveys, as was described in the methodology, and because during the surface surveys an observer could classify a boat as diving one hour and fishing the next.

The surface surveys also allowed us to calculate the percentage of large (>30 ft) and small (<30 ft) boats diving, fishing, or just anchored at the lower keys surface-survey sites (Table 2). All reefs are predominantly used by small dive boats; however, both Sand Key and Western Sambo have higher percentages of large dive boats than other lower keys surface-survey sites. Fishing boats constitute approximately 20% of the boating activity at Sand Key and Sombrero Key, and less at other sites. Distinctly more boats (almost 20% of the boats observed) at Sand Key and Western Sambo

anchor or use mooring buoys but do not dive or fish.

The eight aerial surveys made during lobster season accounted for 75% of the boats observed and 73% of the area utilized by boats. The boats were primarily observed near bridges and on the Gulf side of the keys, not at the offshore reefs.

We used histograms created from the aerial-survey data (Figures 12-23) to decide which locations needed mooring buoys and to evaluate the locations that already have buoys (Chart 2 and Table 1). The number of mooring buoys we suggested was based on accommodating over 90% of boats currently using specific reefs. The increased numbers of boats on holidays, specifically July 4 and during early lobster season, could not be accommodated at Looe Key Reef (Figure 15), Alligator Reef (Figure 17), Conch Reef (Figure 19), Key Largo Dry Rocks Reef (Figure 21), Carysfort South Reef (Figure 22), and Fowey Rocks Reef (Figure 23).

The average number of boats using the patch reef near Big Munson, which is marked with a red daymarker, is significantly higher than the average number of boats using an unmarked patch reef near Cook Island (Table 3). The size and structure of both patch reefs is similar, and the primary difference between the two reefs is location; the unmarked patch reef is 0.5 miles further away from the principal anchorage in the vicinity. Although seven or fewer boats commonly anchored at either patch reef, the difference in the average number of boats anchored at the two reefs is attributable to the frequent use of the Big Munson patch reef by ten or more boats (Figure 24).

## DISCUSSION

The patchy distribution of mooring buoys in the Florida Keys is due to the fact that only a few isolated groups actively install and maintain mooring buoys. Because of the actions of resource managers and concerned boating groups, many mooring buoys were placed in the Looe Key (LKNMS) and Key Largo National Marine Sanctuaries (KLNMS), the Key West area, and in the Marathon area. The distribution of mooring buoys in each of these four regions generally reflects boating activity, although some changes in mooring buoy location and number are warranted and will be discussed later. The current number of mooring buoys placed at specific reefs was based on attempting to accommodate boaters within the confines of available funding. As funding disappeared in the Marathon area mooring buoys were gradually lost and have not been replaced. Mooring buoys were placed on the patch and deep reefs in the Looe Key National Marine Sanctuary in an attempt to attract boaters to alternate areas within the sanctuary. There are no mooring buoys currently in JPCRSP because of<sup>a</sup> lack of ~~funding for~~ mooring buoy maintenance<sup>sunb</sup> and because park staff wants to better evaluate the impact of mooring buoys before they allocate many of them.

Currently, JPCRSP staff are implementing a project to evaluate the use of mooring buoys in the park. Two principal areas concern park staff: the probability that fewer mooring buoys will be needed in this area and the increased sensitivity of corals to human contact due to increased levels of environmental stress. Coral

formations within JPCRSP are patch reefs surrounded by sand halos. These sand halos provide easy and reliable anchoring sites, thus reducing the need for mooring buoys. Patch reefs within Pennekamp may be particularly sensitive to human contact because of the increased environmental stress on reefs near Hawks Channel. Reefs subject to high levels of stress may be less tolerant of human contact and more susceptible to diseases as compared to reefs located in less stressed areas. Until the cumulative effects of natural stress and human contact can be evaluated, no further use of mooring buoys will be sanctioned. (George Jones, JPCRSP manager, pers. comm.).

Our suggestions for mooring buoy locations are based on our direct observations of boats at specific reefs. In the lower keys, the aerial surveys occurred at times of peak boat use; unfortunately, in the upper keys, the aerial survey preceded peak boat use (Figure 1). As a result, the number of mooring buoys suggested for the upper keys may be less than the number necessary to accommodate 90% of the boating activity. The mooring buoy suggestions in Chart 2 and Table 1 do not reflect this underestimation of peak boat use. We are still collecting data, and we hope to better identify the true magnitude of boat use in the upper keys in the future.

The reliability of mooring buoys is a major concern to both boaters and the organizations maintaining the mooring buoys. Specific requests have been made to deploy sturdier buoy systems for very large boats (over 45 feet). Large boats constituted 25%

to 46% of the boats observed during our surface-surveys of reefs, reflecting the increase in demand for sturdier mooring buoys (our survey classified large boats as greater than 30 feet long) (Table 2). Several sturdier and longer-lasting mooring buoy designs exist that would lower the risk of mooring failure and reduce maintenance frequency (John Halas, per. comm.).

Many of the large boats observed in our surveys were commercial dive boats. If properly managed, mooring buoys can allow use of the reef by commercial dive boats and protect the reef from unnecessary damage caused by anchors or divers. To help protect reefs, perhaps mooring buoys can be leased to commercial dive boats for their sole use. Leasing a mooring buoy would allow a commercial dive boat access to areas in which all of the installed mooring buoys are occupied. Using mooring buoys in this fashion would benefit the resource by controlling the access of snorklers or divers to environmentally sensitive areas, and it would benefit commercial dive boats by guaranteeing their access to the reef of their choice. Also, the income gained from leasing the mooring buoys to commercial interests would also provide for the funds to maintain the mooring buoys.

Any discussion of boating in the Florida Keys must include the increase in the number of boats and the change in the location of those boats during lobster season. Unfortunately, because of lobster divers' desire to dive in remote areas and the increased number of divers in all areas, mooring buoys can not adequately serve the boating public during lobster season.

Hurricane Andrew, August 24, completely stopped boating activity just after the peak of lobster season. We suspect our September and October boating patterns are not representative of normal fall boating patterns. But, historically, boating activity at the reef is lower in the fall, so our mooring buoy estimates should not be affected.

Suggestions for mooring buoy deployment at additional reefs and changes in mooring buoy number at existing sites are based solely on our boating observations (Chart 2 and Table 1). The major change suggested in mooring buoy distribution is to deploy mooring buoys at 14 additional reefs. In general, the reefs near the Key West area have too many mooring buoys and there are too few at those reefs slightly further to the east. Eighteen of the surveyed reefs currently have adequate numbers of mooring buoys to accommodate 90% of current boating activity. The aerial-survey data suggest the removal of mooring buoys at only one site, Northwest Dry Rocks in Key Largo, because only one boat was observed in 36 over-flights of that reef. Although the aerial-survey data at Northwest Dry Rocks indicates the reef should not have any mooring buoys, Key Largo dive shops report the reef is used as a second dive site in the late afternoon for several commercial dive boats.

The high number of reefs with adequate numbers of mooring buoys demonstrates that mooring buoys can be deployed based on local knowledge and experience. Many organizations visit reefs on a daily basis, their observations can be used to adequately determine

the number of mooring buoys required to accommodate most boats. Determination of the optimal number of mooring buoys would of course be enhanced by recording the exact number of boats at the reef in a logbook. A second reason for the correlation between mooring buoy numbers and boat counts is that boats often wait for a mooring buoy to become vacant instead of anchoring. This observation emphasizes how well received mooring buoys are to the boating public.

Our comparison of boating patterns at two nearshore patch reefs, one marked and one unmarked, clearly shows that more boats use the marked reef (Figure 24). There are two main differences in boat use between the marked and unmarked reef: on 16 of the 36 days boat counts were made, no boats were observed on the unmarked reef, compared to only 7 days with no boats observed at the marked patch reef; additionally, peak boat numbers at the marked reef are much higher than on the unmarked reef. The difference between use of the marked verses unmarked reefs is <sup>primarily</sup> ~~principally~~ a result of human behavior. Once a boat anchors on the unmarked reef, other boats then know where the reef is and quickly congregate around the original boat. This results in infrequent but moderately high use of the unmarked reef compared to frequent moderately high use and occasional very high use of the marked reef.

Although the lack of a permanent marker on the unmarked patch reef has resulted in less diving pressure, the frequency of groundings and damage from those groundings is higher than on the nearby marked reef (pers. obs.). Site specific observations, like

increased risk of boat groundings, need to be considered when selecting reefs for mooring buoy deployment.

In summary, Table 1 suggests a distribution of mooring buoys that will account for over 90% of the boats using reefs in the FKNMS. The suggested number of mooring buoys for the reefs east of Coffins Patch maybe 21% too low. Mooring buoys are not an adequate tool to control boating activity during lobster season and on Holidays, other management alternatives, possibly closing certain areas to diving for lobsters should be considered. Mooring buoy placement also needs to consider carrying capacities of divers on specific reefs. These diver-carrying capacities can only be developed by monitoring diver-related coral damage and correlating that damage with the number of mooring buoys currently on those reefs. This monitoring process will be long, and the data-collection process will most likely be difficult. Mooring buoy deployment and maintenance can be funded by leasing mooring buoys to specific users thus guaranteeing access to the reef of their choice.

Mooring buoys are readily accepted by the boating public and can be an effective on-site management tool to help alleviate boating damage. Measuring diver impacts on coral around mooring buoys is difficult and will always be open for interpretation, although the health of coral reefs is of critical concern and should be monitored closely, it is doubtful that a causative relationship between diving frequency and coral damage can be identified. Resource managers should act in coordination with experienced local

users to deploy an appropriate number of mooring buoys that in their best judgement will protect the resources and allow responsible continued use of that resource.

## References

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## Acknowledgements

We would like to thank: Lonny Anderson and Dave Eaken for their perseverance during the long hours of surface surveys; Chris Friel and Henry Norris for developing the MRGIS lap<sup>p</sup>-top data collection atlas; our volunteers: Captains Brian, Mick, and Frank O'Conner with the John Pennekamp State Park Concession, the Boy Scouts of America - Sea Base, Larry Laclair, Gary Mangrella, Chris and Margaret Gibson, Captain Dwayne Johnson, Virginia Barker, Ken Hartsing and Bill Green of the Looe Key Sanctuary National Marine Sanctuary, and John Pennekamp Boat Rentals For Fun for use of their boats, and Judy Leiby for reviewing the final report. This project was funded by a Florida Department of Natural Resources grant to the Looe Key National Marine Sanctuary (DNR C-8013). Some data for this project were used from an on-going cooperative project between The Nature Conservancy, the Florida Department of Natural Resources\Division of Marine Resources, and the Florida Department of Natural Resources\Division of Recreation and Parks. The funding for the main project was the result John Hunt and Mark Robertson's efforts, both of whom perceived a need for this type of information many years ago.

TABLE 1. MOORING BUOY LOCATIONS AND SUGGESTIONS FOR ENHANCEMENT, REDUCTIONS OR NEW LOCATIONS WITHIN THE FLORIDA KEYS.

| LOCATION                 | CURRENT <sup>1</sup> | SUGGESTED <sup>2</sup> |  | LOCATION                  | CURRENT <sup>1</sup> | SUGGESTED <sup>2</sup> |
|--------------------------|----------------------|------------------------|--|---------------------------|----------------------|------------------------|
| Western Dry Rocks        | 10                   | 6                      |  | Eastern Dry Rocks         | 14                   | 3                      |
| Rock Key                 | 12                   | 9                      |  | Sand Key                  | 33                   | 11                     |
| Pelican Shoal            | 3                    | 3                      |  | Looe Key Patch Reefs      | 7                    | 1                      |
| Looe Key Deep Reef       | 12                   | 4                      |  | Looe Key Fore Reef        | 34                   | 36                     |
| Middle Sambo             | 0                    | 8                      |  | Western Sambo             | 25                   | 9                      |
| Eastern Sambo            | 0                    | 8                      |  | American Shoal            | 0                    | 7                      |
| Cottrell                 | 9                    | 4                      |  | Sombrero                  | 13                   | 26                     |
| Bahia Honda Patch Reef   | 0                    | 4                      |  | East Washer Women         | 0                    | 3                      |
| Marker 48                | 3                    | 3                      |  | Coffins Patch             | 0                    | 7                      |
| Turtle Shoal             | 3                    | 2                      |  | Tennessee                 | 0                    | 5                      |
| East Tennessee           | 0                    | 4                      |  | Hens & chickens           | 5                    | 18                     |
| Crocker                  | 2                    | 8                      |  | Alligator                 | 4                    | 21                     |
| Davis Reef               | 4                    | 8                      |  | Conch Reef                | 5                    | 17                     |
| Cheeca Rocks             | 2                    | 4                      |  | Pickles                   | 3                    | 3                      |
| Molasses                 | 28                   | 26                     |  | 3-Sisters                 | 2                    | 5                      |
| Sand Island <sup>3</sup> | 4                    | 2                      |  | Benwood                   | 4                    | 4                      |
| White Banks              | 5                    | 8                      |  | French                    | 17                   | 9                      |
| Grecian                  | 12                   | 13                     |  | Dry Rocks <sup>3</sup>    | 16                   | 14                     |
| Elbow                    | 10                   | 7                      |  | Pacific                   | 0                    | 11                     |
| Fowey Rocks              | 0                    | 11                     |  | Triumph                   | 0                    | 8                      |
| Carysfort                | 12                   | 10                     |  | Big Munson                | 0                    | 11                     |
| N Dry Rocks <sup>3</sup> | 3                    | 1                      |  | NW Dry Rocks <sup>3</sup> | 3                    | 2                      |
| Horseshoe                | 1                    | 1                      |  | Turtle Rocks              | 13                   | 3                      |
| Turtle Reef              | 0                    | 7                      |  | NE Patch <sup>3</sup>     | 3                    | 0                      |
| Carysfort South          | 8                    | 4                      |  | Big Pine Shoal            | 0                    | 5                      |

1 Current buoys as of December 1992.

2 Suggestions for moorings accomodate >90% of the observed boats.

3 Reefs located in the Key Largo area.

TABLE 2. PERCENTAGE OF SMALL AND LARGE, FISHING AND DIVING  
BOATS OBSERVED FROM SURFACE SURVEYS AT EACH LOCATION.

| LOCATION         | DIVE  | BOATS | FISHING | BOATS | ANCHORED | BOATS |
|------------------|-------|-------|---------|-------|----------|-------|
|                  | >30FT | <30FT | >30FT   | <30FT | >30FT    | <30FT |
| Sand Key         | 20%   | 40%   | 4%      | 18%   | 6%       | 12%   |
| Western Sambo    | 37%   | 39%   | 3%      | 2%    | 7%       | 12%   |
| Big Munson Patch | 19%   | 67%   | 0%      | 13%   | 0%       | 1%    |
| Looe Key         | 23%   | 65%   | 1%      | 9%    | 1%       | 1%    |
| Sombrero         | 14%   | 61%   | 2%      | 15%   | 3%       | 5%    |

TABLE 3. COMPARISON OF BOATS BETWEEN COOK ISLAND (UNMARKED) AND BIG MUNSON (MARKED) PATCH REEFS. T-TEST WAS PERFORMED ON  $\text{LOG}(10)+1$  TRANSFORMED DATA TO MEET THE ASSUMPTION OF HOMOGENEITY OF VARIANCE.

| LOCATION    | N<br>(days of observation) | MEAN<br>(boats/day) | MAX<br>(boats) | S.E. |
|-------------|----------------------------|---------------------|----------------|------|
| Big Munson  | 36                         | 3.9                 | 17             | 0.70 |
| Cook Island | 36                         | 1.8                 | 7              | 0.37 |

$T = -2.8121$

$DF = 70$

$\text{Prob} > (T) = .0064$

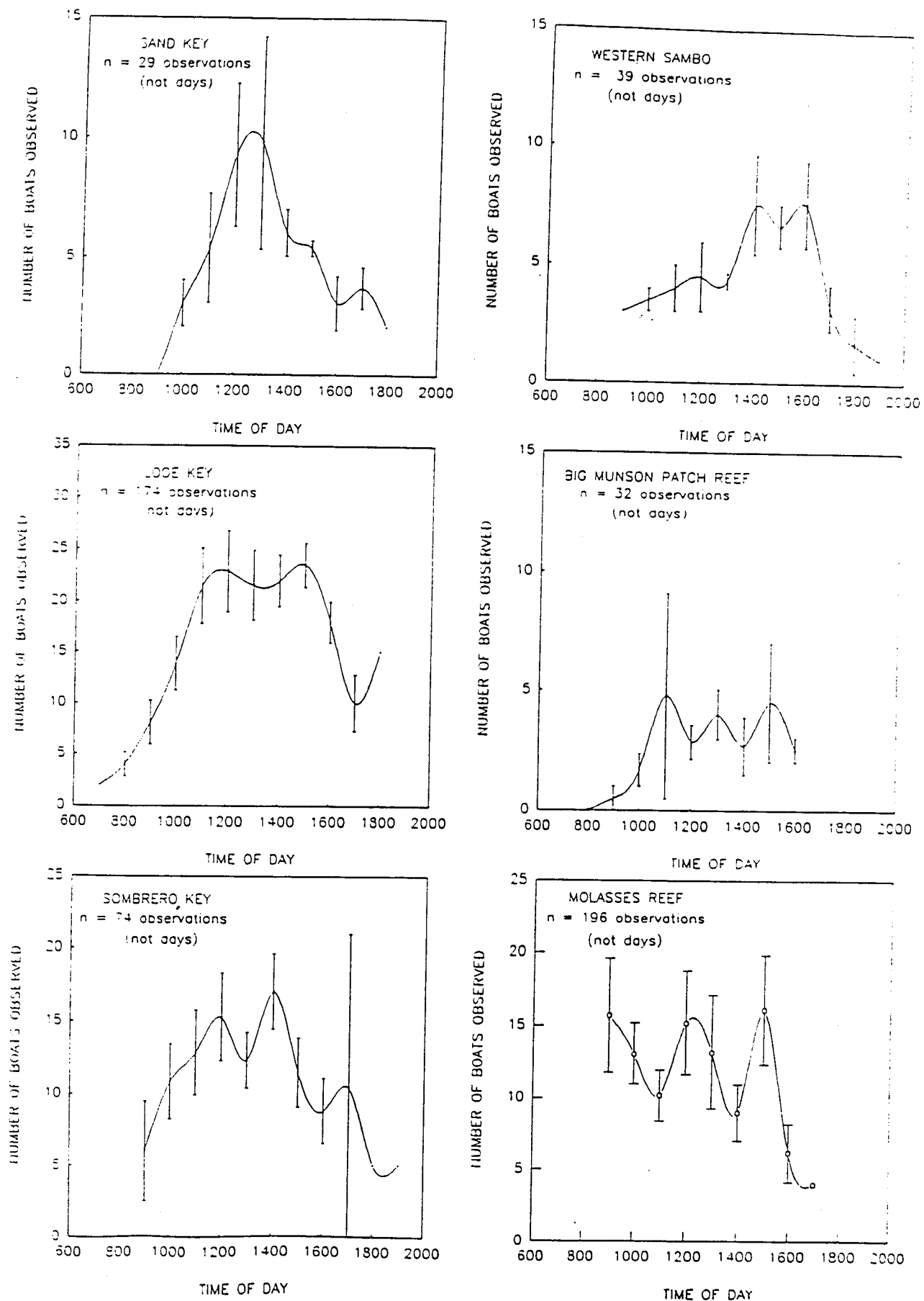


Figure 1. Mean boat counts and standard errors for reefs based on hourly counts of stationary boats. Observations from Sand Key, Western Sambo, and Big Munson patch reefs are limited in number and may not accurately estimate boat number and activity.

Figure 2. Sand Key reef boat counts and classifications from aerial surveys from June 1, 1992 to March 6, 1993.

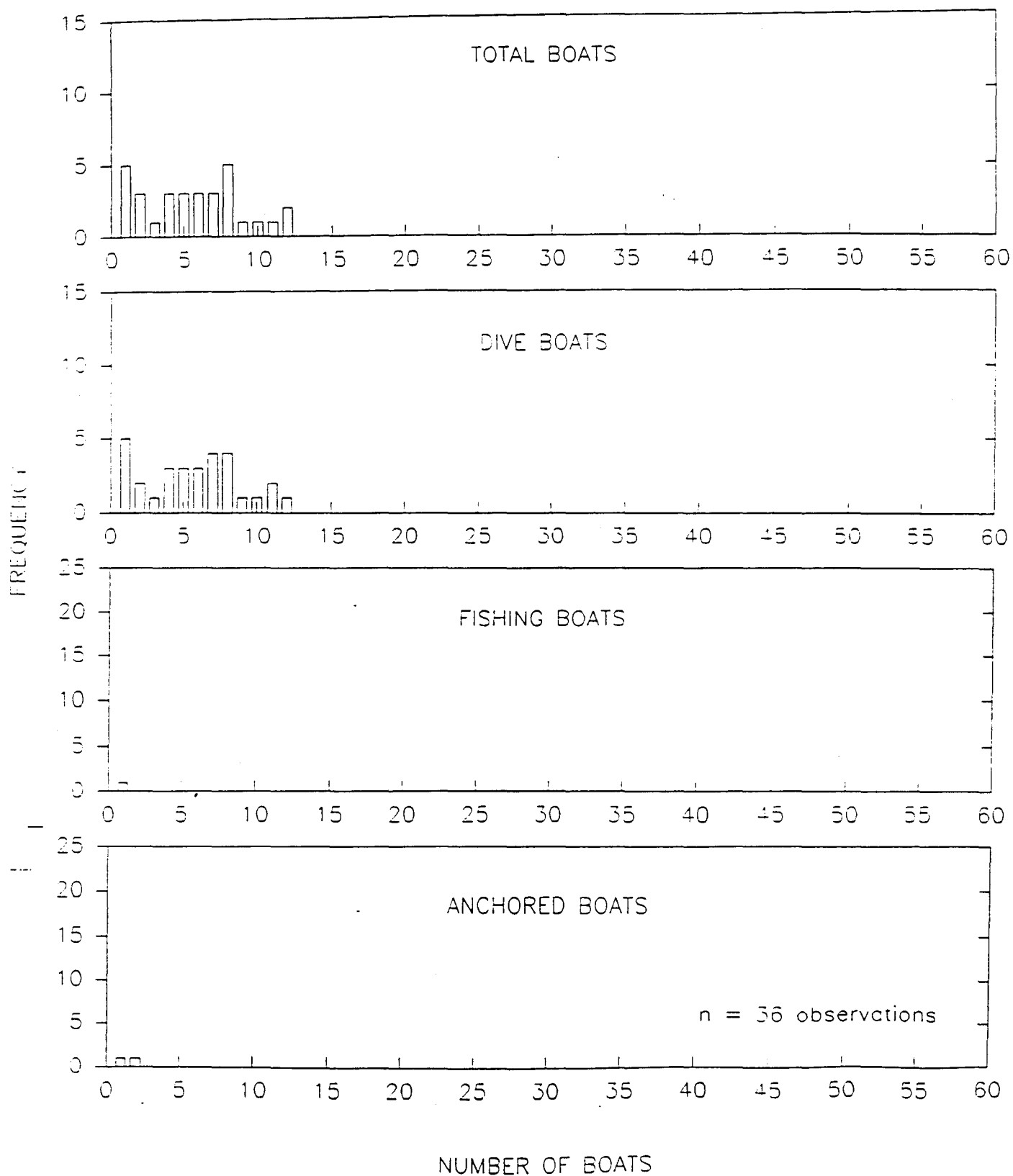


Figure 3. Sand Key reef boat counts and classifications from surface surveys from June 1, 1992 to March 6, 1993.

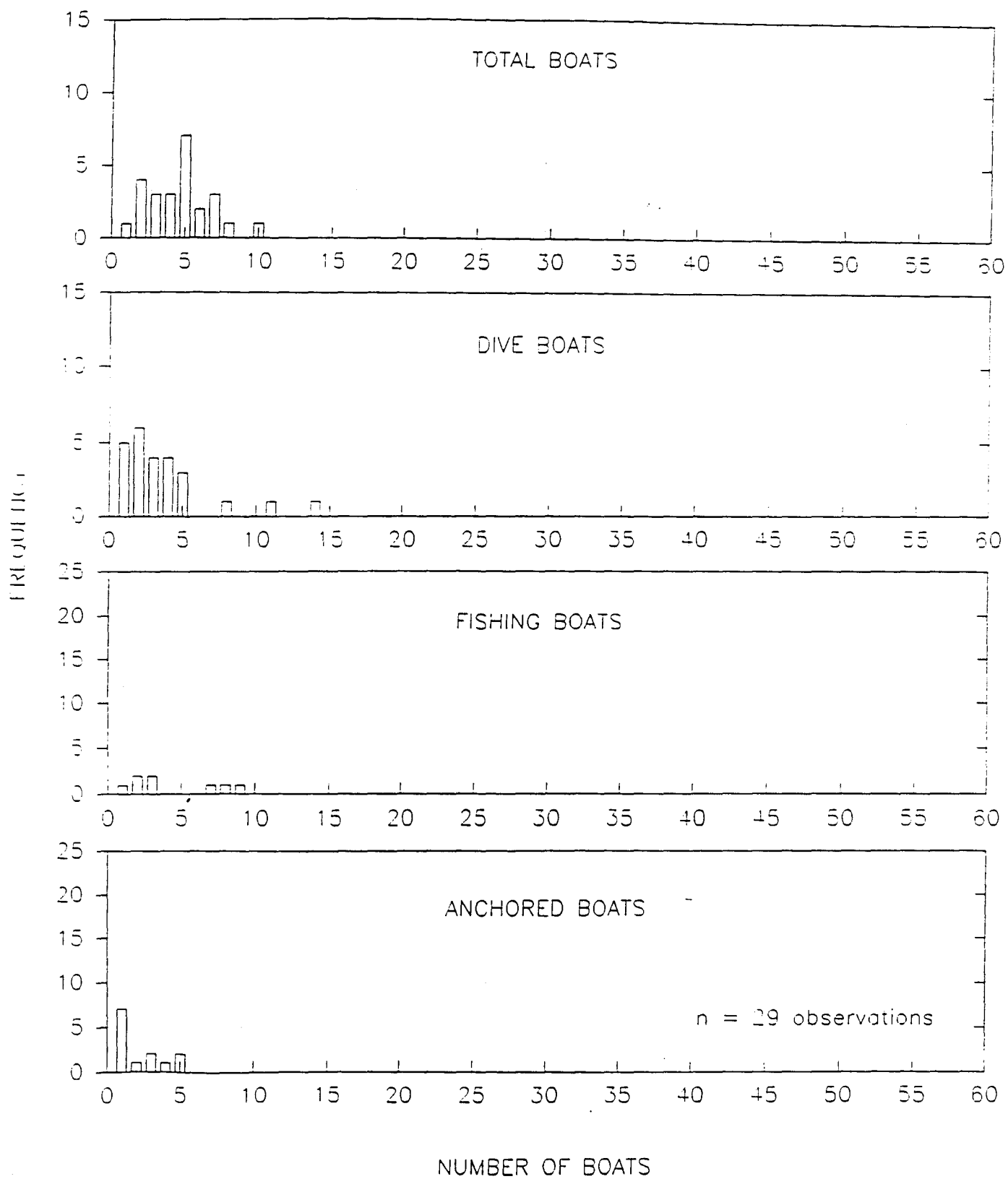


Figure 4 Western Samoa reef boat counts and classifications from aerial surveys from June 1, 1992 to March 6, 1993.

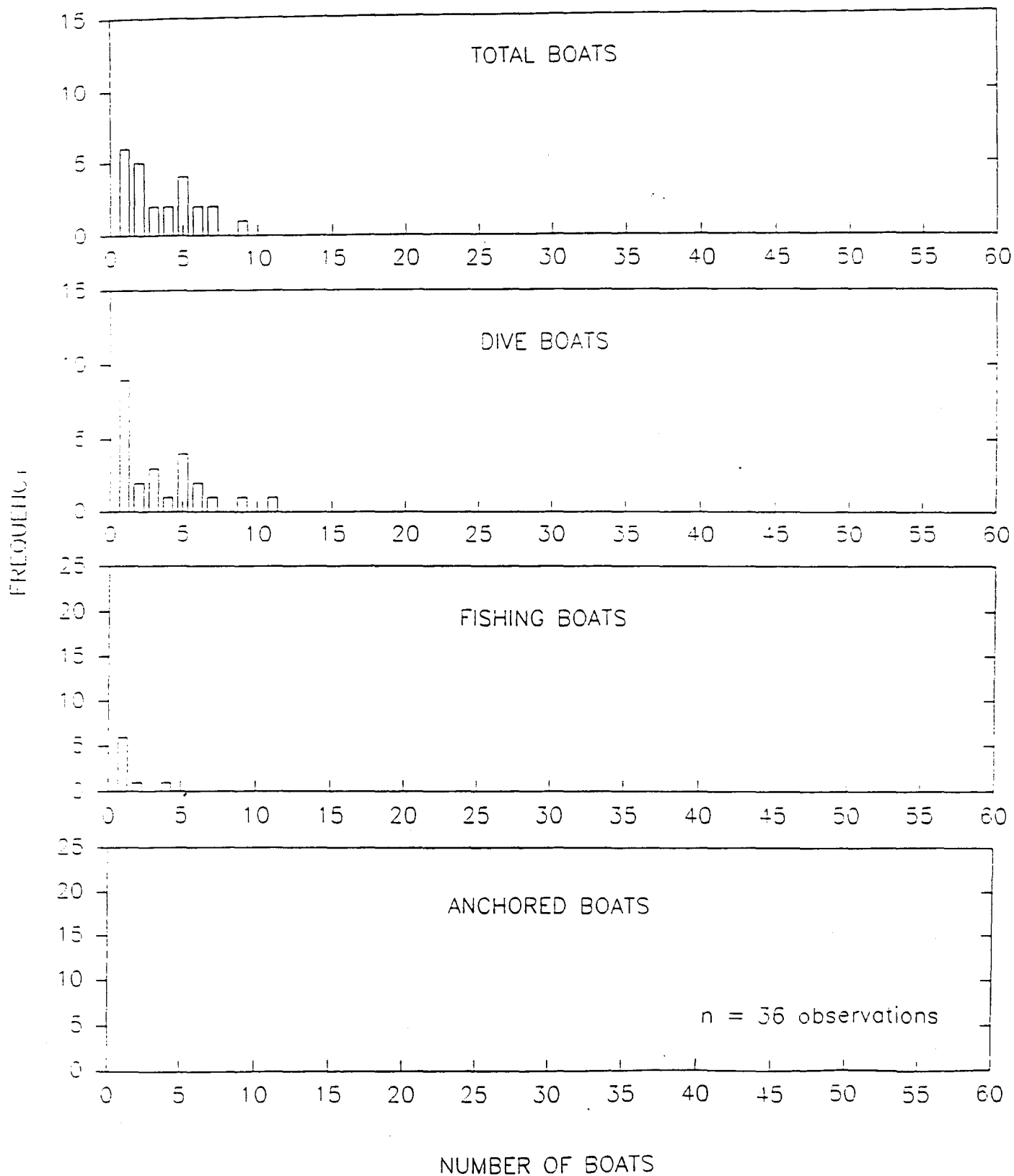


Figure 5. Western Sambo reef boat counts and classifications from surface surveys from June 1, 1992 to March 6, 1993.

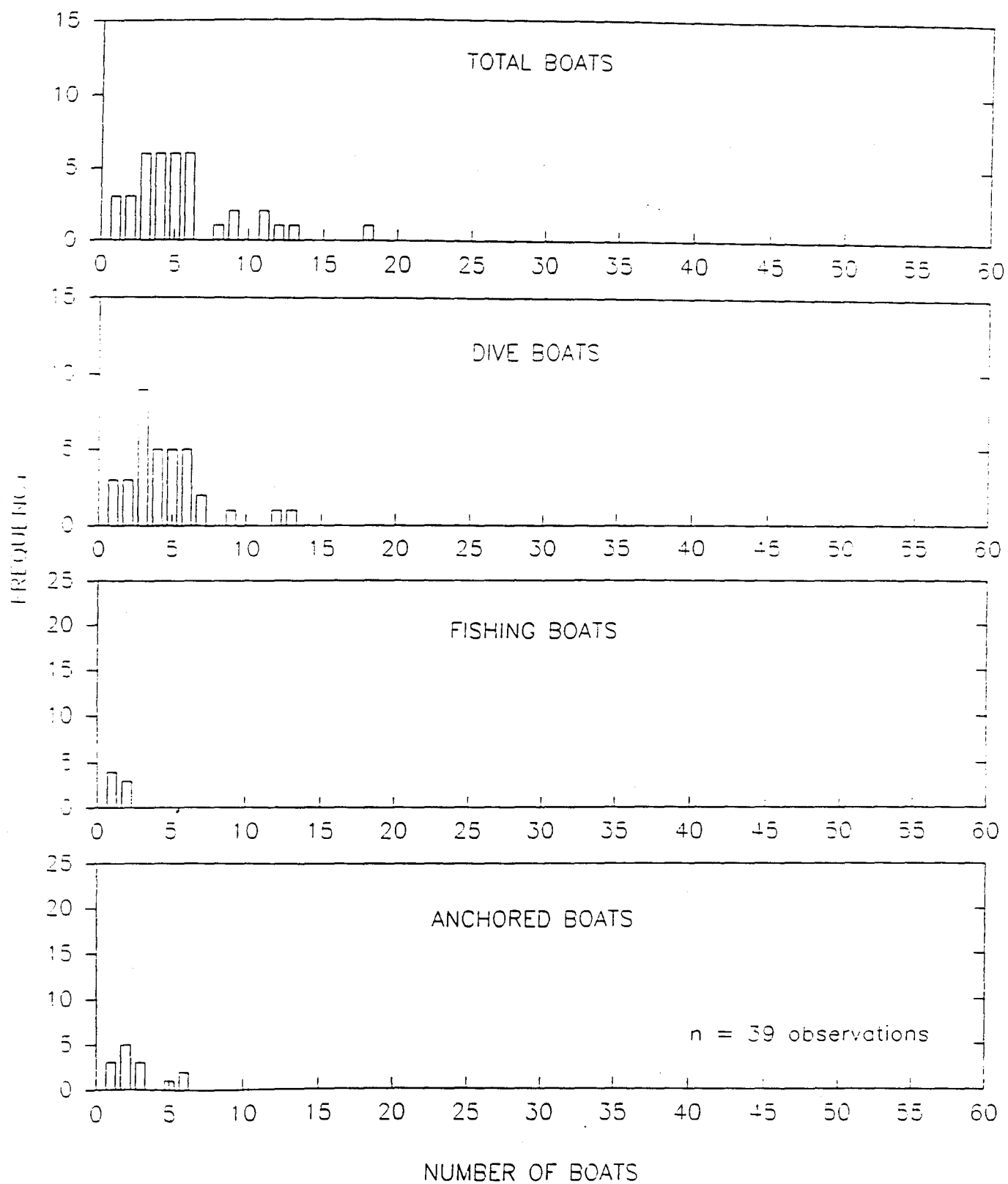


Figure 6. Big Munson patch reef boat counts and classifications from aerial surveys from June 1, 1992 to March 6, 1993.

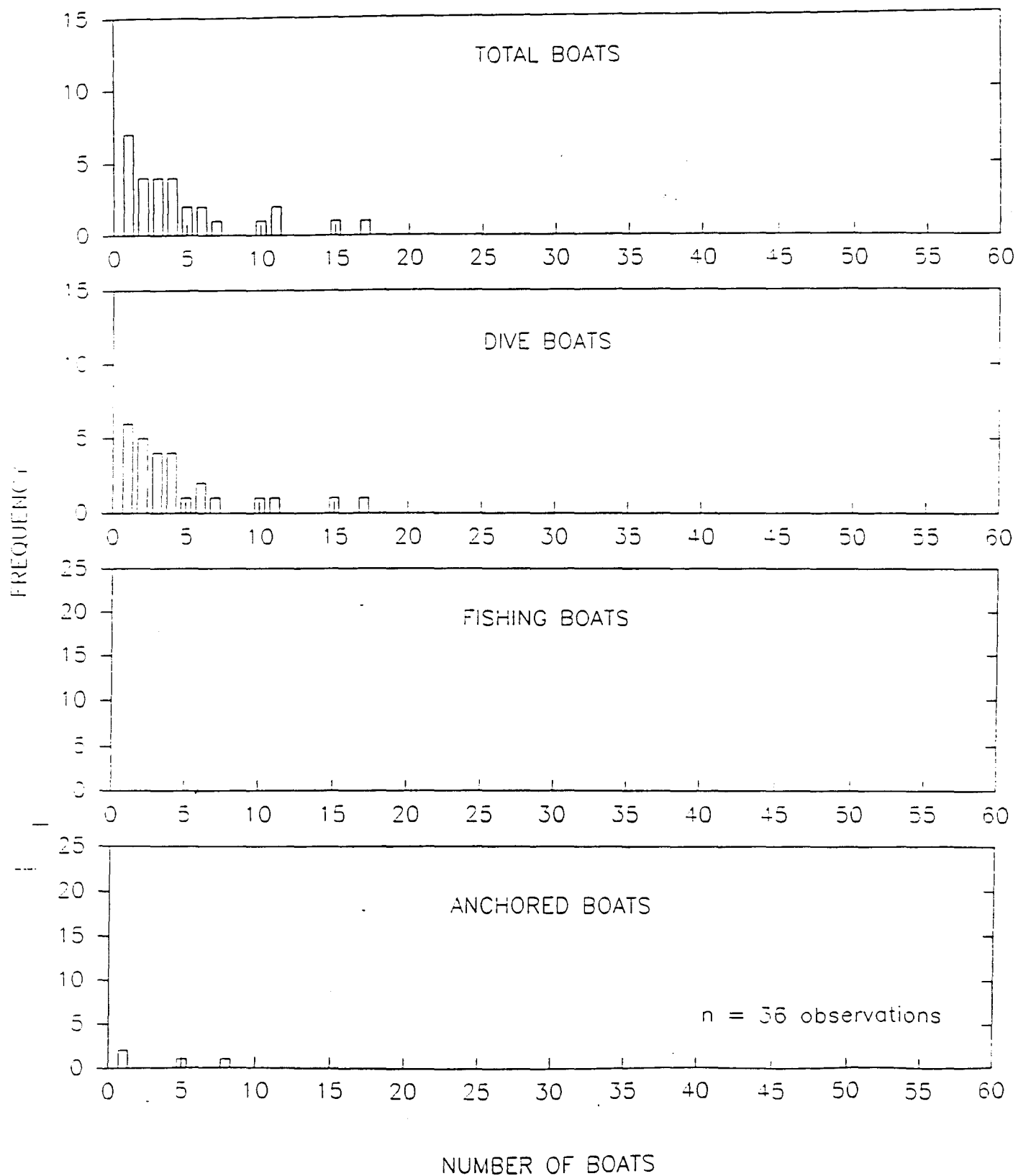


Figure 7. Big Munson patch reef boat counts and classifications from surface surveys from June 1, 1992 to March 6, 1993.

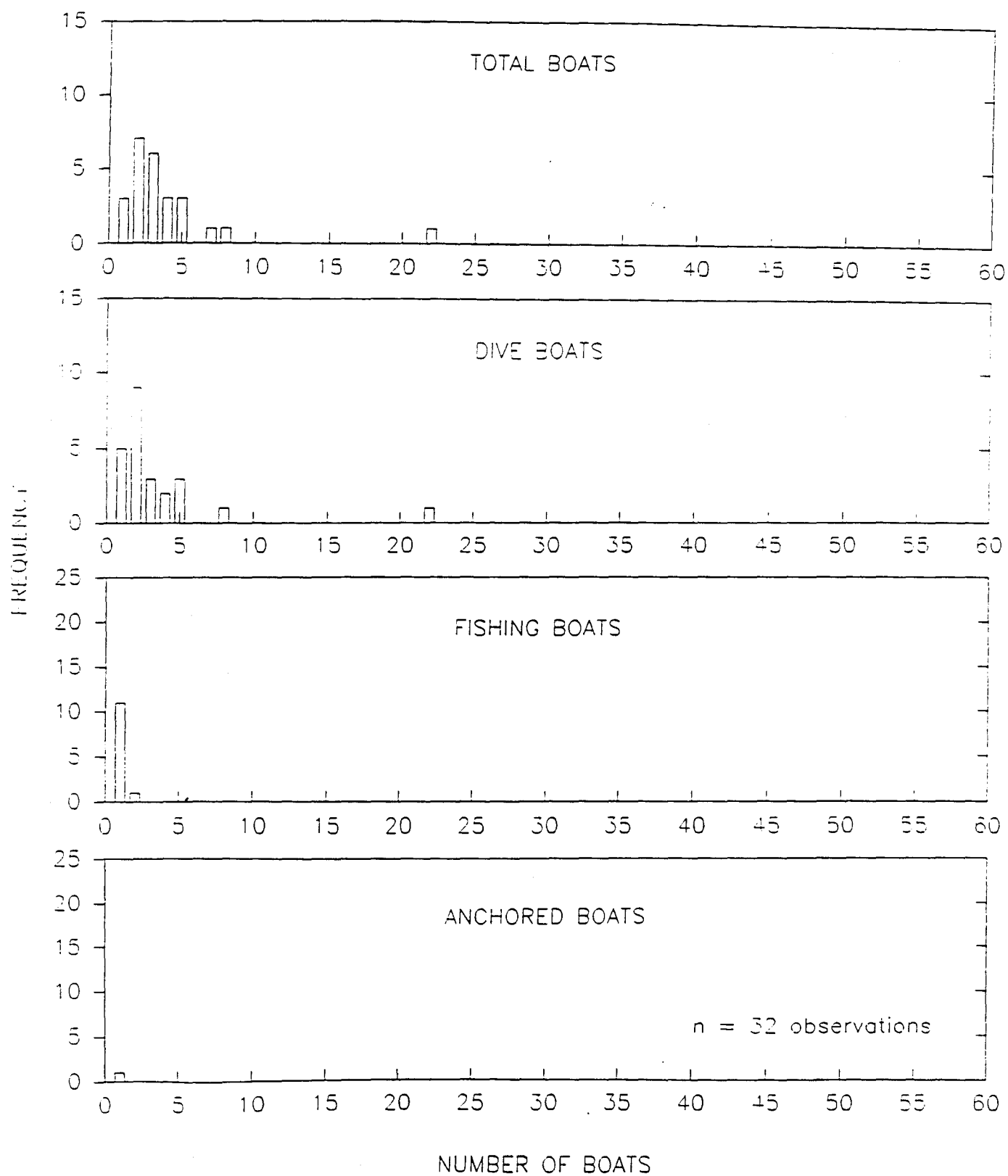


Figure 9. Looe Key fore reef boat counts and classifications from surface surveys from June 1, 1992 to March 6, 1993.

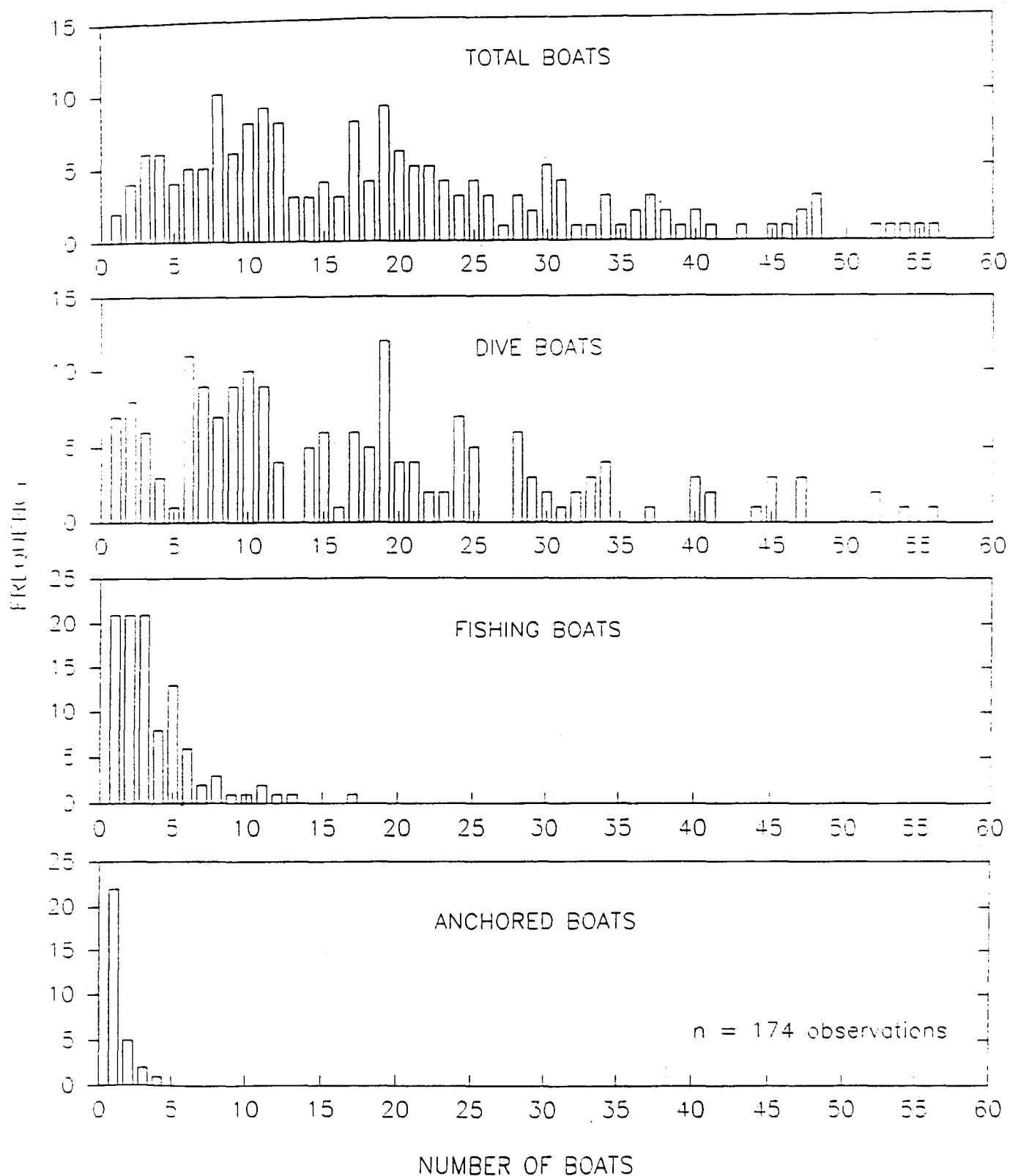


Figure 2. Looe Key fore reef boat counts and classifications from aerial surveys from June 1, 1992 to March 6, 1993.

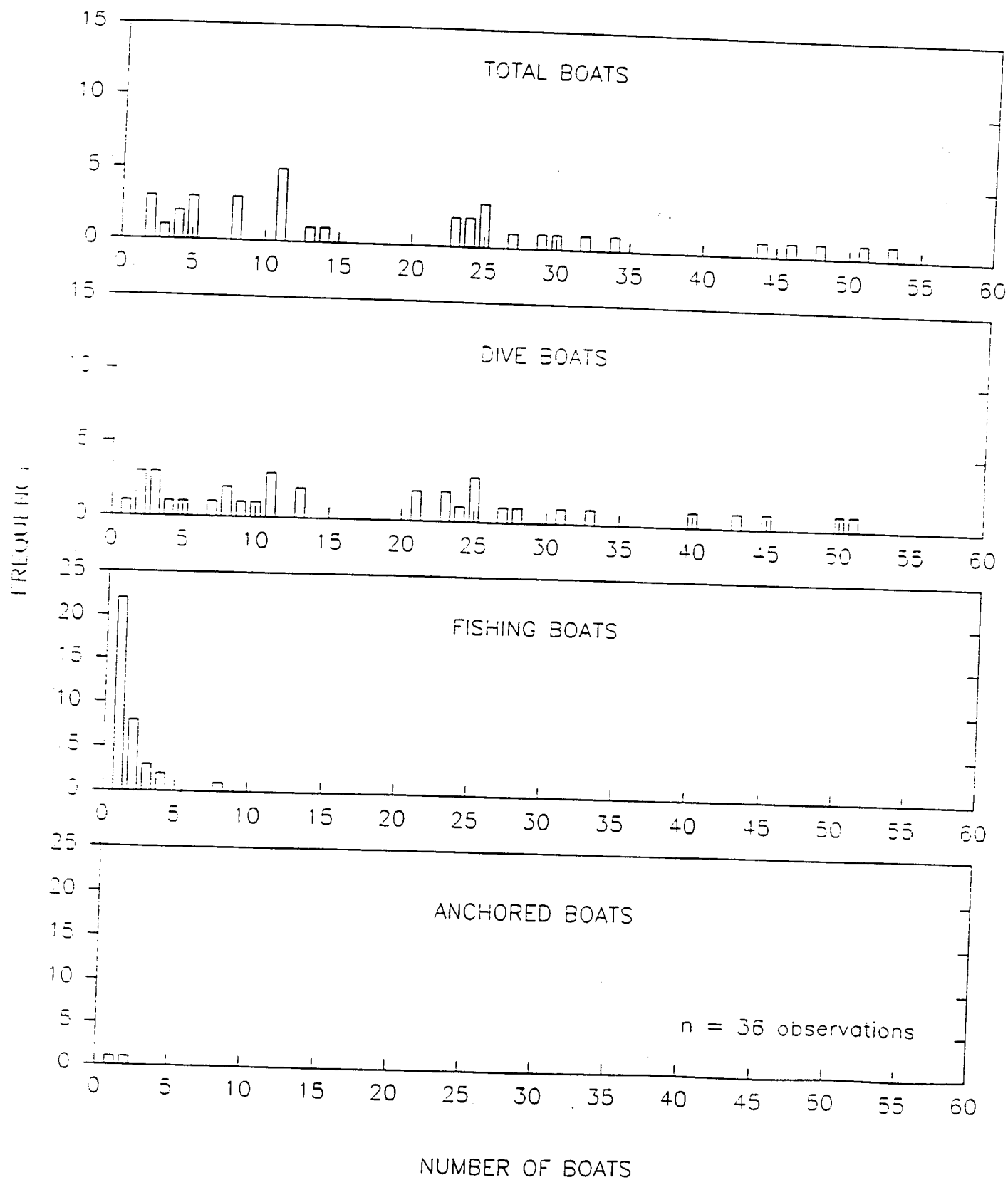


Figure 10. Sombrero reef boat counts and classifications from aerial surveys from June 1, 1992 to March 6, 1993.

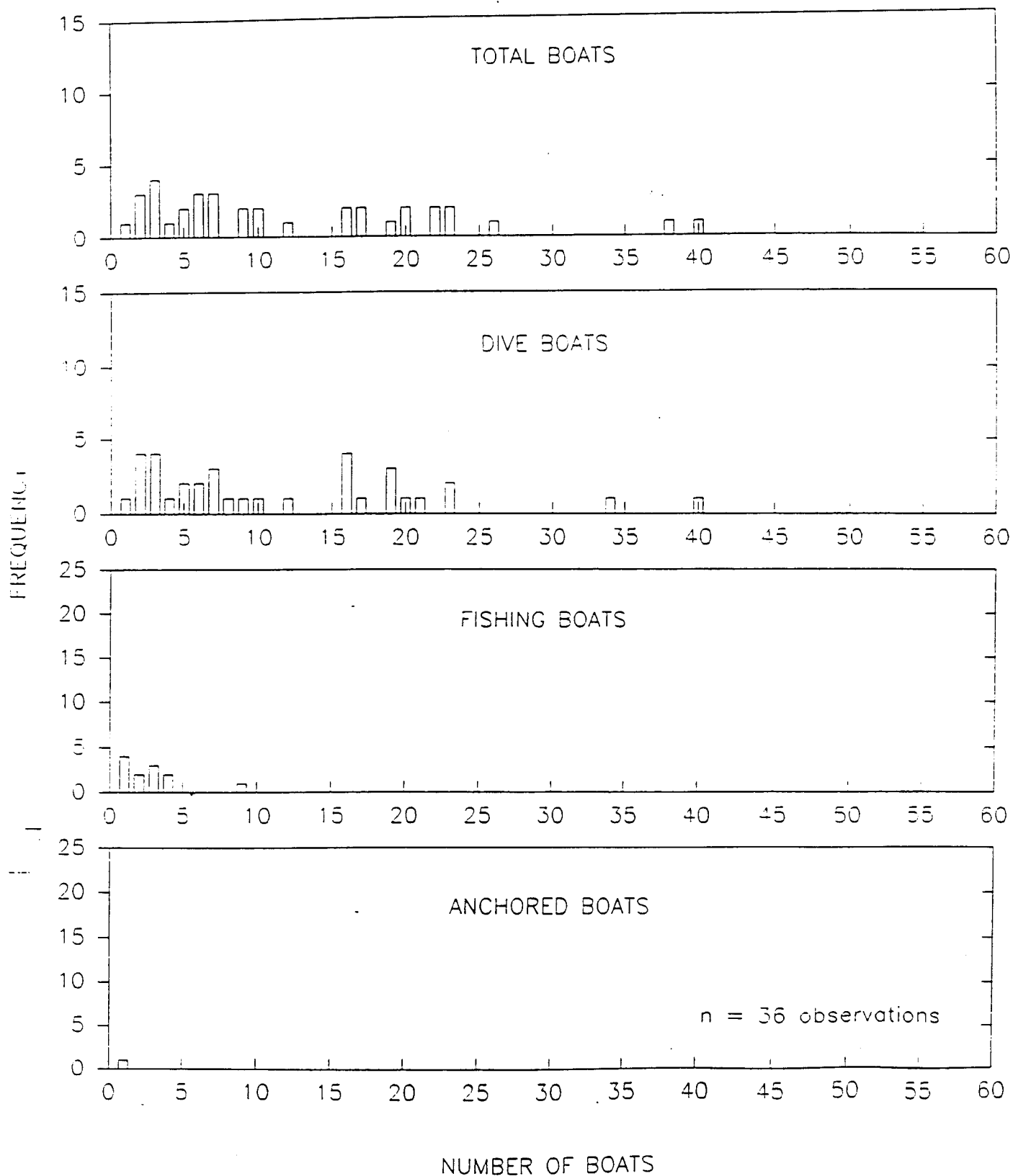


Figure 11. Sombrero reef boat counts and classifications from surface surveys from June 1, 1992 to March 6, 1993.

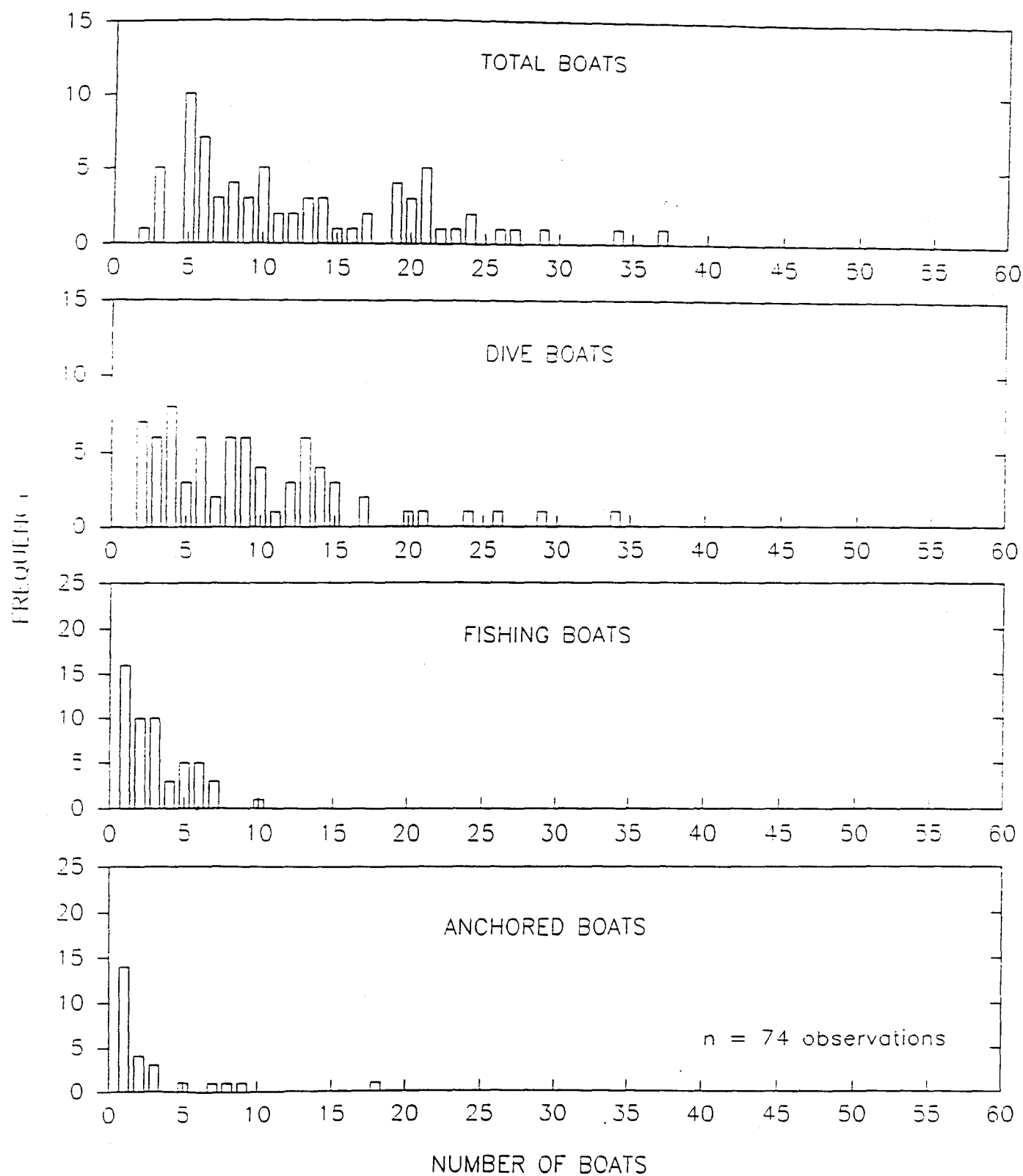


Figure 12. Total boat counts from aerial surveys in the Key West area from June 1, 1992 to March 6, 1993.

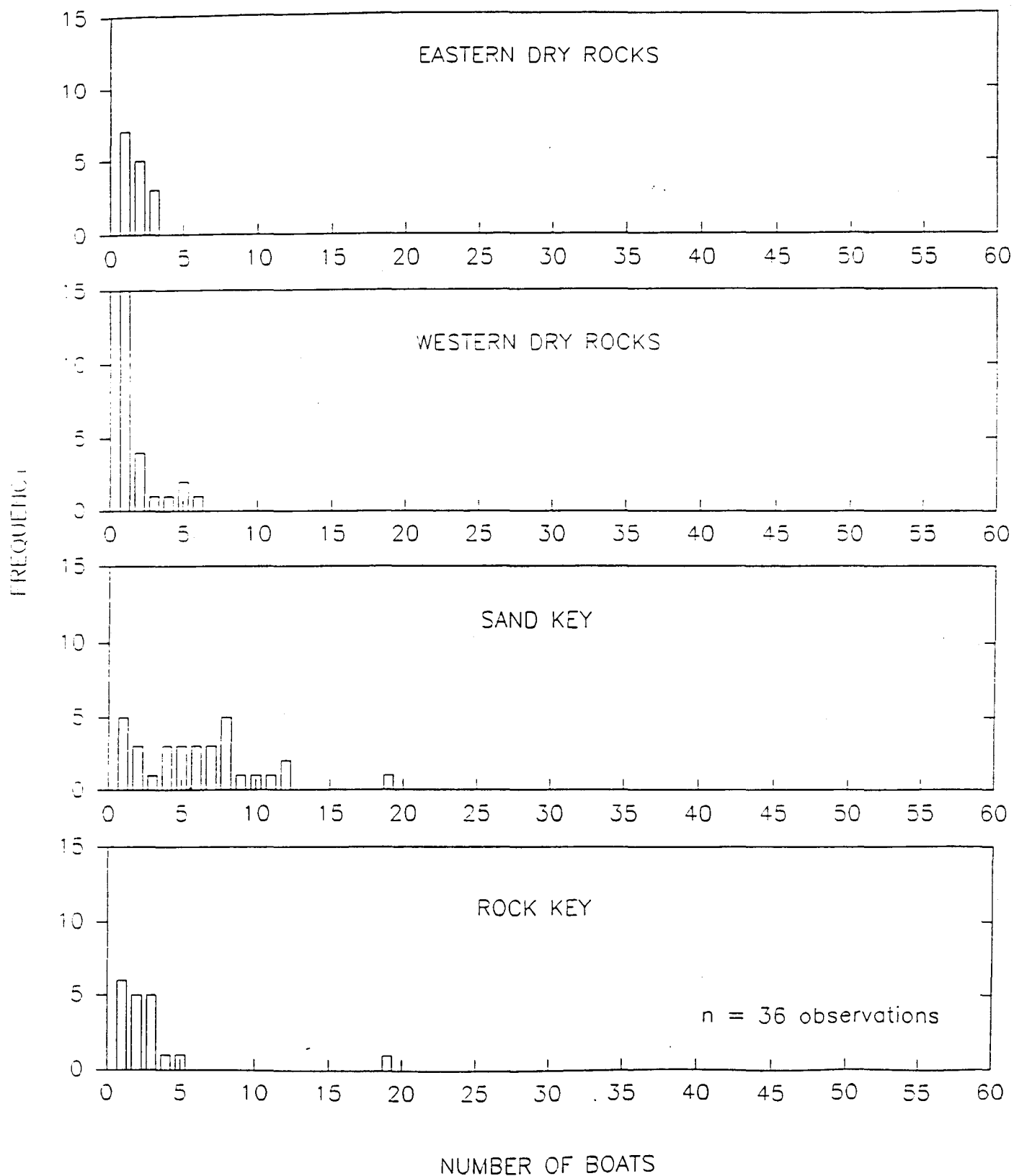


Figure 13. Total boat counts from aerial surveys in the Boca Chica area from June 1, 1992 to March 6, 1993.

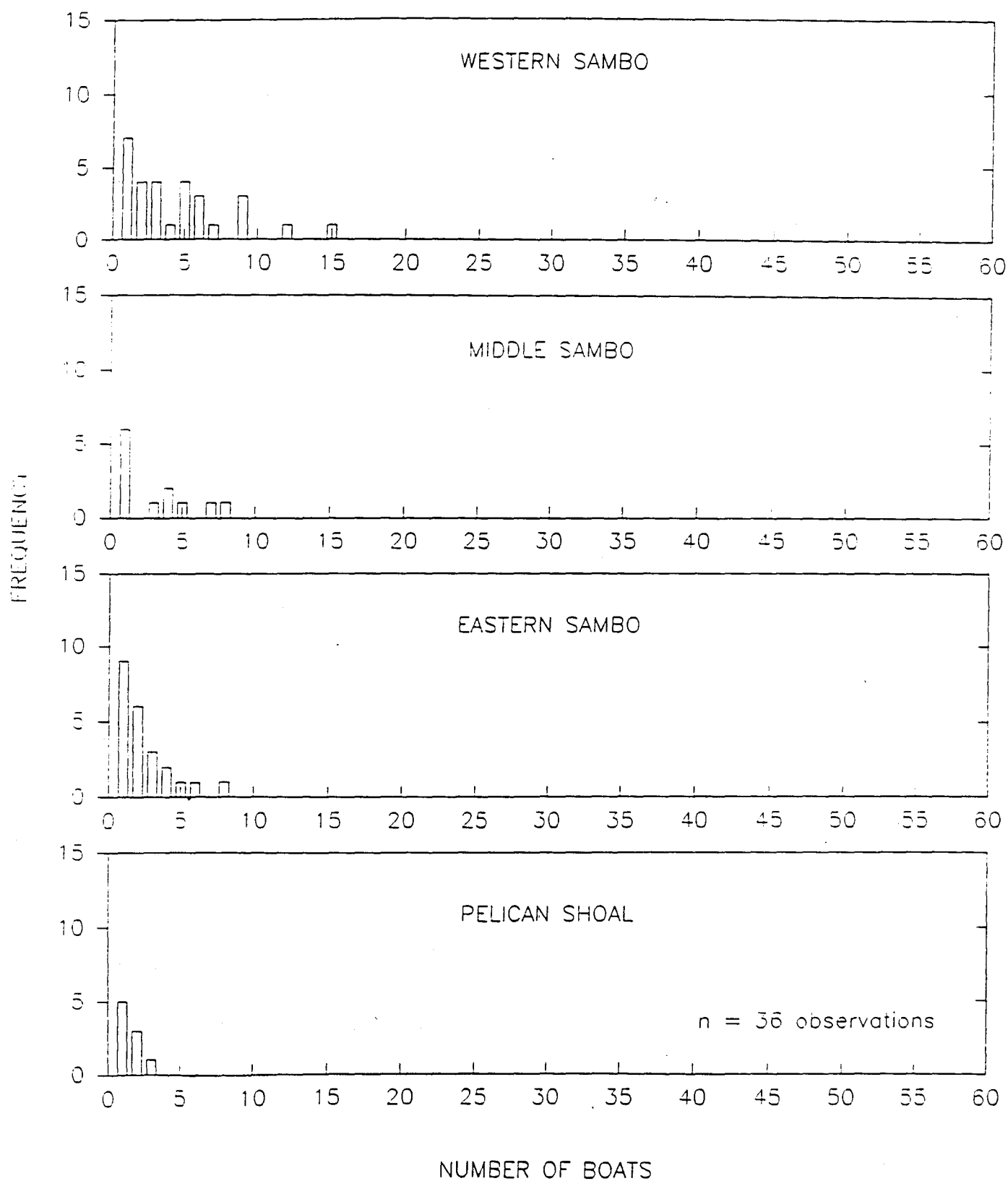


Figure 14. Total boat counts from aerial surveys in several lower keys areas from June 1, 1992 to March 6, 1993.

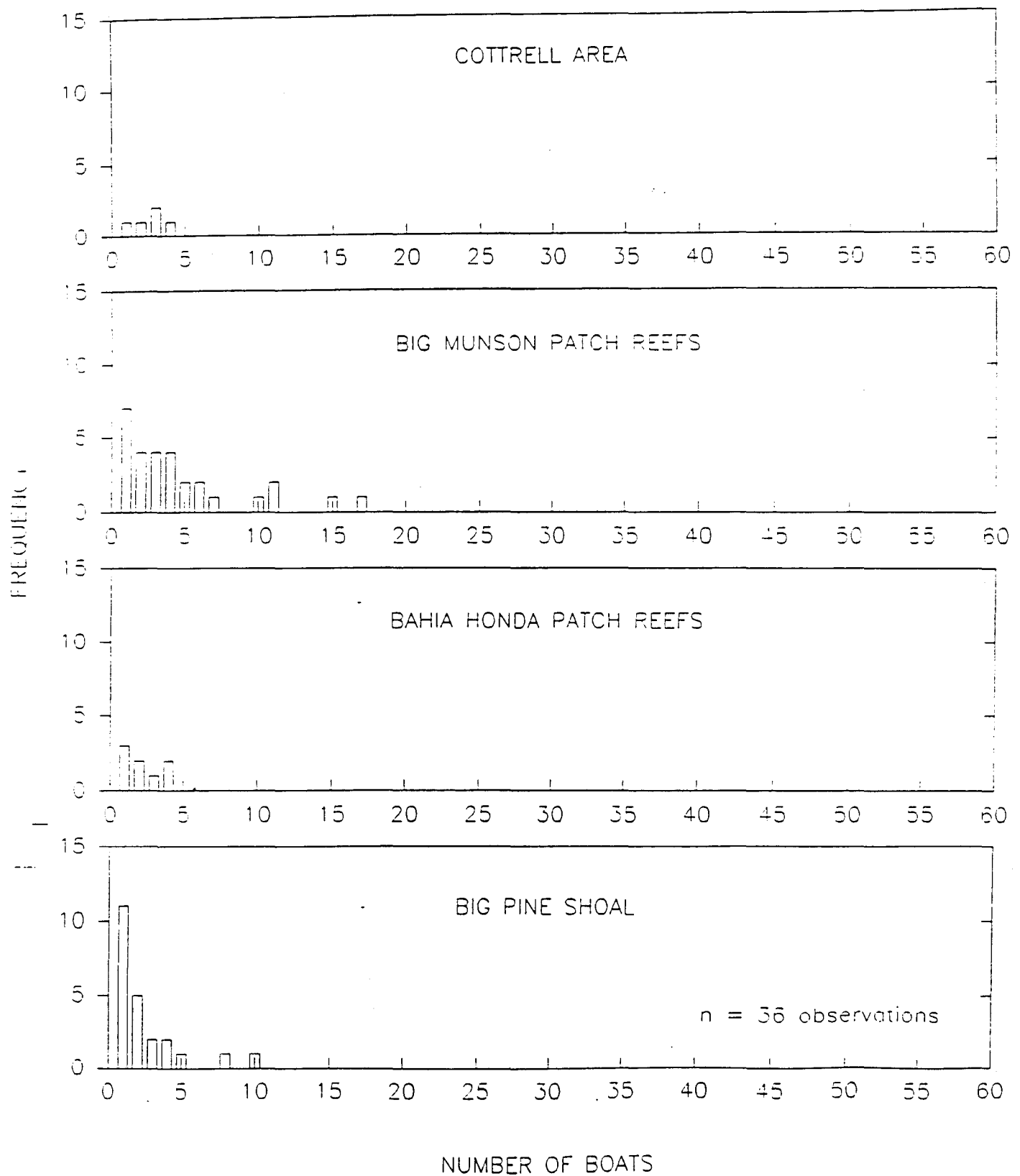


Figure 14. Total boat counts from aerial surveys in several lower keys areas from June 1, 1992 to March 6, 1993.

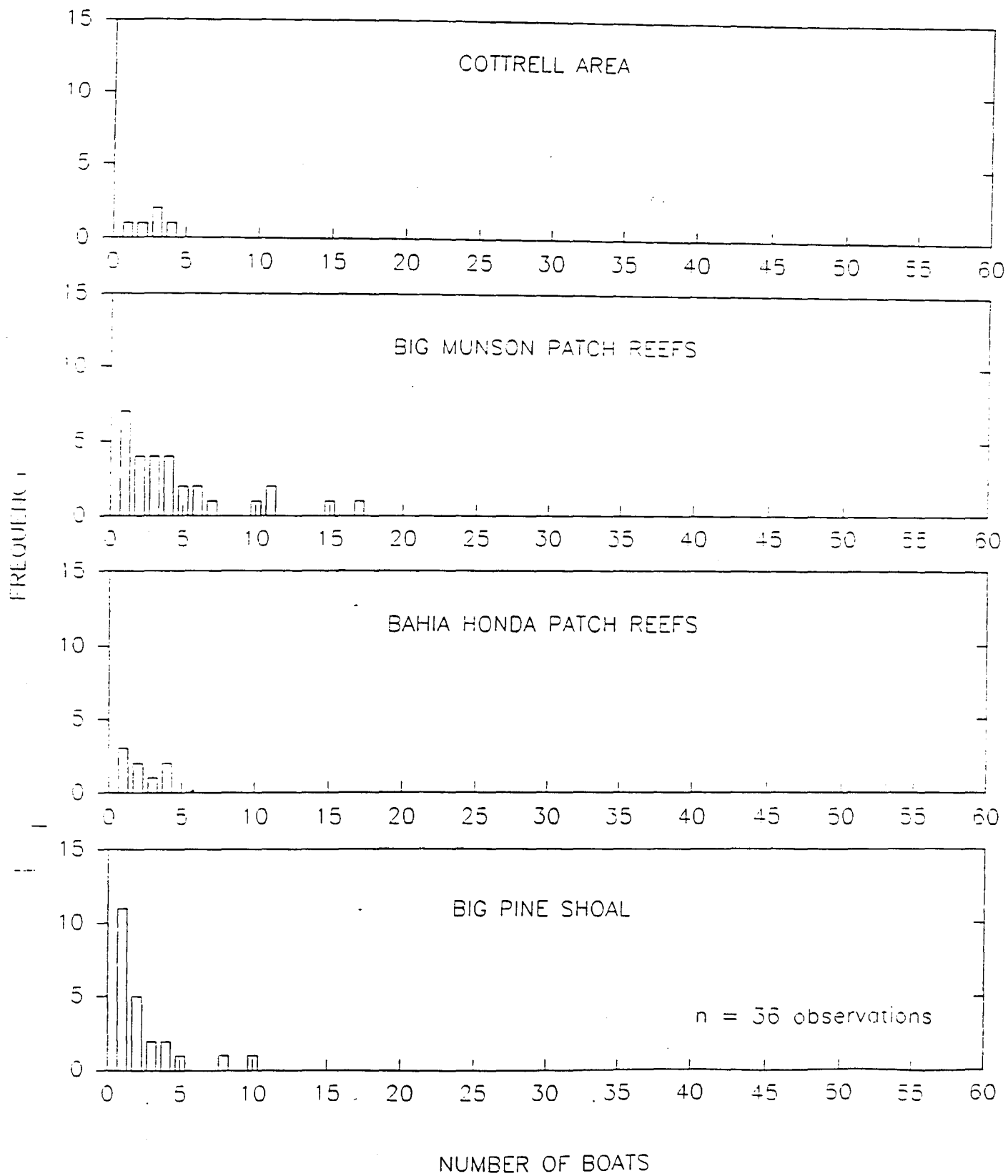


Figure 16. Total boat counts from aerial surveys in the Marathon area from June 1, 1992 to March 6, 1993.

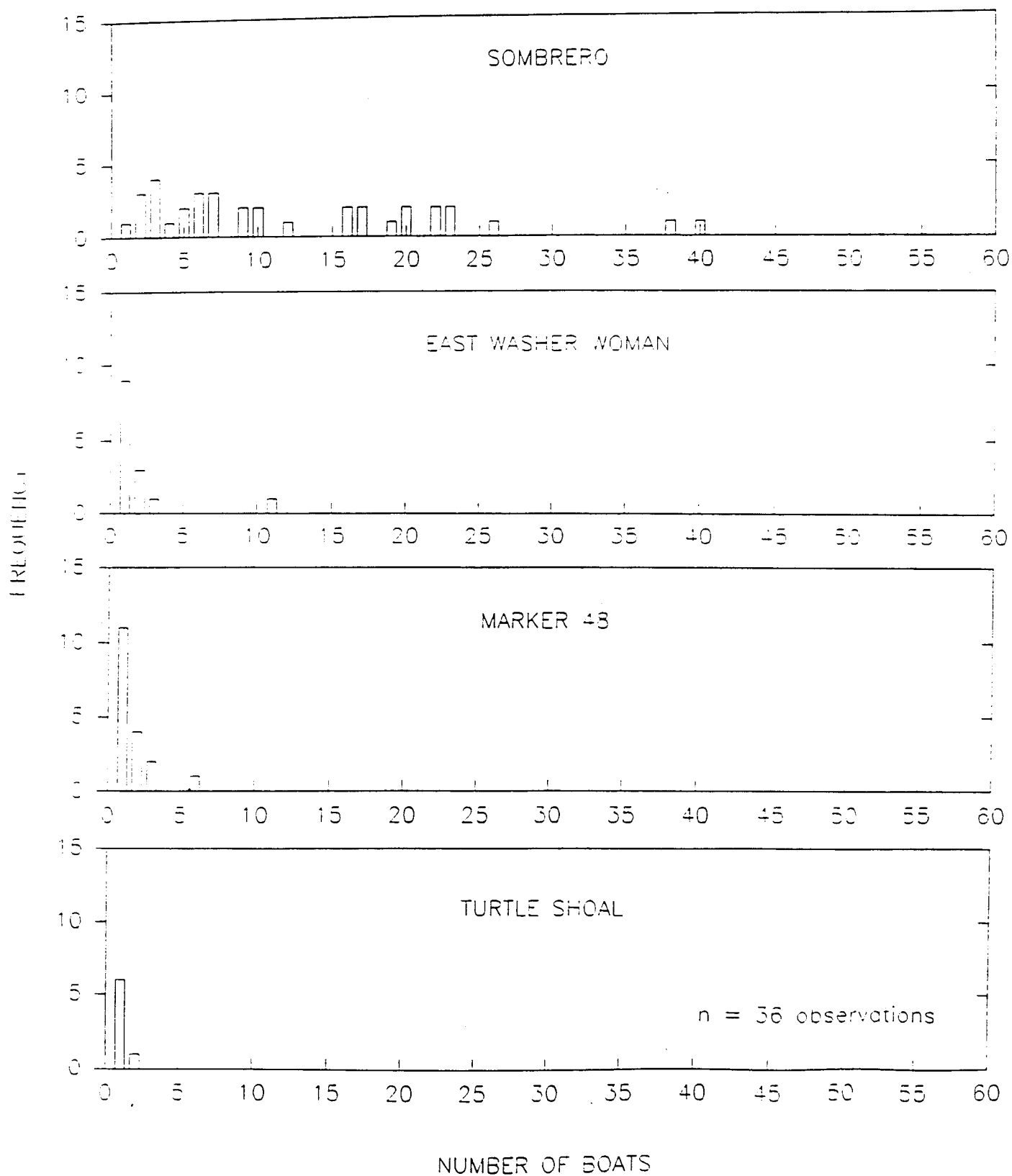


Figure 17. Total boat counts from aerial surveys in the Grassy Key area from June 1, 1992 to March 6, 1993.

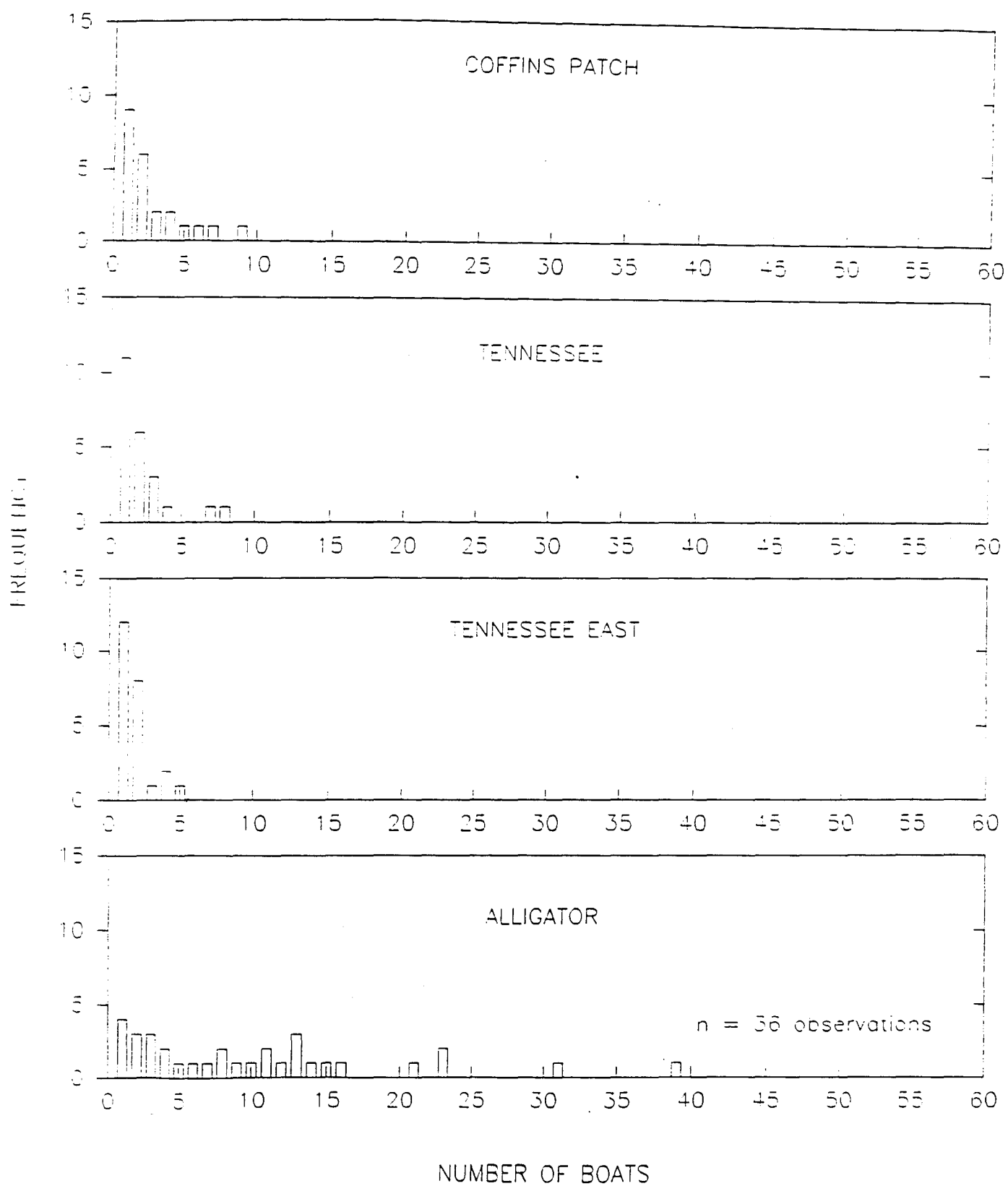


Figure 18. Total boat counts from aerial surveys in the Islamorada area from June 1, 1992 to March 6, 1993.

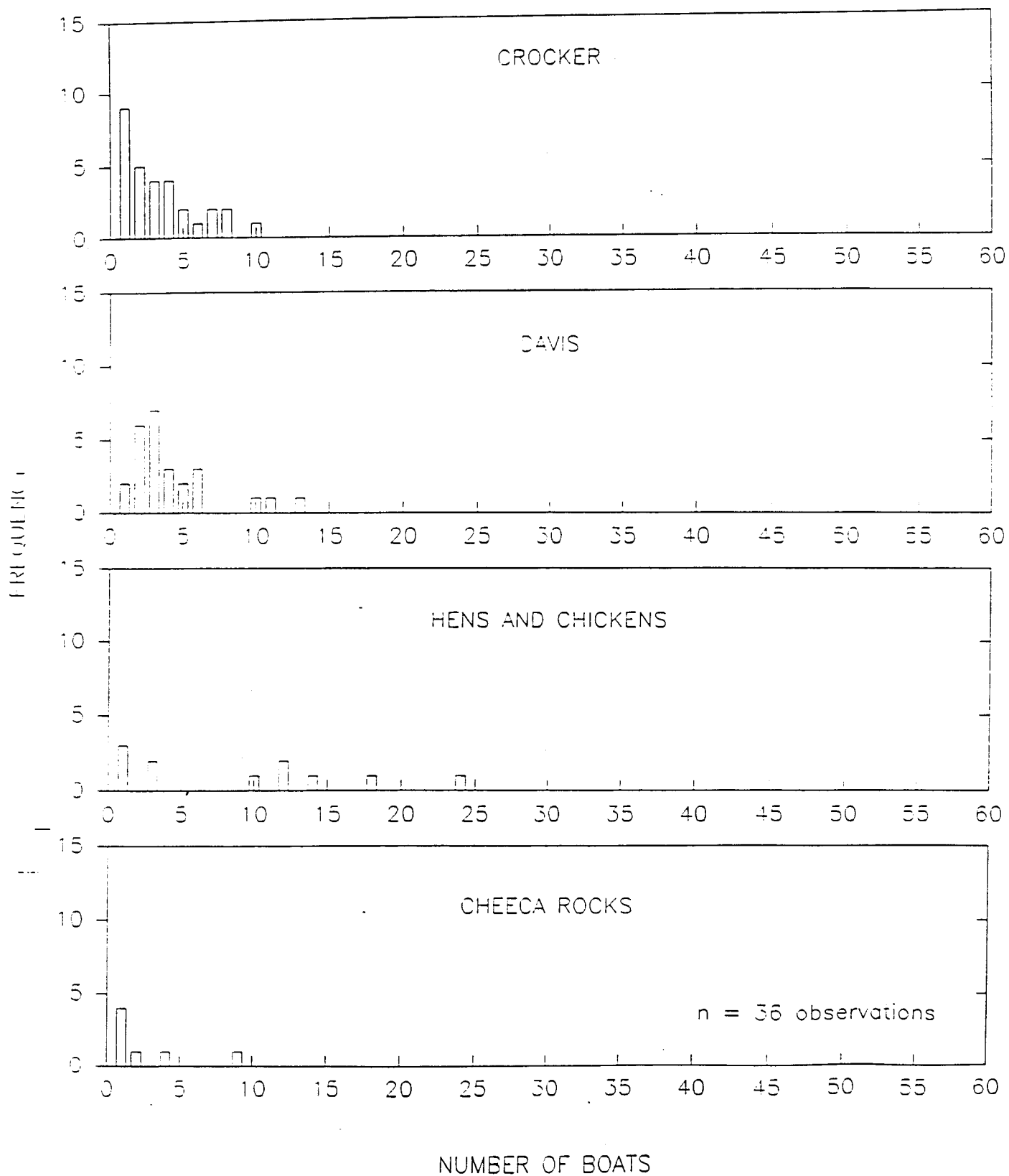


Figure 19. Total boat counts from aerial surveys in the Tavernier area from June 1, 1992 to March 6, 1993.

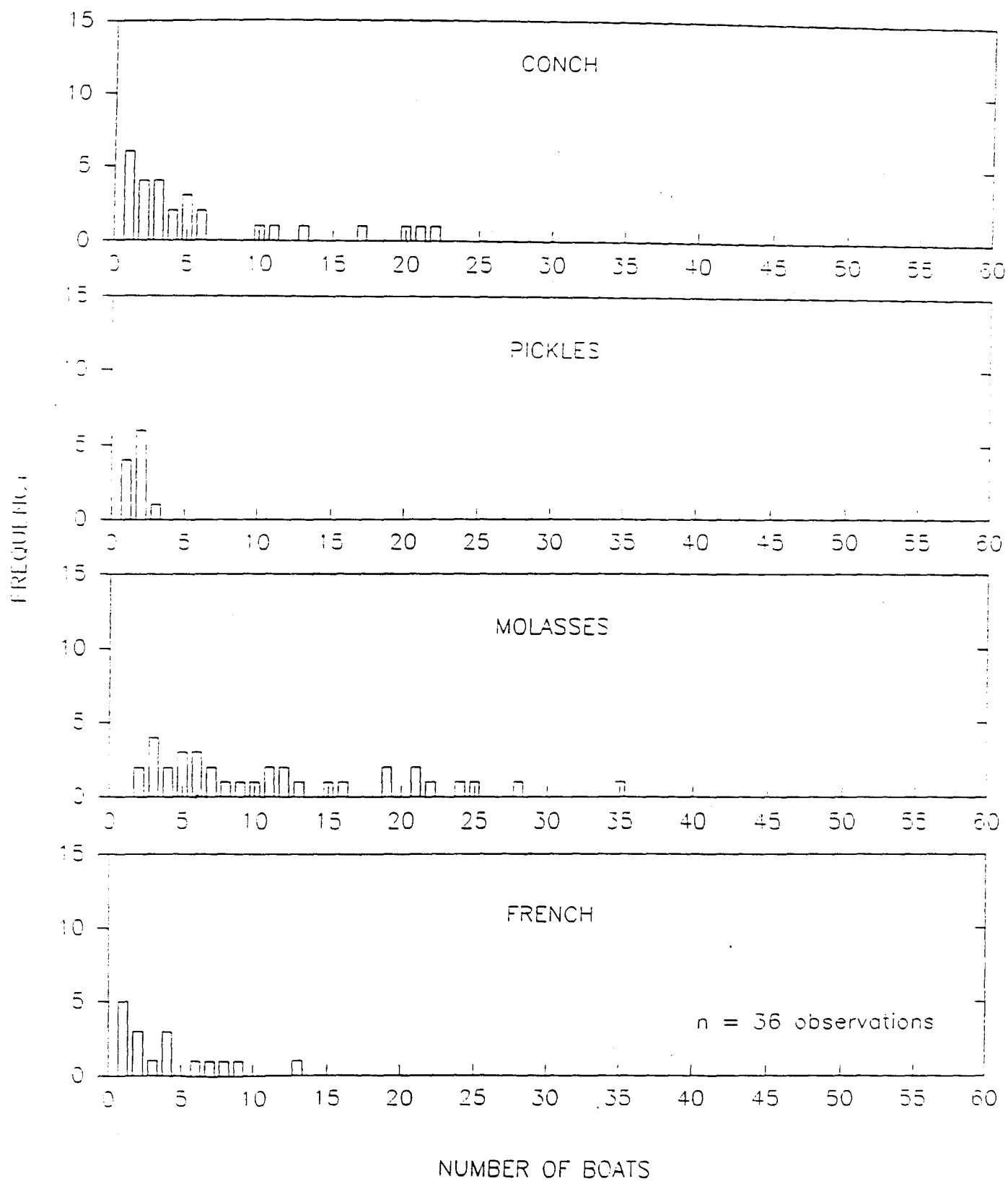


Figure 20. Total boat counts from aerial surveys in the Key Largo area from June 1, 1992 to March 5, 1993.

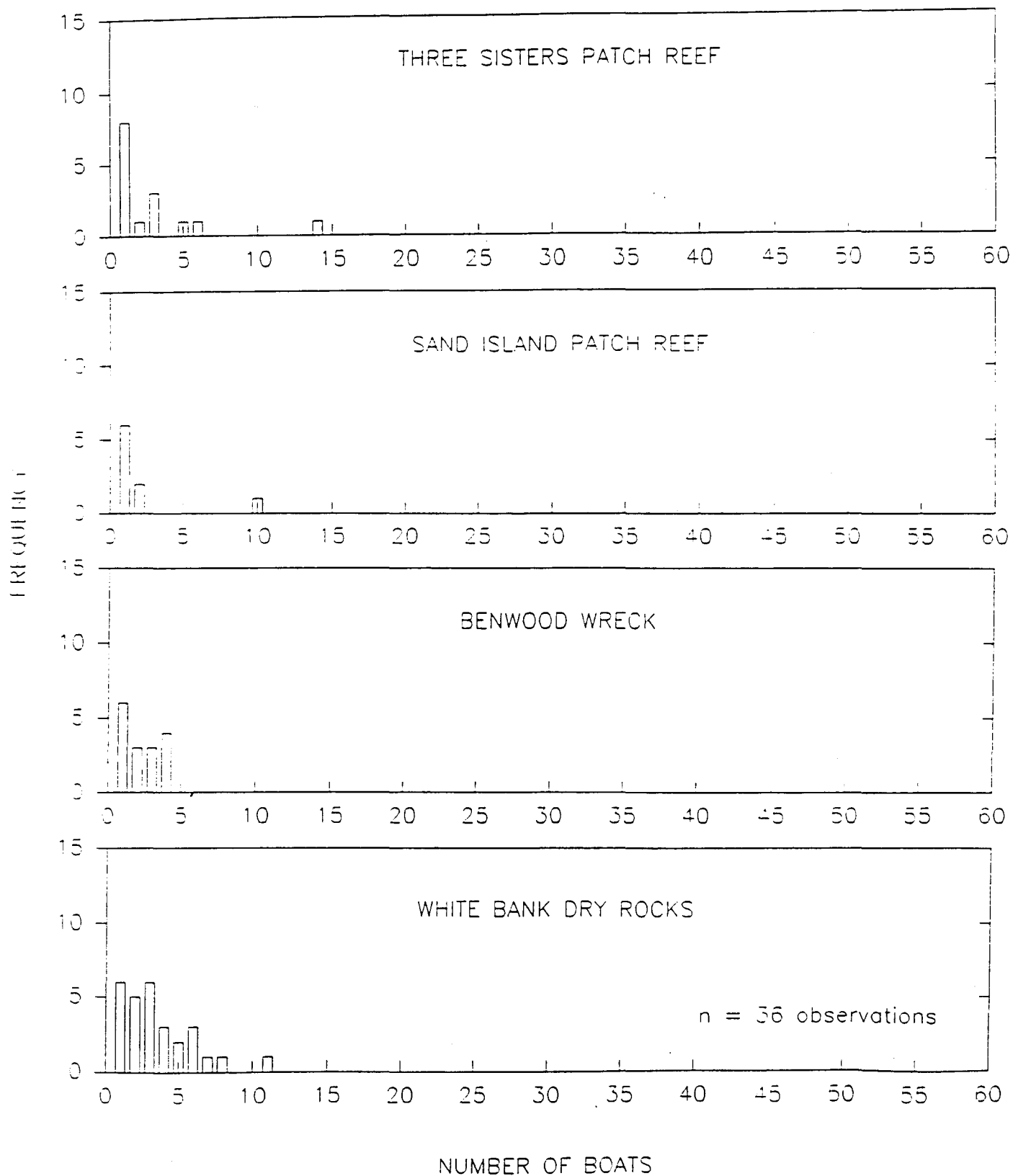


Figure 21. Total boat counts from aerial surveys in the Key Largo area from June 1, 1992 to March 6, 1993.

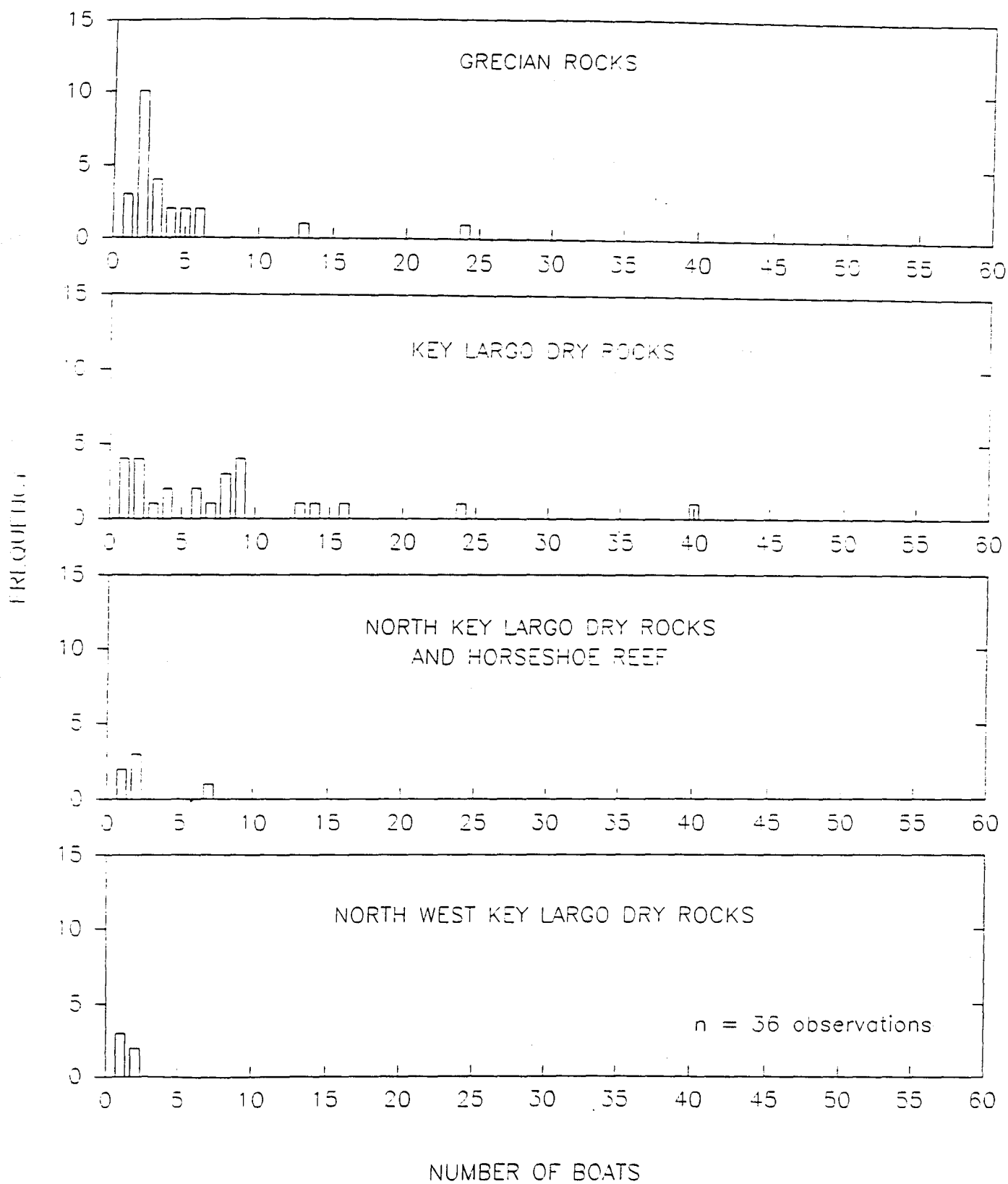


Figure 22. Total boat counts from aerial surveys in the North Key Largo area from June 1, 1992 to March 6, 1993.

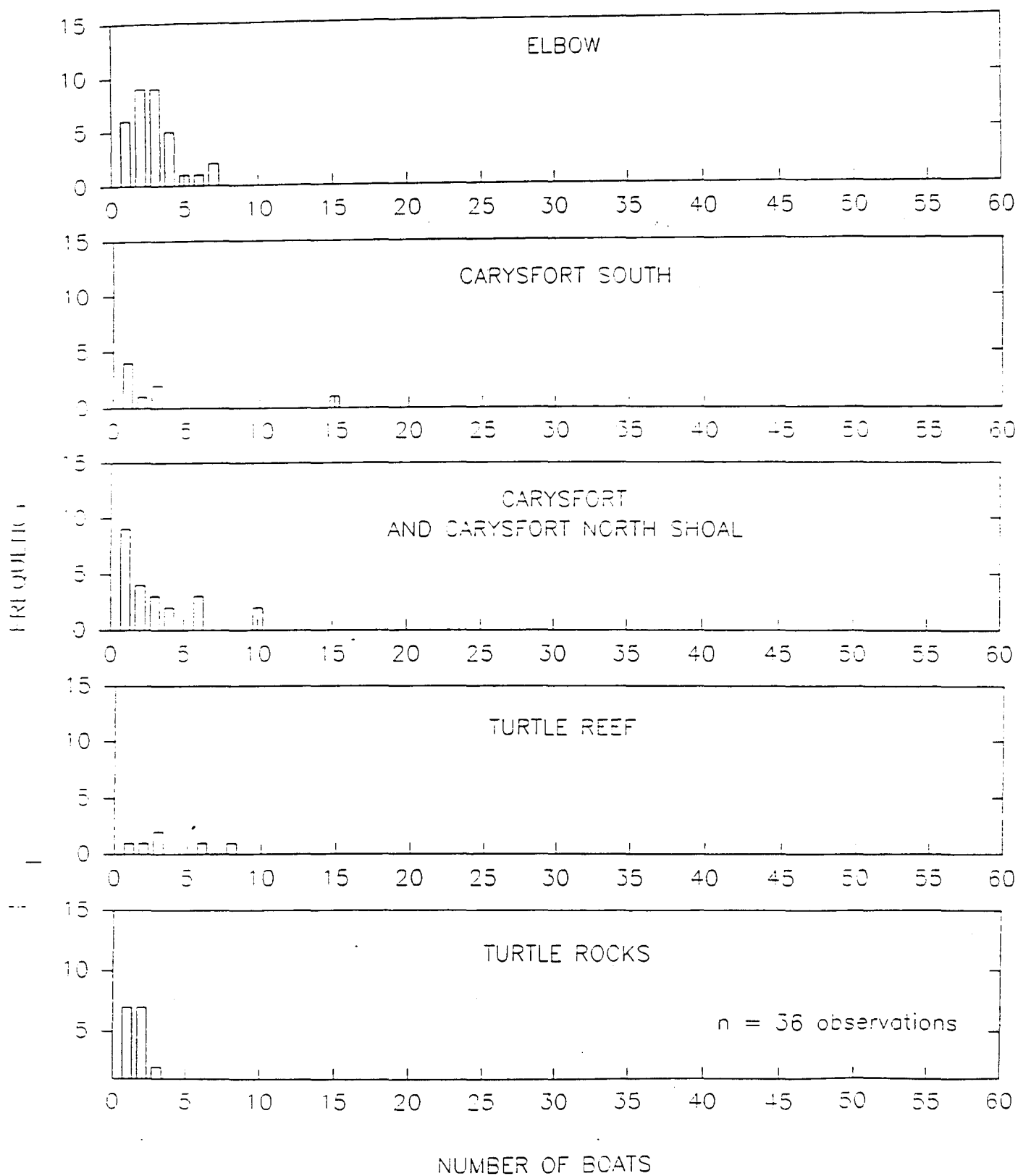


Figure 23. Total boat counts from aerial surveys in the Key Biscayne area from June 1, 1992 to March 5, 1993.

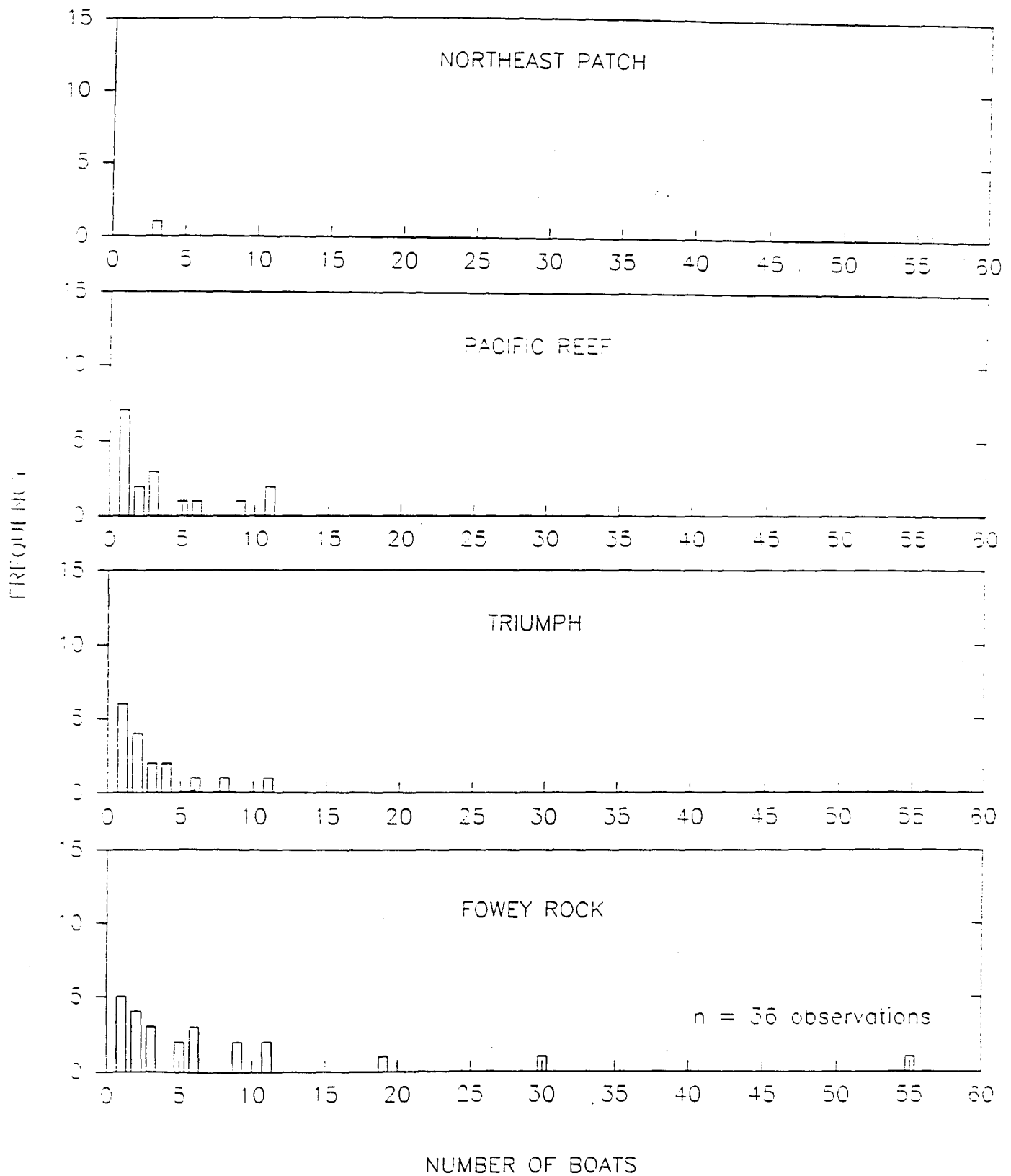
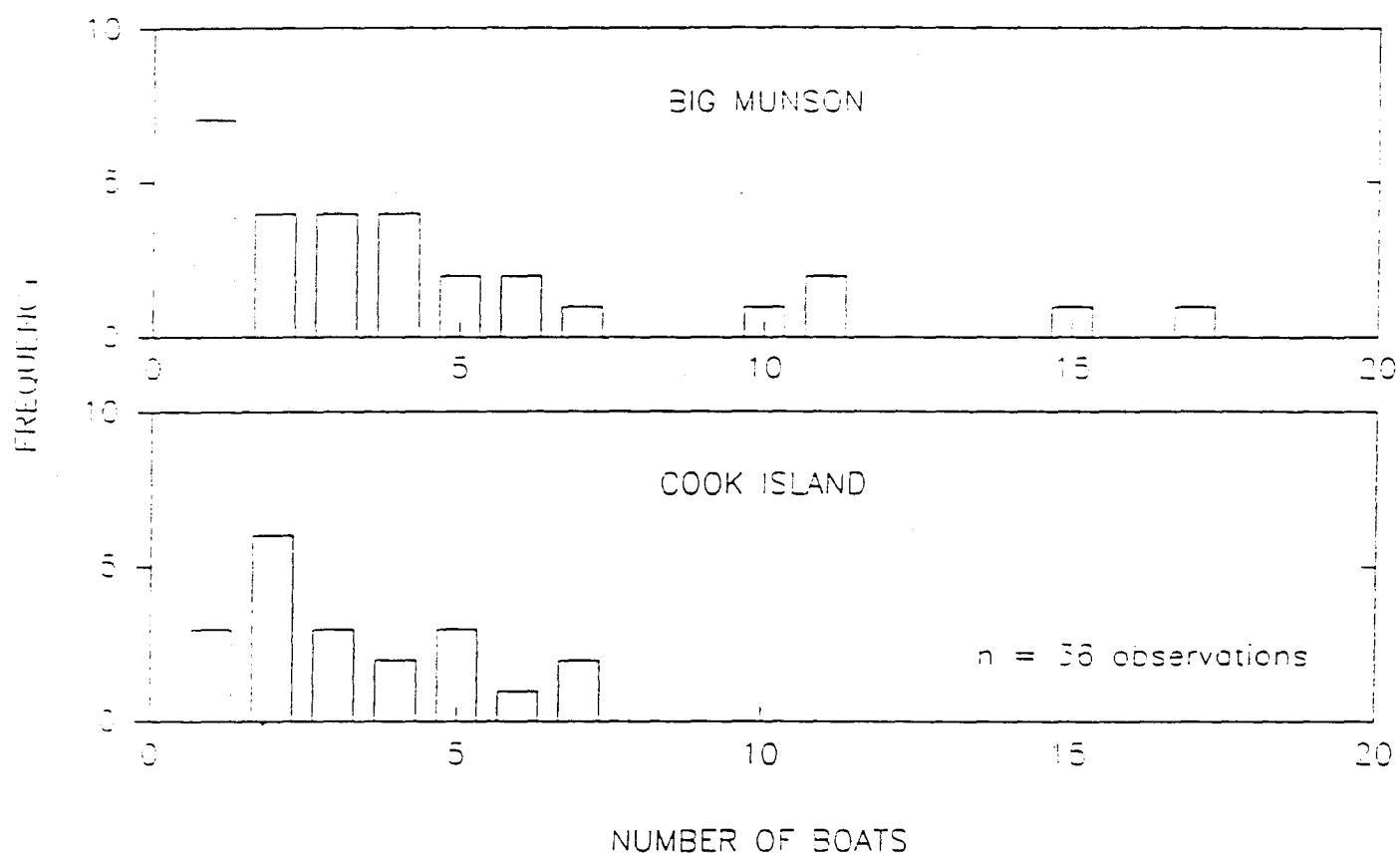


Figure 24. Total boat count comparison between Big Munson and Cook Island patch reefs. Data was collected by aerial surveys between June 1, 1992 and March 6, 1993.



**APPENDIX 1. Organizations responsible for deploying and maintenance of mooring buoys in the Florida Keys National Marine Sanctuary.**

Reef Relief  
P.O. Box 430  
Key West, Fl 33041

Looe Key National Marine Sanctuary  
Bahia Honda State Park  
Rt. 1, Box 782  
Big Pine Key, Fl 33043

Florida Keys Marine Sanctuary, Inc.  
111 Saguaro Lane  
Marathon, Fl 33050

Coral Reef Foundation  
P.O. Box 3088  
Key Largo, Fl 33037

John Pennekamp Coral Reef State Park  
P.O. Box 487  
Key Largo, Fl 33037

Key Largo National Marine Sanctuary  
P.O. Box 1083  
Key Largo, Fl 33037