A CHARACTERIZATION OF BOAT TRAFFIC IN TERRA CEIA BAY, FLORIDA

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION CONTRACT FINAL REPORT

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Executive Summary:  A Characterization of Boat Traffic in Terra Ceia Bay, Florida

Principal Investigator:  Jay F. Gorzelany

While boater compliance studies serve as an important management tool for evaluating the effectiveness of existing speed zones, most studies have done systematic data collection prior to sign placement. As a result, most studies are unable to compare vessel speeds both before and after speed zones were established and to evaluate of success or failure of sign posting. The goals of this study are to provide a baseline characterization of recreational boating activity in Terra Ceia Bay (Manatee County), Florida, prior to the establishment of new boat speed regulations that are scheduled for the area. This will provide valuable information prior to the establishment of speed restrictions and sign placement in Terra Ceia Bay, and can be used as a reference for comparison with future studies.

Field studies of Terra Ceia Bay were separated into three project tasks: land-based boat traffic surveys; boat-based speed gun surveys; and aerial surveys to assess boat distribution and numbers. The land survey site was located along the southern portion of Terra Ceia Bay in an area designated as a future slow speed zone. The boat survey site was located along the western portion of Terra Ceia Bay in an area designated as a future 25 mph zone. Both land-based and boat-based surveys were conducted over six days between February and May 2003. An equal number of weekday and weekend surveys were performed. Aerial surveys included all navigable waters within Terra Ceia Bay. The aerial survey task is ongoing and this report serves as a progress report on fieldwork completed to date. To date, four aerial surveys were conducted between December 2002 and February 2003, and four aerial surveys were conducted between March and May 2003. An equal number of weekend and weekday surveys was conducted.
A total of 2,219 vessels was surveyed among the three project tasks. Vessels in Terra Ceia Bay were predominantly small powerboats that utilize the area as both a boating destination and travel corridor to other locations. Some seasonal trends were observed in boating activity, though field surveys to date have been limited to winter and spring. Results to date indicate that boating activity in Terra Ceia Bay is relatively low during cold months, and increases considerably in warmer months. Ongoing aerial surveys for one full year will better characterize seasonal changes in boat use in Terra Ceia Bay. Land surveys also indicate that Terra Ceia Bay experiences a two- to threefold increase in boat traffic on weekends. Mean vessel speed in the survey area designated as a future 25 mph zone was 23.77 mph. Less than 10% of all surveyed boat traffic in this area was targeted at excessive speed (35 mph or greater). This suggests that the future 25 mph zone along the western portion of Terra Ceia Bay should not have a significant impact on the majority of boaters in this area. In contrast, more than 80% of vessel traffic along the southern portion of Terra Ceia Bay was traveling at planing speed through an area designated as a future slow speed zone. Changes in speed regulation are expected to have a significant impact on boater behavior at this site.

After sign placement, this study will be repeated in order to evaluate any changes in boat traffic patterns, including speeds, which may have occurred.
Title of Project: A Characterization of Boat Traffic in Terra Ceia Bay, Florida

Principal Investigators: Jay F. Gorzelany

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Goals of the Project:

To survey and characterize current boat traffic patterns in Terra Ceia Bay, Florida prior to the establishment of new manatee speed zones that are planned during 2003.

Introduction:

A better understanding of recreational boating activity and boater behavior is critical to the long-term survival of the Florida manatee. A great deal of effort at the federal, state, and local level has been placed on reducing collisions with manatees by regulating boating through the use of speed restricted zones and exclusion areas. In spite of recent protection efforts, boat strikes remain the most significant problem faced by manatees in Florida (U.S. Fish and Wildlife Service, 2001), and still account for 25% to more than 30% of the annual manatee mortality.

The extent to which speed zones change boater behavior, either by reducing overall speeds of watercraft or by altering travel patterns, remains unclear. A limited number of quantitative boat traffic and compliance studies have been performed, and most have been associated with assessments of boater compliance in conjunction with previously established speed zones (Ward, 1988, Morris, 1994, Gorzelany, 1996, 1998, 1999, 2000, Tyson and Combs, 1999, Shapiro, 2001). While these studies serve as an important management tool for evaluating the effectiveness of existing speed zones, no systematic data collection was conducted prior to sign placement. As a result, these studies were unable to compare vessel speeds both before and
after speed zones were established, and the evaluation of success or failure of sign posting without pre-rule data is limited. A 20 percent level of non-compliance, for instance, may or may not be an adequate indication of the effectiveness of a new speed zone, because there is no information on how fast boats were traveling prior to sign placement. The goals of this study are to provide a baseline characterization of recreational boating activity in Terra Ceia Bay (Manatee County), Florida, prior to the establishment of new boat speed regulations that are scheduled for the area. This will provide valuable information prior to the establishment of speed restrictions and sign placement in Terra Ceia Bay, and can be used as a reference for comparison with future studies. After sign placement, this study will be repeated in order to evaluate any changes in boat traffic patterns, including speeds, which may have occurred.

Methods:

Surveys of Terra Ceia Bay were divided into three separate tasks; Land-based surveys of boat traffic, boat based speed gun surveys, and aerial surveys of boat distribution and abundance. Methodology for each task is described individually as follows:

**Land-Based Surveys of Boat Traffic (Future Slow Speed Zone)**

A land-based survey site was established along the southern portion of Terra Ceia Bay on Snead Island in an area designated as a future slow speed zone (Figure 1). Teams of trained observers recorded each vessel transitioning within an established viewing area. For each boat observation, the time of day, vessel type, size, origin, destination, and qualitative speed were recorded on standard field data sheets.
Field data were recorded using standard boat survey methods established for previous compliance studies conducted in southwest Florida (Gorzelany, 1996, 1998, 1999). Vessel size categories, taken from standard Florida Marine Patrol size classes, were designated as:

- Less than 12 feet
- 12 to 15 feet
- 16 to 25 feet
- 26 to 39 feet
- 40 to 64 feet
- 65 to 109 feet
- Greater than 109 feet

Vessel type classes were designated as follows:

- Open Fisherman
- Ski / Sport / Runabout
- Deck Boat
- Yacht / Cruiser
- Pontoon Boat
- Personal Watercraft
- Scarab / Cigarette
- Jonboat
- Sail Boat
- Other

Origin and destination were also recorded for each vessel. Possible directions of travel for vessels at this site were:

- To / From the South (Snead Cut / Manatee River)
- To / From the North (Terra Ceia Bay)
- To / From the West (residential canals along the west shore)
- To / From the East (residential canals and Tropic Isles trailer park along the east shore)
- To / From Cut’s Edge Marina (small marina to the south)
- To / From within the survey area (boats which originate or terminate within the survey area)

Vessel speed definitions were taken from Gorzelany (1999, 2000) and were originally adapted from the Florida Administrative Code 62N-22. Individual speed categories are described as follows:
**Idle Speed:** The minimum speed that maintains steerage of a vessel, or the speed at which a vessel is normally docked. Little or no displacement of water is observable from either the bow or stern, and the vessel remains level in the water at all times. This speed has also been defined as approximately 1 to 3 miles per hour (Gorzelany, 1996).

**Slow Speed:** The speed at which all vessels are completely off plane and fully settled in the water. Some minimal water displacement at either the bow or stern (or both) may be observed. This speed has also been defined as approximately 5 to 7 miles per hour (Gorzelany, 1996).

**Plowing Speed:** An intermediate speed between planing speed and slow speed. The bow of the vessel typically rides higher than the stern, and substantial displacement of water occurs. Depending on the size and type of vessel, plowing may occur at a variety of speeds, but is most often observed between 10-20 miles per hour (Gorzelany, 2000). This speed designation is used specifically for vessels with planing-type hulls.

**Cruising Speed:** A qualitative speed designation uniquely applied to a relatively fast-moving vessel with a non-planing-type hull (e.g.; a pontoon boat or displacement hull vessel). It is identified by noticeable water displacement from the bow and/or stern and an observed speed faster than the previously defined Slow Speed designation. Similar to those at Plowing Speed, vessels at Cruising Speed most often travel at speeds between 10-20 miles per hour (Gorzelany, 2000).

**Planing Speed:** A vessel with a planing-type hull traveling at sufficient speed to partially raise the hull out of the water during travel. Vessel planing speeds vary widely depending upon vessel size and hull design; however the majority of planing vessels travel at speeds in excess of 15 miles per hour (Gorzelany, 1996).
Along with vessel data, environmental conditions including weather, wind speed and
direction, and wave height were recorded. Boating conditions were also qualitatively evaluated
as Poor, Fair, Good, or Excellent. Additional comments related to vessel identification, type, or
specific activity was also recorded when possible. Incidental manatee and sea turtle sightings
were also noted.

A total of six field days, comprised of three weekday and three weekend day surveys,
was completed between February and April, 2003. Each survey day consisted of two 3-hour
surveys, with a morning survey conducted from 0900 hrs to 1200 hrs, and an afternoon survey
from 1300 hrs to 1600 hrs. For analytical purposes, vessel counts were separated into a series of
one-hour intervals (0900-0959hrs, 1000-1059hrs, 1100-1159hrs, 1300-1359hrs, 1400-1459hrs,
and 1500-1559hrs).

Boat-Based Speed Gun Surveys (Future 25 mph Zone)

Boat-based speed gun surveys were performed along the western portion of Terra Ceia
Bay between Snead Island and Rattlesnake Key in an area designated as a future 25 mph zone
(Figure 1). Surveys were conducted from an unmarked 20 ft Wellcraft® open fisherman boat
anchored along the marked channel near the entrance to Terra Ceia Bay. Data collection
followed essentially the same methodology as for land-based surveys with the exception that one
additional parameter (numerical speed) was also recorded for each targeted vessel. A Prolaser I
lidar speed gun was used for speed data collection.

Origin and destination designations for the speed gun survey site were as follows:

- To / From the West (Anna Maria Sound / Tampa Bay)
- To / From the East (into Terra Ceia Bay)
- To / From the North (toward Rattlesnake Key)
- To / From the South (toward Snead Island)
Vessels traveling East-to-West or West-to-East typically remained within the marked channel; however many boats transitioned well outside the marked channel as they traveled into and out of Terra Ceia Bay. Due to the limitations in the range of the lidar gun, along with the inherent error due to cosine effect (Gorzelany, 1999) only vessels for which a reliable numerical speed could be acquired were recorded. As a result, not all vessels in-use were recorded during speed gun surveys, and this dataset was, therefore, not used to determine boat traffic patterns and trends. By comparison, all vessels in use were recorded from the land survey site and boat traffic patterns and trends were evaluated.

A total of six field days were completed between February and May, 2003. Sampling frequency and survey intervals were the same as those for land surveys.

Aerial Surveys of Boat Distribution and Abundance

Comprehensive aerial surveys of all navigable waters in Terra Ceia Bay were performed utilizing a Cessna 172 aircraft at an altitude of 500 feet. Field data collection was performed using the single observer / videographer method used for previous studies conducted in Lee and Charlotte Counties (Gorzelany, 1998; 2000). This method utilizes a single observer/ videographer in the right front seat of the aircraft. An image-stabilizing Hi8mm Sony Digital 8 camcorder with date and time stamp was used to record all vessels in-use throughout Terra Ceia Bay while flying a standard flight path. The observer also provided voice-over audio recording of both geographic information and vessel information through a microphone attached to an aircraft headset. Once completed, survey footage was transferred to a high grade VHS videotape at the laboratory and analyzed by a data recorder. For each vessel observed, the vessel type, size, activity, and direction of travel (if any) was recorded on a standard field data sheet. Because aerial video surveys provide
a lower level of precision than land or boat based surveys in vessel type identification, vessel type
categories were reduced to:

- Small powerboat
- Large powerboat
- Sailboat
- Personal Watercraft
- Other

Vessel size categories remained the same as those used for land and speed gun surveys. Only vessels "in-use" were surveyed. This included vessels that were anchored, adrift, or underway. Moored and/or docked vessels were not recorded.

Along with vessel data, environmental conditions including weather, wind speed and wind
direction were recorded. Boating conditions were also qualitatively evaluated. Data were
ultimately transferred to ArcView GIS 3.1 format and plotted onto a series of digital orthophotos.
Each plotted point was also linked to a Microsoft Excel spreadsheet file, which contained individual 
vessel data.

The aerial survey portion of this project is an ongoing study, and field data collection is
anticipated through fall 2003. Quarterly surveys are planned (December-February 2002-03, 
(one morning and one afternoon) and two weekend surveys (one morning and one afternoon) are
planned for each sampling quarter, along with one additional survey to be conducted over a holiday
weekend.
Quality Assurance:

Upon the completion of each survey day, field data were reviewed by the site leader and returned to Mote Marine Laboratory for data entry and analysis. Data were entered into a Microsoft Excel 2000® spreadsheet using an IBM compatible Pentium® computer. Following data entry, a minimum of 10% of all field data was rechecked for accuracy against the original survey sheets by a quality assurance data manager. All original field data sheets were retained in three ring binders and are available for examination upon request. Data were compiled and displayed graphically with ArcView GIS 3.1, Microsoft Excel 2000®, and Adobe Photoshop 7.0®. Descriptive statistics were performed using Microsoft Excel®. The Prolaser lidar speed gun was serviced and recertified by Kustom Signals, Inc. in September, 2002.

Results:

A total of 2,219 vessels was surveyed and evaluated for this project, including 1,150 vessels from land surveys, 839 vessels from speed gun surveys, and 230 vessels from aerial surveys. Results for each individual project task are as follows:

Land Surveys (Future Slow Speed Zone)

A total of 1,150 vessels was surveyed from the Terra Ceia Bay land survey site. Survey dates and daily vessel counts are provided in Table 1. The highest single day vessel count (n = 434 boats) was recorded on Saturday, April 19, and the lowest single day vessel count (n = 70 boats) was recorded on Friday, February 14. The number of vessels observed generally increased during the study. For surveys conducted in February, mean vessel counts ranged from 11.6 vessels observed per hour on weekdays to 24.3 vessels observed per hour on weekends. In
April, vessel counts increased to 19.0 vessels per hour on weekdays and 72.3 vessels per hour on weekends.

The lowest levels of boat traffic occurred during the first time interval (0900-0959 hrs). The highest levels of boat traffic occurred between 1400-1459 hrs, though all afternoon intervals were similar. An overall increase in traffic was observed later in the day, though this trend was more apparent on weekends than weekdays. In general, boat traffic recorded at the land survey site exhibited a two- to threefold increase on weekends versus weekdays. For all survey dates combined, the mean number of vessels observed during weekdays was 16.6 vessels per hour. For weekend surveys, the mean number of vessels increased to 47.3 vessels observed per hour. A comparison of weekday and weekend vessel counts, along with comparisons by time of day is provided in Figure 2.

Vessel composition at the land survey site by type and size category is provided in Figures 3a-b. Vessel type was predominantly open fisherman (62%), followed by yacht/cruisers (12%) and ski runabout (9%). All other vessel types observed at the land site, including pontoon boats, deck boats, sailboats, jonboats, and personal watercraft comprised only 17% of all vessels surveyed. Vessel size was predominantly in the 16ft to 25ft size range. Other vessel size classes comprised only 15% of all vessels observed.

Data on boat travel patterns in this area are shown in Table 2. Direction of travel for the majority of vessels (60%) was along the marked channel between Snead Cut and Terra Ceia Bay. A larger proportion of boat traffic originated from the eastern portion of the study area than the western portion. The vast majority of vessel traffic (97%) was observed to transition through the survey area rather than remain within the survey area (3%).
A summary of qualitative speed observations is provided in Figures 4a-b. The majority of vessel traffic in this area traveled at planing speed (79% of all vessel traffic on weekdays and 84% of all vessel traffic on weekends). For both weekend and weekday surveys combined, only 118 out of 1150 observations (10%) were of vessels traveling at speeds that were consistent with the future speed restriction in this area (idle speed or slow speed).

Survey conditions were generally consistent among survey dates, with boating conditions evaluated as either “Good” or “Excellent” during 96 percent of all surveys. Differences in both air and water temperatures varied among survey dates, with an average increase in both air and water temperature of approximately 8-10 degrees Celsius between February and April 2003 (National Weather Service data).

**Speed Gun Surveys (Future 25 mph Zone)**

A total of 839 vessels were targeted over six survey days at the Terra Ceia Bay speed gun site. Survey dates and vessel counts are provided in Table 1. Highest single-day vessel counts occurred on Sunday, 16 March (221). Lowest single day counts occurred on Tuesday, 6 May (43).

Vessel composition by type and size category at the speed gun site was essentially similar to the land survey site (Figures 5a-b). Vessel traffic was primarily open fisherman type boats (73%), yacht/cruiser type boats (11%), and ski/runabout type boats (6%). Also similar to the land survey site, boats in the 16ft to 25ft size class comprised the vast majority of vessels surveyed (91%), with all other size classes comprising only 9 percent of all boats surveyed.

Of the 839 vessels surveyed, 750 (89%) were traveling at planing speed, 57 (7%) were traveling at either plowing or cruising speed, and 32 (4%) were traveling at either slow or idle
speed. A summary of numerical speed data from this task is provided in Table 3. Mean vessel speed for all surveyed vessels was 23.77 mph. Removal of slow-moving vessels (traveling at either idle or slow speed) from the statistical comparison increased the mean vessel speed to 24.54 mph. Finally, mean vessel speed for vessels identified as planing-only was 25.50 mph. Highest recorded vessel speed was 54 mph. Figure 6 displays the frequency distribution of boat speeds at this site in 1 mph increments. Of the 839 observations conducted at this site, 348 (41%) were made of boats traveling at speeds in excess of 25 mph, and 52 (6%) were made of boats traveling 35 mph or greater.

Boat registration numbers and/or identifiable names were obtained from 506 of the 839 vessels surveyed. These identified boats will be used in the post-rule follow-up study in order to determine whether individual boater behavior has been modified as a result of changes in speed regulation.

Aerial Surveys

A total of eight aerial video surveys was performed between December 2002 and May 2003. Four surveys were performed between December 2002 and February 2003, and four were done between March and May 2003. Aerial survey dates, along with total vessel counts, are provided in Table 1. A total of 230 vessels in-use was surveyed. The number of vessels in Terra Ceia Bay varied noticeably among survey dates, ranging from as few as 7 vessels in-use on Saturday, January 7, 2003 to as many as 97 vessels in-use on Sunday, April 13, 2003.

The composition of surveyed vessels is shown in Figures 7a-b. The majority of surveyed vessels (88%) were identified as small powerboats, and the most common size class observed (85%) was 16ft to 25ft.
Figures 8-15 display the geographic distribution of vessels in-use for each survey date. In general, highest concentrations of vessels were along the western portion of Terra Ceia Bay between Snead Island and Rattlesnake Key. This area appears to be both a common travel corridor for vessels traveling to and from Terra Ceia Bay, and also a fishing destination. Relatively high numbers of vessels were also observed near Bird Key to the north and through Snead Cut to the south. In contrast, a much lower level of boating activity appears to occur along the eastern portion of Terra Ceia Bay. This trend is most apparent in the composite figure displaying vessel sightings from all eight flights combined (Figure 16).

Because the aerial survey portion of this project is ongoing, the results to date are considered preliminary and only indicate general trends. A more detailed analysis, including spatial analysis, will be performed upon completion of the field data collection. Ultimately these data will be compared with surveys conducted after speed zones are established in Terra Ceia Bay, in order to determine whether boat traffic patterns have changed as a result of new regulatory sign placement.

Discussion:

Field data results were fairly consistent among the three project tasks, indicating that Terra Ceia boat traffic in general is composed of relatively small powerboats, some of which utilize portions of Terra Ceia Bay for fishing, while others utilize the bay as a travel corridor to other areas. The direction of travel for the majority of vessels observed at the land survey site (60%) was along the marked channel to/from Snead Cut and Terra Ceia Bay. Whereas the ultimate destination of boats entering Terra Ceia Bay could not be determined, observations from the speed gun survey site and aerial surveys suggest that a significant amount of this traffic
enters Terra Ceia Bay from Snead Cut and turns west along the marked channel. Some of these vessels terminate near the mouth of Terra Ceia Bay to either fish or to capture baitfish for fishing in other areas. Other vessels continue out of Terra Ceia Bay to the west toward Anna Maria Sound, Tampa Bay, or the Gulf of Mexico. Results indicate that the future slow speed zone adjacent to the land site is more of a travel corridor than a boating destination. This is not to suggest that numerous vessels are not moored along the residential canals in this area, but rather that vessels underway do not remain in the area. The future 25 mph zone adjacent to the speed gun site serves as both a travel corridor for vessels traveling to and from Terra Ceia Bay, and also as a boating destination, primarily for fishing.

While this study does not represent a full year of fieldwork, some seasonal trends in boating activity were apparent among all three project tasks. Boating activity in Terra Ceia Bay was relatively low during the colder months (December – February) and increased noticeably as both air and water temperatures increased. Increasing boat traffic in the spring is likely due to improving boating conditions, and a greater variety of user groups on the water. These results are consistent with other boating studies recently conducted along the central Florida west coast (Gorzelany, 1996, 1998, 1999).

While land surveys provided useful information on boat traffic patterns, there are limitations in their interpretation because they were only conducted over a four-month period, with no surveys performed during late spring or summer when the level of activity of watersports-related user groups would likely increase. Vessel composition would likely change as well, as a higher proportion of personal watercraft would probably be observed. It is noteworthy that personal watercraft were not observed at all during land surveys until March 23, and that 84 percent of all personal watercraft observations occurred during the last weekend.
survey on April 19. Due to the nature of the February–May survey period, it is also likely that some of the changes in user groups may result from a change from a higher proportion of short-term seasonal residents in the winter to a higher proportion of long-term year-round residents in the spring (and likely into the summer). Because the aerial survey component of this study is continuing, the collection of additional aerial data may capture some additional information on seasonal boating patterns in Terra Ceia Bay.

One of the more striking observations in this study was the relatively low number of vessels in-use throughout Terra Ceia Bay during the colder months of the year. Only 20 vessels or fewer were identified during five of the eight aerial surveys, including all four surveys conducted between December 2002 and February 2003. Data collected to date indicate that high levels of boating activity in Terra Ceia Bay appear to be limited to weekends during the warmer months of the year. Ongoing surveys through the summer should further illustrate this. These results seem to suggest that low levels of cold weather boat traffic, along with the fact that very few manatees occur in Terra Ceia Bay during the colder months of the year results in a relatively low risk of boat-manatee interaction during this time. As a result, seasonal manatee speed zones in Terra Ceia Bay may have been a suitable alternative to year-round speed zones.

Speed gun data suggest that the future 25 mph zone along the western portion of Terra Ceia Bay will not be a hardship to the majority of boaters in this area. Mean vessel speeds, even among planing-only vessels, were only 25.50 mph in an area that is currently unregulated. In addition, only 6% of boats in this area were targeted at speeds of 35 mph or greater.

In contrast, the future slow speed zone at the southern end of Terra Ceia Bay near Snead Cut will have a significant impact on boater behavior. A total of 947 out of 1150 vessels
surveyed (82%) were observed to be traveling at speeds that would be considered blatantly non-compliant (Gorzelany, 1996) with the future slow speed zone.

In spite of some of the limitations in data collection, adequate surveys have been conducted in order to interpret any change associated with the establishment of new speed zones. I do recommend, however, that post-rule surveys be conducted during the same time of year (February-May) in order to make the two datasets more comparable.

**Conservation Benefits:**

Studies of recreational boat traffic patterns and the evaluation of the boat speed zones in Florida have widespread management and conservation implications. With continued emphasis on speed zones as a management alternative for manatee protection, assessing the effectiveness of speed regulation as an overall management tool is essential. Although it is difficult to measure the direct “success” of speed zones in terms of manatee survivorship, it can be measured in terms of boater behavior and reaction to regulatory changes. A significant reduction in the numbers of speeding vessels through established manatee habitat and travel corridors may lead to a reduction in the relative risk of collision between boats and manatees. In addition, the determination of changes in travel patterns by recreational vessels as a result of newly established speed zones can also serve to as an important management tool. The determination of the effectiveness of regulatory zones in reducing boat speeds, thereby reducing risk of injury to manatees, can be assessed through these types of studies.
Acknowledgements:

Thanks to the many Mote Marine Laboratory Marine Mammal Program volunteers who assisted with the field data collection for this project, particularly Gene Stover, Lew Wehunt, John Nicholson, Jann Warfield, Carol Pelletier, and Robert Duncan. Special thanks to Dr. Raymond Raitz, who generously provided access to his property and his vessel for portions of our field data collection. Thanks also go to Lt. Col. Rolland S. Freeman (ret.) for his assistance with aerial surveys, and to staff technician Kerri Scolardi, who effectively coordinated the aerial survey portion of this study. Thanks finally to Sarah Gorzelany for assistance with the data management and quality assurance aspects of this project.

Literature Cited:


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Figure 3a,b. Vessel distribution by type and size at the Terra Ceia Bay land survey site.

Figure 4a,b. Relative proportion of vessels traveling at different speeds as observed from the land survey site.

Figure 5ab. Vessel distribution by type and size at the Terra Ceia Bay speed gun survey site.

Figure 6. Frequency distribution of vessel speeds at the Terra Ceia Bay speed gun site.

Figure 7a,b. Vessel distribution by type and size; Terra Ceia Bay aerial survey task

Figure 8. Terra Ceia Bay aerial survey; Tuesday, December 17, 2002. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 9. Terra Ceia Bay aerial survey; Saturday, January 16, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 10. Terra Ceia Bay aerial survey: Friday, 14 February 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 11. Terra Ceia Bay aerial survey; Sunday, February 23, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 12. Terra Ceia Bay aerial survey; Wednesday, March 12, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 13. Terra Ceia Bay aerial survey; Sunday, March 22, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 14. Terra Ceia Bay aerial survey; Sunday, April 13, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 15. Terra Ceia Bay aerial survey; Thursday, May 8, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.

Figure 16. Composite image of all eight aerial survey flights combined. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Table 1. Terra Ceia Bay survey dates and vessel counts.

**Land Surveys**

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**Speed Gun Surveys**

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**Aerial Surveys**

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<th>Survey Date</th>
<th>Day</th>
<th>Vessels Surveyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/17/2002</td>
<td>Tuesday</td>
<td>9</td>
</tr>
<tr>
<td>1/18/2003</td>
<td>Saturday</td>
<td>7</td>
</tr>
<tr>
<td>2/14/2003</td>
<td>Friday</td>
<td>18</td>
</tr>
<tr>
<td>2/23/2003</td>
<td>Sunday</td>
<td>20</td>
</tr>
<tr>
<td>3/12/2003</td>
<td>Wednesday</td>
<td>32</td>
</tr>
<tr>
<td>3/22/2003</td>
<td>Sunday</td>
<td>35</td>
</tr>
<tr>
<td>4/13/2003</td>
<td>Sunday</td>
<td>97</td>
</tr>
<tr>
<td>5/8/2003</td>
<td>Thursday</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total Vessels Surveyed</strong></td>
<td></td>
<td><strong>230</strong></td>
</tr>
</tbody>
</table>
Table 2. Summary of origin / destination data from the Terra Ceia Bay land survey site.

<table>
<thead>
<tr>
<th></th>
<th>Vessels with destination within the survey area</th>
<th>Vessels with destination outside the survey area</th>
</tr>
</thead>
<tbody>
<tr>
<td>From East to all other destinations</td>
<td>147 (13%)</td>
<td>1115 (97%)</td>
</tr>
<tr>
<td>From West to all other destinations</td>
<td>48 (4%)</td>
<td>424 (37%)</td>
</tr>
<tr>
<td>From Cuts Edge Marina to all other destinations</td>
<td>45 (4%)</td>
<td>459 (40%)</td>
</tr>
<tr>
<td>From Snead Cut to all other destinations</td>
<td>459 (40%)</td>
<td>48 (4%)</td>
</tr>
<tr>
<td>From Terra Ceia Bay to all other destinations</td>
<td>424 (37%)</td>
<td>45 (4%)</td>
</tr>
<tr>
<td>From within the survey area to all other destinations</td>
<td>27 (2%)</td>
<td>1150</td>
</tr>
<tr>
<td>Total Vessels Observed</td>
<td>1150</td>
<td>1150</td>
</tr>
</tbody>
</table>

Vessels with destination within the survey area 35 (3%)

Vessels with destination outside the survey area 1115 (97%)

Total Vessels Observed 1150
Table 3. Summary of statistical data from the Terra Ceia Bay speed gun site.

<table>
<thead>
<tr>
<th>Subset</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Mode</th>
<th>Range Of Speeds</th>
<th># Vessels (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Vessels</td>
<td>23.77</td>
<td>7.80</td>
<td>24</td>
<td>24</td>
<td>2 - 54</td>
<td>839</td>
</tr>
<tr>
<td>Plowing, Cruising, and Planing Vessels Only</td>
<td>24.54</td>
<td>6.96</td>
<td>24</td>
<td>24</td>
<td>5 - 54</td>
<td>807</td>
</tr>
<tr>
<td>Planing Vessels Only</td>
<td>25.50</td>
<td>6.12</td>
<td>25</td>
<td>24</td>
<td>10 - 54</td>
<td>750</td>
</tr>
</tbody>
</table>
Figure 1. Location of boat- and land-based survey sites in Terra Ceia Bay. The blue dot corresponds to the location of the land survey site and the red dot corresponds to the location of the speed gun survey site.
Figure 2. Vessel traffic by time interval (land survey site). All survey dates are combined.
Figure 3a,b. Vessel distribution by type and size at the Terra Ceia Bay land survey site.
Figure 4a,b. Relative proportion of vessels traveling at different speeds as observed as observed from the land survey site.
Figure 5ab. Vessel distribution by type and size at the Terra Ceia Bay speed gun survey site.

Distribution By Vessel Type
Speed Gun Survey Site

Distribution By Vessel Size
Speed Gun Survey Site
Figure 6. Frequency distribution of vessel speeds at the Terra Ceia Bay speed gun site.
Figure 7a,b. Vessel distribution by type and size; Terra Ceia Bay aerial survey task

Distribution By Vessel Type
Aerial Survey Task

Distribution By Vessel Size
Aerial Survey Task
Figure 8. Terra Ceia Bay aerial survey; Tuesday, December 17, 2002. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 9. Terra Ceia Bay aerial survey; Saturday, January 16, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 10. Terra Ceia Bay aerial survey: Friday, 14 February 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 11. Terra Ceia Bay aerial survey; Sunday, February 23, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 12. Terra Ceia Bay aerial survey; Wednesday, March 12, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 13. Terra Ceia Bay aerial survey; Sunday, March 22, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 14. Terra Ceia Bay aerial survey; Sunday, April 13, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 15. Terra Ceia Bay aerial survey; Thursday, May 8, 2003. Vessels in-use are displayed in yellow. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.
Figure 16. Composite image of all eight aerial survey flights combined. Arrows indicate direction of travel, while points indicate vessels either anchored or adrift.