Padilla Bay
National Estuarine Research Reserve

Technical Report No. 15

GUEMES CHANNEL AND PADILLA BAY:

SURFACE CURRENTS DURING FLOOD TIDE

Douglas A. Bulthuis

Anne M. Conrad

October 1995

Publication No. SHWR-96-91

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Padilla Bay National Estuarine Research Reserve
10441 Bayview-Edison Road
Mount Vernon WA 98273-9668
(360)428-1558

Padilla Bay National Estuarine Research Reserve is managed by the Shorelands and Environmental Assistance Program, Washington State Department of Ecology, in cooperation with the Estuarine Reserves Division, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The preparation of this document was financially aided through a grant to the Washington State Department of Ecology with funds obtained from NOAA/Office of Ocean and Coastal Resource Management, and appropriated for Section 306 or 315 of the Coastal Zone Management Act of 1972, as amended.

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Bibliographic citation: Bulthuis, D. A. and A. M. Conrad. 1995. Guemes Channel and Padilla Bay: surface currents during flood tide. Washington State Department of Ecology, Padilla Bay National Estuarine Research Reserve Technical Report No. 15, Mount Vernon, Washington. 133pp.

This is a report of the Washington State Department of Ecology. Partial financial support for this publication was provided by grants under the federal Coastal Zone Management Act, Sections 306 and 315, administered by the office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration.

Padilla Bay National Estuarine Research Reserve
Shorelands and Water Resources Program
Washington State Department of Ecology

1043 Bayview-Edison Road
Mt. Vernon, WA 98273

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ABSTRACT

Bulthuis, D. A. and A. M. Conrad. 1995. Guemes Channel and Padilla Bay: surface currents during flood tide. Washington State Department of Ecology, Padilla Bay National Estuarine Research Reserve Technical Report No. 15, Mount Vernon, Washington. 133pp.

Guemes Channel is one of the three (sources) of tidal water to Padilla Bay. More than 80% of the volume of water in Padilla Bay at high tide flows into the bay during a single spring tide cycle. In this study, the movement of surface currents from Guemes Channel into Padilla Bay during spring tides was investigated with surface drogues. Fifteen to thirty drift sticks were placed between Southeast Point and March Point, Hat Island and March Point and south of Hat Island on four dates near the time of predicted Lower Low Water. The location and time of each drift stick was determined about every 30 minutes until predicted Higher High Water. Surface currents between Southeast Point and March Point move east during flood tide and then divide and flow in three directions. Most of the water flows either north between Saddlebag and Guemes Islands or south down the Swinomish Channel. A small portion of water continues to move east into Padilla Bay. The surface water directly south of Hat Island is the major source of water that flows into the southern half of Padilla Bay.

INTRODUCTION

Guemes Channel connects Padilla Bay to Rosario Strait and is one of several potential sources of water to the bay during flood tides (Fig. 1). Most of Padilla Bay is intertidal with an estimated 75% of the high tide volume of the bay between MHHW and MLLW on a depth-volume curve (Shannon Point Marine Lab Physical Oceanography Class 1991). Thus, most of the water in Padilla Bay at spring high tide has flowed into the bay during the preceding flood tide. Flood tides from Guemes Channel may bring seawater from Rosario Strait into Padilla Bay and may carry pollutants or oil from Guemes Channel into the bay. Guemes Channel is generally oriented east to west with a sill near the eastern end between Anacortes and Guemes Island. East of the sill, Guemes Channel opens out to Fidalgo Bay and Padilla Bay. Tidal currents in the main channel are strong, and can exceed five knots (Island Canoe 1987).

Previous studies on currents and water movement in Guemes Channel have focused on the likely movement of potential pollutants from individual wastewater outfalls or oil spills (Saxton and Young 1948, Sylvester and Clogston 1958, Seattle Marine Laboratories 1974, City of Anacortes 1984). Saxton and Young (1948) reported the movement of floats from the location of sulfite waste liquor outfalls in Anacortes into Padilla Bay during floodtide. Sylvester and Clogston (1958) measured currents with floats and drogues in Guemes Channel. They concluded that during weak flood tides and on the first half of strong floods, water movement from Guemes Channel radiates outward into Fidalgo and Padilla Bays. On a strong flood, the current reverses off March Point and forms a clockwise back-eddy. Seattle Marine Laboratories (1974) and the City of Anacortes (1984) reported strong westerly currents in Guemes Channel during ebb tides using both surface and subsurface drogues. These studies focused on the movement of water away from a particular outfall or pier in Guemes Channel. Together

they indicate a net ebb flow in Guemes Channel and movement of water from Guemes Channel into Rosario Strait. None of the studies measured or reported movement of water from the eastern end of Guemes Channel into Padilla Bay.

The purpose of this study was to determine the pattern of movement of surface water from the eastern end of Guemes Channel into Padilla Bay during flood tides. Surface drogues were set out and followed on four different occasions and data on surface currents in the vicinity were gleaned and summarized from published and unpublished reports.

METHODS

Surface currents during flood tides were measured with drift sticks on four dates: August 4, 18, 30, and 31, 1993. Drift sticks, two inches by two inches by two feet were constructed from wood and individually weighted with lead at one end to attain a buoyancy that kept the sticks oriented vertically with the top six inches (painted bright orange with black numbering) above the water surface. Fifteen to thirty drift sticks were deployed and followed each date. The time and location of each drift stick was determined about every half hour until predicted high water when the drift sticks were recovered. Location and time of each drift stick was measured by driving the research vessel alongside the stick and recording time and latitude/longitude with on board GPS (Magellan with a stated accuracy of about 100 m). On days when surface currents carried the sticks in divergent directions, the time between readings increased to greater than every 30 minutes. On most days, most of the sticks were recovered, but a few sticks were lost. On August 4, 1993, one half of the drift sticks were flagged with two foot lengths of thin bamboo stakes with orange flagging tape attached to the top of the bamboo stakes. Drift sticks were flagged in an attempt to increase visibility. However,

flagged drift sticks were more strongly affected by the wind, and drift sticks were not flagged on subsequent dates.

On August 4, 1993, drift sticks were set out in a line between Hat Island and March Point near the time of low tide (Fig. 2). On August 18, drift sticks were deployed in a line between Southeast Point on Guemes Island and the Shell Oil Company Pier near the time of predicted low water in Guemes Channel. On August 30, drift sticks were deployed along the northern half of a line between Southeast Point on Guemes Island and the Shell Oil Company Pier (Fig. 2). Drift sticks were deployed three times along this line on August 30: 1 and 1/2 hours after predicted low water in Guemes Channel at Anacortes, 2 and 1/4 hours after predicted low water, and 2 and 3/4 hours after predicted low water. On August 31, drift sticks were deployed five times along a line extending about 1.2 km directly south from Hat Island (Fig. 2). Five drift sticks were set out at predicted low water in Guemes Channel and five sticks were set out four more times at approximately hourly intervals thereafter.

Data from the latitude and longitude coordinates were charted in DeltaGraph® with a background of the shoreline around the eastern end of Guemes Channel. The resulting dots and inferred movement of the drift sticks indicates their approximate location. However, the data presented in this manner has not been geo-referenced and should be seen as approximate locations relative to shorelines and latitude/longitude. Measured latitude/longitude and time are reported for each drift stick in Appendix A.

RESULTS

Surface current studies

Drift sticks were released between Hat Island and March Point on August 4 about 45 minutes before predicted lower low water (LLW) in Swinomish Channel (Fig. 3). During the first hour after being released, the sticks drifted in three different directions (Fig. 4). Those closest to Hat Island (within 0.8 km) drifted east toward Padilla Bay. The three sticks closest to March Point drifted west toward Guemes Channel, and the sticks in the middle moved south toward Swinomish Channel. During the next two hours of flood tide the sticks heading east and south continued in the same directions, moving into Padilla Bay and into Swinomish Channel (Fig. 5). Among the group heading west toward Guemes Channel, one stick continued to do so and was last seen at 3:01 p.m., two hours after LLW, heading west in Guemes Channel (Fig. 5). The rest of the sticks that had moved west during the first hour drifted slowly south over the intertidal area between March Point and Swinomish Channel during the next two hours (Fig. 5). During the last half of the flood tide, these sticks moved into the Swinomish Channel and headed south in the channel (Fig. 6). During the flood tide as a whole, all but one stick moved in two directions: directly east into Padilla Bay and south into Swinomish Channel (Fig. 6). One stick moved west. No sticks were seen drifting southeast into southern Padilla Bay.

Drift sticks were released between Southeast Point, Guemes Island, and March Point on August 18, about 15 minutes before predicted LLW in Guemes Channel at Anacortes (Fig. 7). Sticks numbered 1 through 19, extending about 1.1 km south of Southeast Point, all moved west during the first half hour (Fig. 8). Most then moved north onto the shore of Guemes Island and drifted slowly along the shore for the remainder of the flood tide. Five of the nineteen sticks moved west into Guemes Channel and were last seen 30-65

minutes after predicted LLW heading west in Guemes Channel. Two of the northern 19 sticks (#11 and #19) eventually moved off the shore of Guemes Island, around Southeast Point, and north toward Huckleberry Island (Fig. 8). Drift sticks #20 through #26 were released about mid channel between Guemes Island and March Point. These seven sticks first moved west and then turned around (sweeping either north or south), moved east, and then spread out radially heading north, east, and south (Fig. 9). One stick (#25) was located in Padilla Bay about an hour before predicted HHW and five sticks were found in Swinomish Channel moving south (Fig. 10).

Because of the restricted number of sticks that were seen and recovered among those released within 1 km of Southeast Point on August 18 (Fig. 10), the next set of drift sticks were released in this area (Fig. 2) on August 30 and followed closely to detect any eastward movement. Sticks were first deployed at 11:35 (1 h, 25 min after predicted LLW in Guemes Channel). These sticks all moved west into Guemes Channel and were recovered (Fig. 11). These sticks were deployed a second time just south of Southeast Point at 12:30 (2 h 10 min after predicted LLW), and again, moved west and were recovered (Fig. 12). Three of the drift sticks had moved south and were not recovered. The rest of the drift sticks were deployed a third time south of Southeast Point, this time at 12:50, 2 h 40 min after predicted LLW (Fig. 13). During the first hour after this third deployment, the sticks changed direction and moved east and south (Fig. 14). During the period between 1:36 and 3:04 p.m. (3 h 26 min to 4 h 54 min after predicted LLW) these sticks all moved east directly toward Hat Island (Fig. 15). During the next hour and a half the sticks divided, most going north and then northwest toward Huckleberry Island and Guemes Island (Fig. 16). Three of the drift sticks moved south of Hat Island, two of those moving into Padilla Bay (Fig. 16). During the last two hours that these drift sticks were tracked (between 3:51 and 6:00 p.m., 5 h 41 min to 7 h 50 min after predicted LLW) the drogues around Huckleberry Island moved north, slowed down

and began to turn around (Fig. 17). One stick, near Hat Island, reversed direction and headed west into Guemes Channel (Fig. 17). The three sticks that had moved south of Hat Island continued southeast into Padilla Bay (Fig. 17). When the drift sticks are charted showing all locations and times for which they were seen on August 30, the paths form a confusing criss-cross pattern (Fig. 18). This is caused in part because some sticks were not seen very often or were only seen during the early part of the experiment. Nonetheless, it is clear that most of the sticks moved east toward Hat Island and then north, with very few entering Padilla Bay (Fig. 18).

On August 31, drift sticks were deployed five times in a line straight south of Hat Island at about hourly intervals from the time of predicted LLW in Guemes Channel (Fig. 19). Drift sticks that were deployed near the time of low water (10:46 a.m.) moved southeast in the channels along the western border of Padilla Bay and then moved up the channels and over the intertidal flats (Fig. 20). A similar pattern was observed when drift sticks were released at 11:50 a.m., 1:00 p.m., and 2:00 p.m. (Figs. 21, 22, and 23). Sticks deployed at 3:30 p.m. moved toward Padilla Bay for about an hour and a half and then, about one hour before predicted HHW, the movement slowed or stopped with some indication of a westward movement away from Padilla Bay (Fig. 24). The overall movement of drift sticks released south of Hat Island on August 31 was southeast with a few sticks moving east (Fig. 25).

PREVIOUS STUDIES

Saxton and Young (1948) investigated the dispersion of sulfite waste liquor from Anacortes into the surrounding waters. Drogues released on an ebbing tide in Guemes Channel moved into Rosario Strait. Drogues released on a flooding tide in Guemes Channel showed a tendency to ground close to Anacortes, indicating a large eddy off Cap Sante. One float, which was released in the main channel, traveled into Padilla Bay.

In 1958, Texaco funded a study of the marine environment off March Point prior to the operation of the oil refinery (Sylvester and Clogston, 1958). Included in their report are data on water quality, biology, and current studies. Current meter and drogue studies were conducted in Guemes and Swinomish Channels under varying conditions. In their summary they stated:

> "Current meter studies were made over a tidal cycle in Guemes Channel and in Swinomish Channel. These studies together with planimetered areas and volumes indicate that on the greater ebb, Guemes Channel passes from two to three times the volume of water that lies in the entire tidal prism of Fidalgo and Padilla Bays. During a flood tide, the discharge through Guemes Channel is only slightly greater than the intertidal volume in Fidalgo and Padilla Bays. . . These observations are of course modified by strong winds or by weak tides."

> "Current studies using floats and drags were made in Guemes Channel, from the point of future refinery effluent release, off William Point and in Swinomish Channel. These studies indicate that on the weak flood tides and on the first half of the strong floods, water movement is radially outward from Guemes Channel and into Fidalgo and Padilla Bays. On a strong flood, the current reverses off March Point about the time of maximum strength and forms a clockwise back-eddy extending northwesterly into Guemes Channel. Through the first two-thirds of a strong ebb tide, water movement away from the refinery pier is rapid and floats will quickly pass through Guemes Channel and into Rosario Strait. Two hours and longer after maximum ebb in Guemes Channel, the drag or current movements away

from the refinery pier are slow and are generally in a westerly direction towards outer Fidalgo Bay." (Sylvester and Clogston 1958, Appendix B-1).

Thirteen years later, oceanographic, biological, and engineering studies were conducted for the Scott Paper Co. regarding their outfall into Guemes Channel (Seattle Marine Laboratories, 1974). Drogues were set at surface, midwater, and near bottom depths to define possible stratification of currents in the channel during ebb and flood tides off Anacortes. Drogues released during ebb tides flowed westerly into Rosario Strait. Drogues released during flood tides drifted easterly; all were recovered prior to any movement out of Guemes Channel. The flow of the water mass within the channel appeared uniform from surface to near bottom based on comparable velocities of all the drogues (Appendix B-3).

Water movement and current patterns near the western end of Guemes Channel were measured for the proposed Ship Harbor Marina (City of Anacortes, 1984). Drogue tracks were plotted over both ebb and flood tides in and around the project boundary. Analysis of the trajectories indicated that an eddy forms in the Ship Harbor area moving opposite to the main channel circulation on both flood and ebb tides. (Appendix B-2).

During the summer of 1985, drogue and current studies were conducted in Guemes Channel by a Shannon Point Marine Center Oceanography class (Summers *et al.*, 1985). These studies confirmed the general east-west direction of water movement over flood and ebb tides in the channel. (Appendix B-4) A second study by Shannon Point Marine Laboratory (Shannon Point Marine Lab, 1991), set out drogues at the eastern end of Guemes Channel. During flood tide experiments, a drogue deployed north-northeast of Cap Sante moved east, while another deployed due east of Cap Sante traveled first

westerly, before changing direction and flooding east (Appendix B-5). A drogue set closer to Hat Island moved first south then east, and one released at the north end of Swinomish Channel traveled south within the channel. Further research during non-flood tides south of Hat Island and at the north end of Swinomish Channel indicated that ebbing water flows westerly into Guemes Channel (Appendix B-5).

DISCUSSION

The San Juan Current Guide (Island Canoe 1987) summarized published information from current stations in the San Juan Islands, Gulf Islands, and the Strait of Juan de Fuca. At seven locations in this whole area the authors indicate that currents are "not predictable." Two of those "not predictable" locations are designated in the present study area: south of Huckleberry Island and north of March Point. The drift stick studies reported here provide some definition to the flood tide currents in this area. However, "not predictable" remains an apt description of these currents. This is illustrated by normalizing the drift stick data to predicted LLW at Anacortes for all dates in the present study. During the first one and a half hours, drift stick trajectories south of Guemes Island moved in many directions, sometimes at right angles to each other (Fig. 26).

Data from all dates that drift sticks were deployed in the present study were combined by normalizing the time relative to predicted LLW in Swinomish Channel. Before predicted LLW, currents between Southeast Point, Guemes Island, and March Point move westward while currents south of Hat Island move eastward (Fig. 27). Closer to March Point, currents move south into Swinomish Channel or west into Guemes Channel (Fig. 27). During the first hour and a half after predicted LLW in Swinomish Channel, currents between Hat Island and March Point, and currents in Swinomish Channel move south into Swinomish Channel and east into Padilla Bay (Figs. 28 and

26). During this same time currents south of Southeast Point are moving east. These data imply that during early flood, water is moving south past Huckleberry and Saddlebag Islands, and from there moving radially toward Guemes Channel, Swinomish Channel and into Padilla Bay (Fig. 26). This is consistent with predicted currents north of Huckleberry Island on August 30 (Appendix A-6) when currents were southerly during this time period, but not consistent with predicted currents on August 18 (Appendix A-5). The inconsistencies may be because the predicted current station is one mile north of Huckleberry Island, near the Padilla Bay tidal flats and primary currents are those flooding to or ebbing from Padilla Bay. After the first hour and a half, the current south of southeast point reverses and water south of Hat Island continues to flow south and east (Fig. 29). During the middle third of the predicted flood tide, currents would be expected to be near their maximum speeds. During this time, water from Guemes Channel flows eastward and appears to divide at Hat Island with some water moving north between Saddlebag and Guemes Islands, some moving south into Swinomish Channel, and some moving east into Padilla Bay (Fig. 30). Considering all of the drift sticks released between Guemes Island and March Point, very few moved eastward into Padilla Bay (Figs. 10 and 18). Finally, during the last third of the flood tide, water moves north between Hat and Guemes Islands and southeast in the channels southeast of Hat Island (Fig. 31). In Swinomish Channel during the last third of flood tide, the water continues moving south, then spills into Padilla Bay and onto the flats toward March Point, and then reverses direction in the channel and begins to flow north (Fig. 31, Bulthuis and Conrad 1995).

Sylvester and Clogston (1958) concluded that during the first half of strong floods, water movement is radially outward from Guemes Channel and into Fidalgo and Padilla Bays. Similarly, the Canadian Hydrographic Service (1983) model indicates movement of water from Guemes Channel into Padilla Bay during flood tides. Our

studies indicate that the water moving toward Padilla Bay from Guemes Channel during a strong flood appears to move east toward Hat Island, divide into portions going north and south, with only a small central part moving east into Padilla Bay (Fig. 9). This was striking when seven drift sticks were released 75-100 m apart, two moved north toward Huckleberry Island, one moved east toward Hat Island, one moved into Padilla Bay, and three moved south down the Swinomish Channel (Fig. 9). The major source of water for the southern part of Padilla Bay appears to come from the area directly south of Hat Island (Cf. Figs. 2, 6, and 25) and not from Guemes Channel. This conclusion must be qualified because the present study measured only surface currents. The area between Hat Island and Guemes Channel includes deep holes and shallow sills, and below surface currents may bring Guemes Channel water into Padilla Bay. However, previous studies that used subsurface drogues in Guemes Channel and vicinity, did not report any differences between surface and subsurface currents (Sylvester and Clogston 1958, Seattle Marine Laboratory 1974, City of Anacortes 1984, Summers *et al.* 1985).

Sylvester and Clogston (1958) concluded that "on a strong flood, the current reverses off March Point about the time of maximum strength and forms a clockwise back-eddy extending northwesterly into Guemes Channel." No clear evidence for this back-eddy was seen during maximum flood in the present study, although drift sticks were in the vicinity of March Point (Fig. 30). Nor did the models of tidal currents produced by the Canadian Hydrographic Service (1983) indicate an eddy during maximum flood. However, early in the flood tide, there was some evidence for a clockwise eddy south of Southeast Point and counterclockwise eddy closer to March Point (Figs. 8-10).

Surface currents measured in the present study were those associated with spring tides, because such tides were considered the most likely to produce movement of Guemes

Channel water into Padilla Bay. Neap tides may result in different surface current patterns because of the different influence of Swinomish Channel currents and the currents flowing south from Georgia Strait and past Saddlebag Island. This study also measured surface currents only during the flood tide of a single tidal cycle. Over several tidal cycles, Guemes Channel water may mix with water from other sources and move into Padilla Bay.

In conclusion, the present study indicates that surface currents during flood tide in the area of the junction of Guemes Channel, Padilla Bay, and Swinomish Channel are variable. During maximum flood tide, water flowing from Guemes Channel radiates outward flowing north between Saddlebag and Guemes Islands, south into Swinomish Channel, and east into Padilla Bay. Early in the flood tide, surface currents appear to move in a clockwise eddy south of Southeast Point, Guemes Island. Very little of the water between Southeast Point and March Point at low water slack enters Padilla Bay. The surface water directly south of Hat Island is the major source of water that floods east and southeast into Padilla Bay.

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ACKNOWLEDGMENTS

Sincere thanks are due to Sherri Rodgers, Robin Cottrell, and Mark Olson who assisted in the field deploying, tracking, finding, and retrieving drift sticks; and to Dr. Alyn Duxbury for suggesting the use of drift sticks to determine surface currents in the bay. This study was funded in part by a grant from the National Oceanic and Atmospheric Administration, National Ocean Service, Ocean and Coastal Resources Management, Sanctuaries and Reserves Division with funds appropriated for Section 315 of the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies.

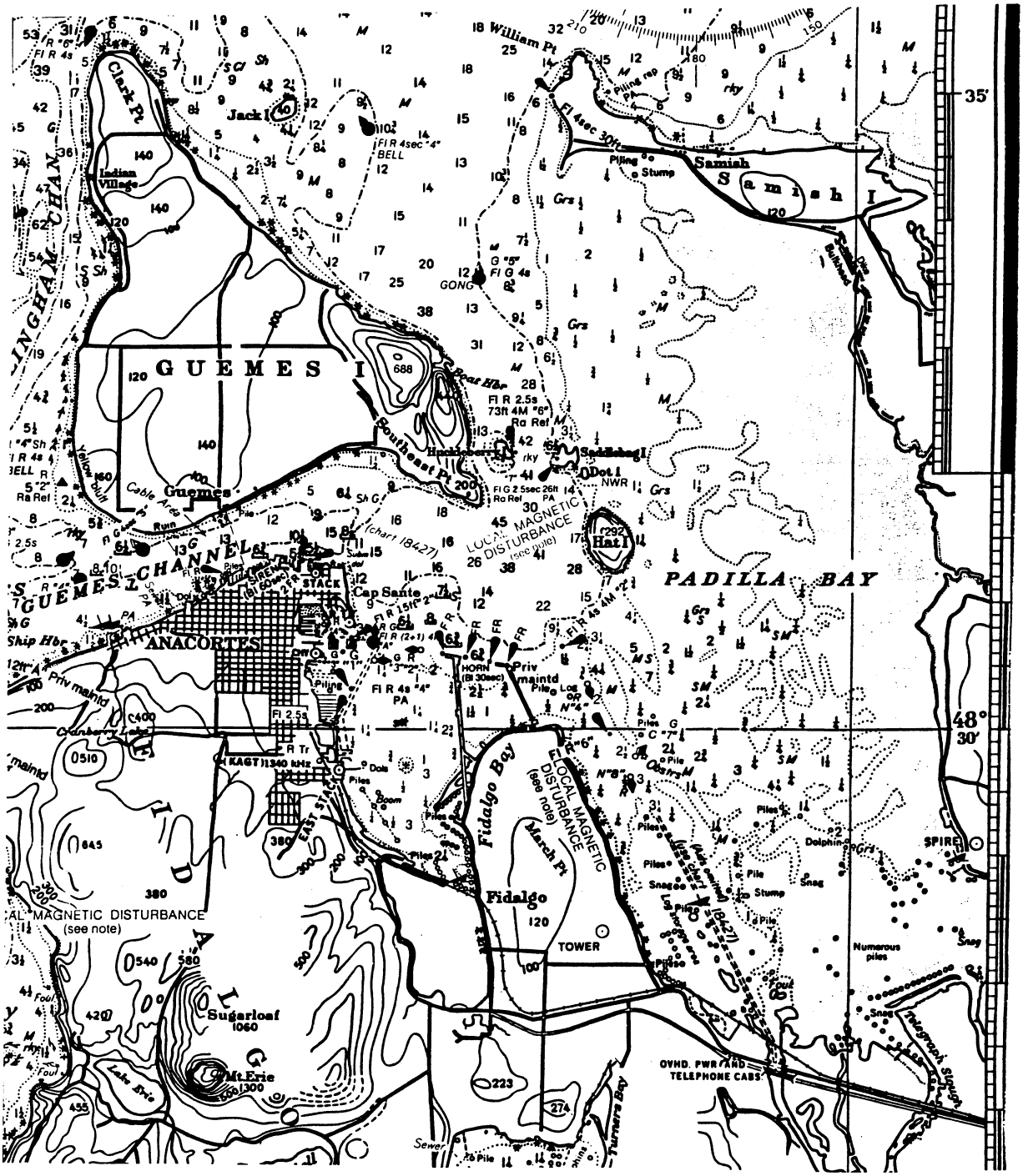


Figure 1. Padilla Bay and Guemes Channel as charted on U.S. Department of Commerce, NOAA, National Ocean Service, nautical chart 18421: Strait of Juan de Fuca to Strait of Georgia.

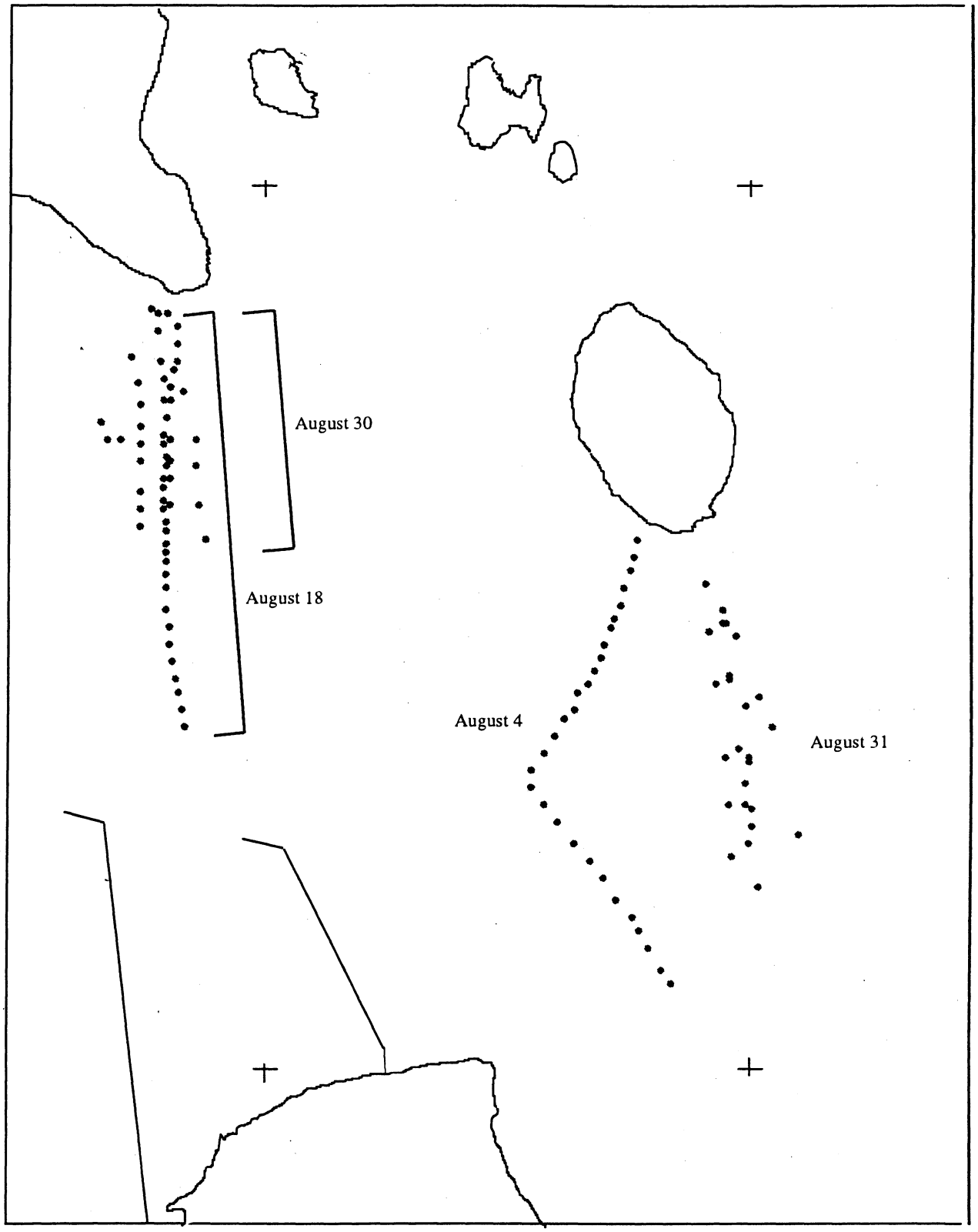


Figure 2. Locations that drift sticks were deployed during August 1993 during studies on the surface currents during flood tides from Guemes Channel into Padilla Bay.

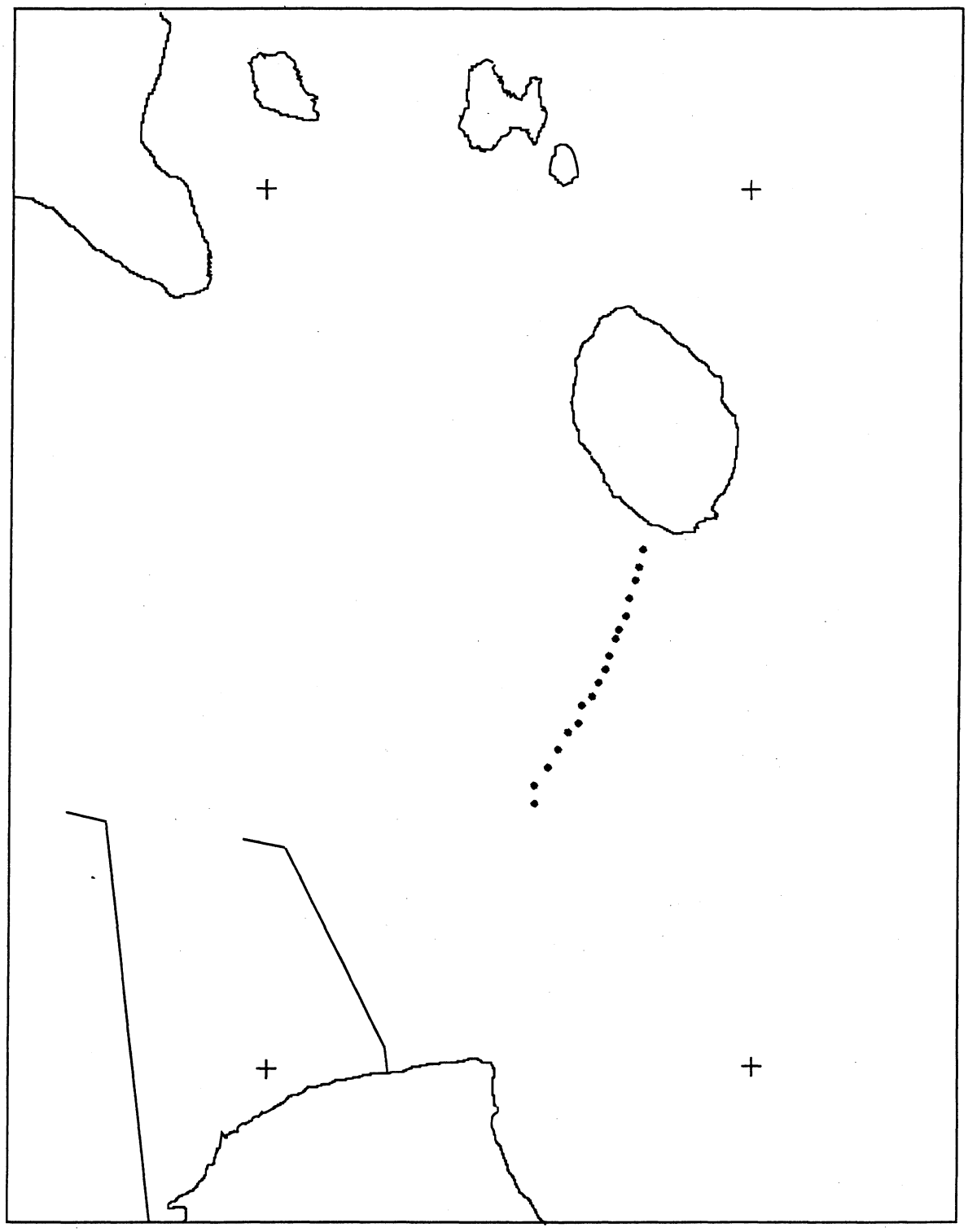


Figure 3. Locations at which drift sticks were deployed at the eastern approach to Guemes Channel on August 4, 1993 between 12:13 pm and 12:19 pm at the beginning of a flood tide (LLW in Swinomish Channel was predicted for 1:00 pm, HHW for 7:46 pm).

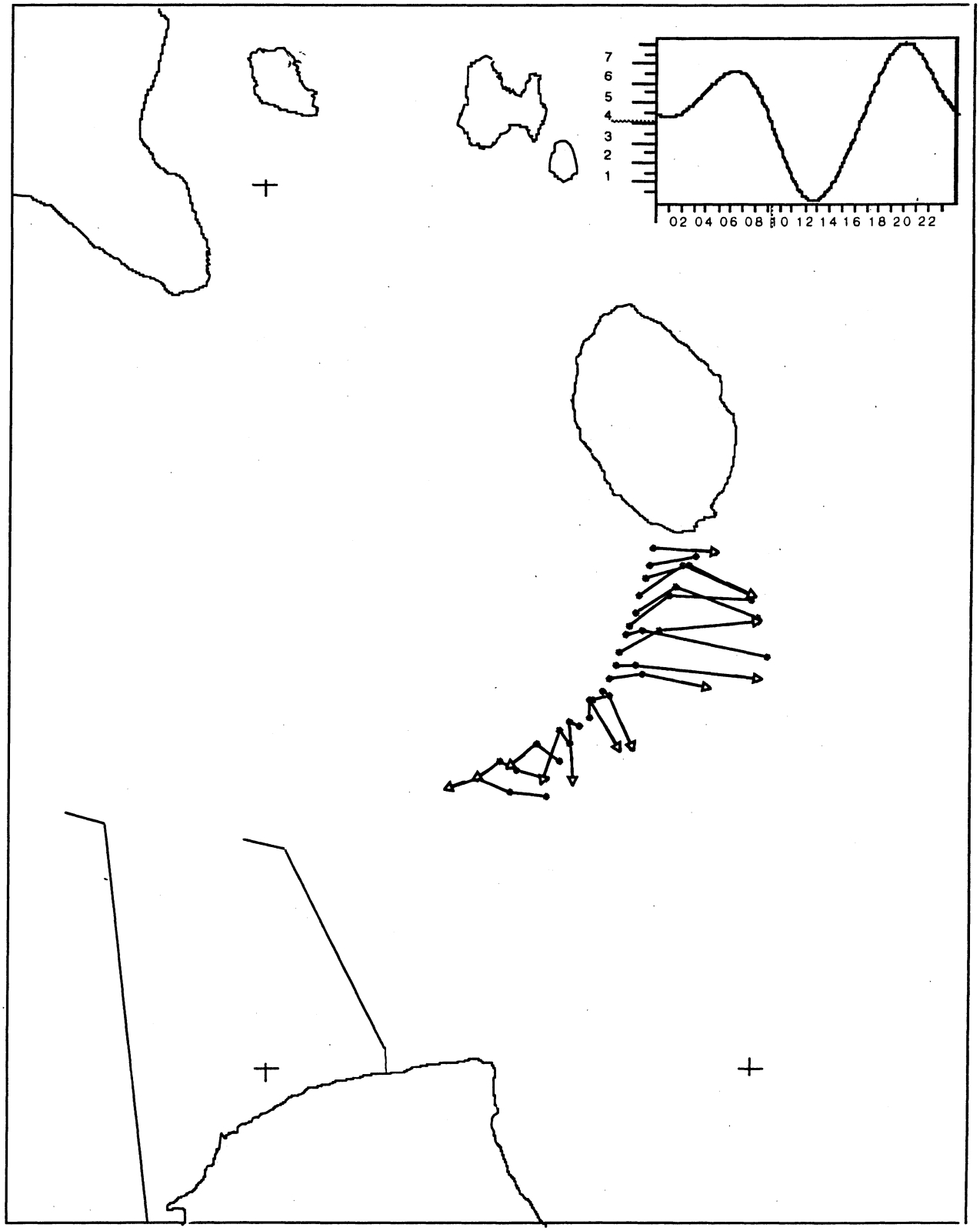


Figure 4. Movement of drift sticks that were deployed between Hat Island and March Point Light on August 4, 1993 during the first hour after deployment near the time of the turn of the tide from ebb to flood. Sticks were deployed between 12:13 and 12:19 pm; LLW in Swinomish Channel was predicted to occur at 1:00 pm; dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates tidal curve for the day in the Swinomish Channel at the Padilla Bay entrance (height in feet).

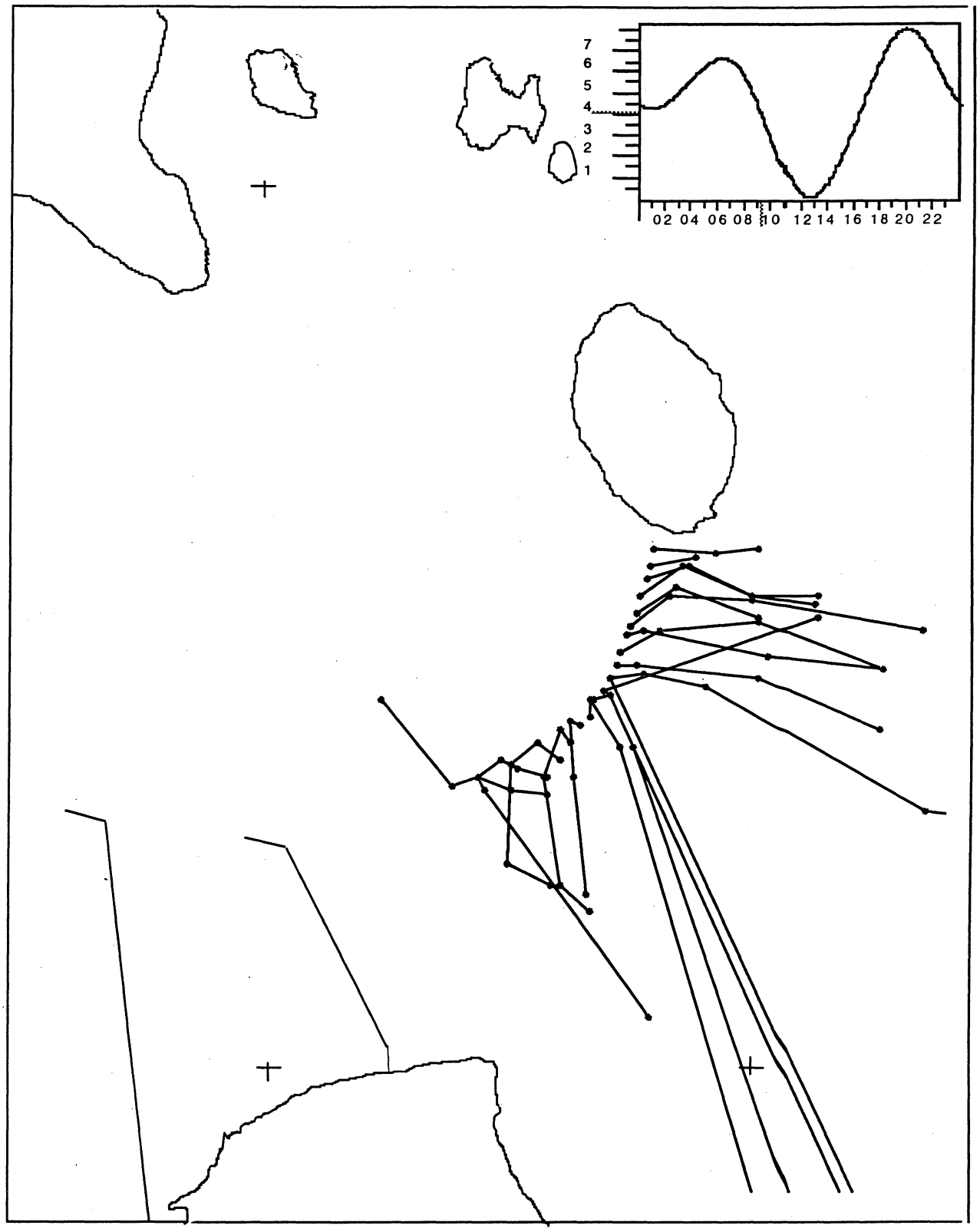


Figure 5. Movement of drift sticks that were deployed between Hat Island and March Point Light on August 4, 1993 during the first three hours after deployment. Sticks were deployed about 12:15 pm; LLW in Swinomish Channel was predicted to occur at 1:00 pm; dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates tidal curve for the day in Swinomish Channel at the Padilla Bay entrance (height in feet).

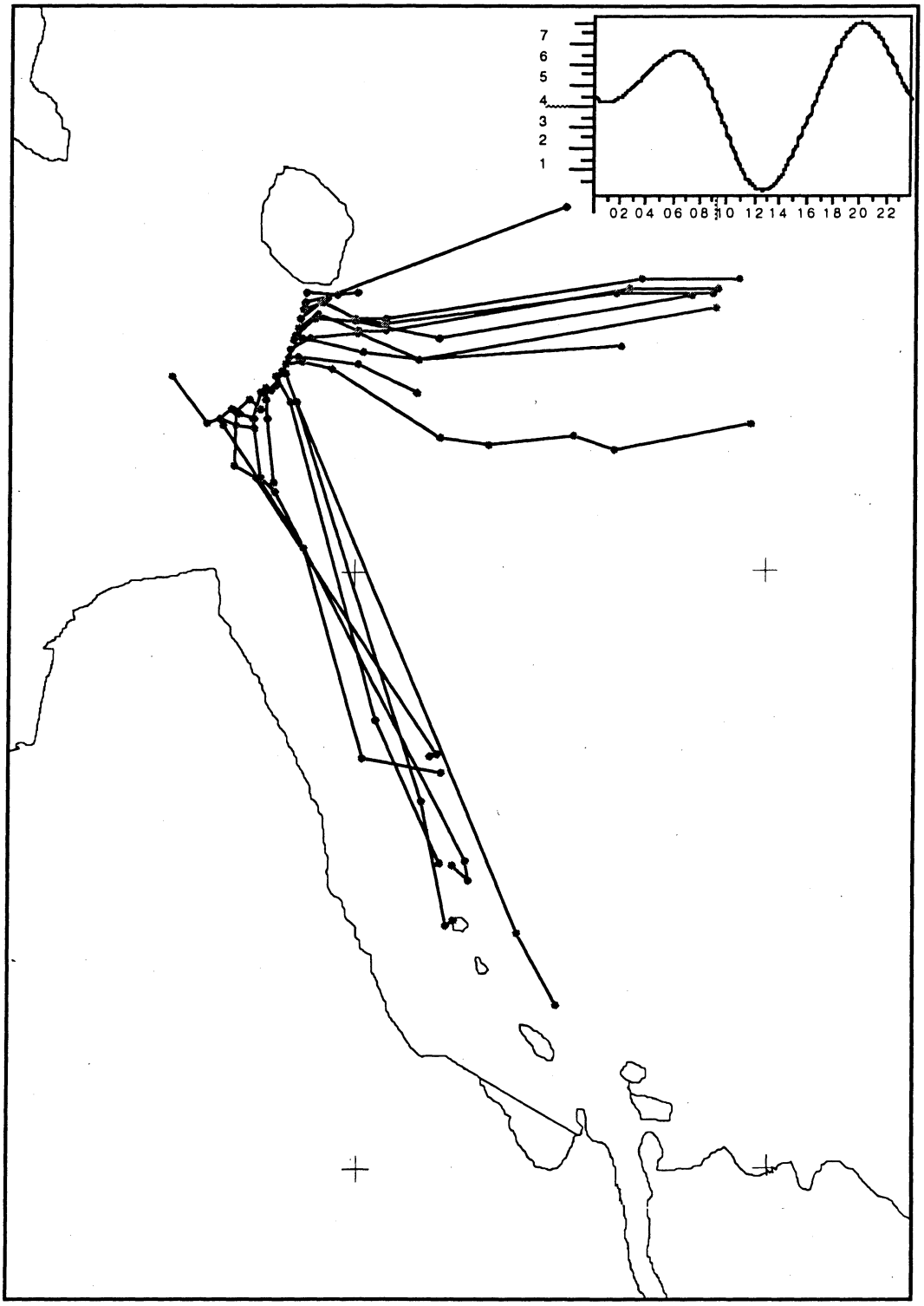


Figure 6. Movement of drift sticks that were deployed between Hat Island and March Point Light on August 4, 1993. Sticks were deployed about 12:15 pm; the last stick was retrieved at 8:16 pm; LLW in Swinomish Channel was predicted to occur at 1:00 pm, HHW at 7:45 pm; dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates tidal curve for the day in the Swinomish Channel at the Padilla Bay entrance (height in feet).

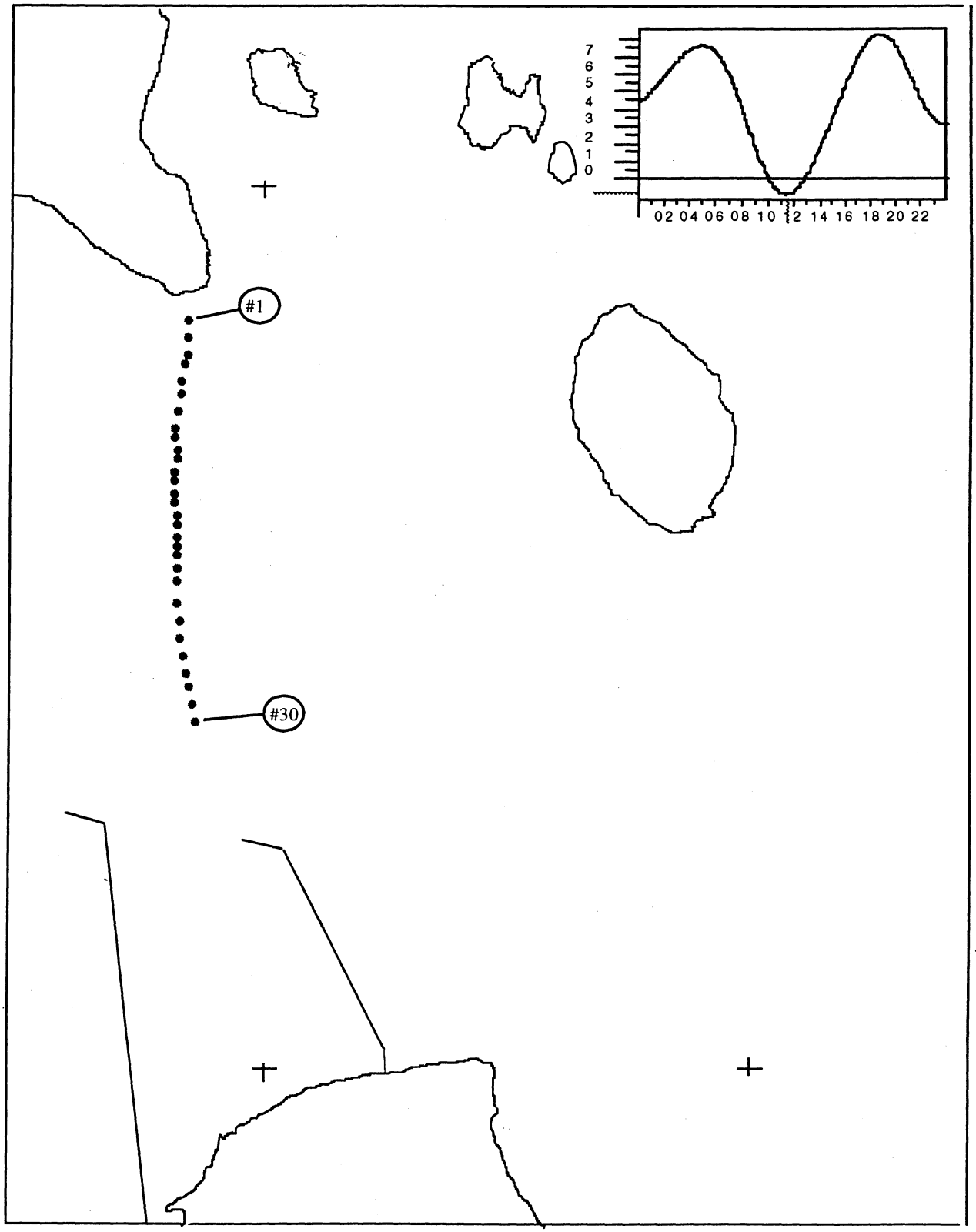


Figure 7. Locations at which 30 drift sticks were deployed between Guemes Island and March Point near the eastern end of Guemes Channel on August 18, 1993 between 11:03 am and 11:16 am near the beginning of a flood tide (LLW in Guemes Channel at Anacortes was predicted for 11:27 am, HHW for 6:35 pm). Graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

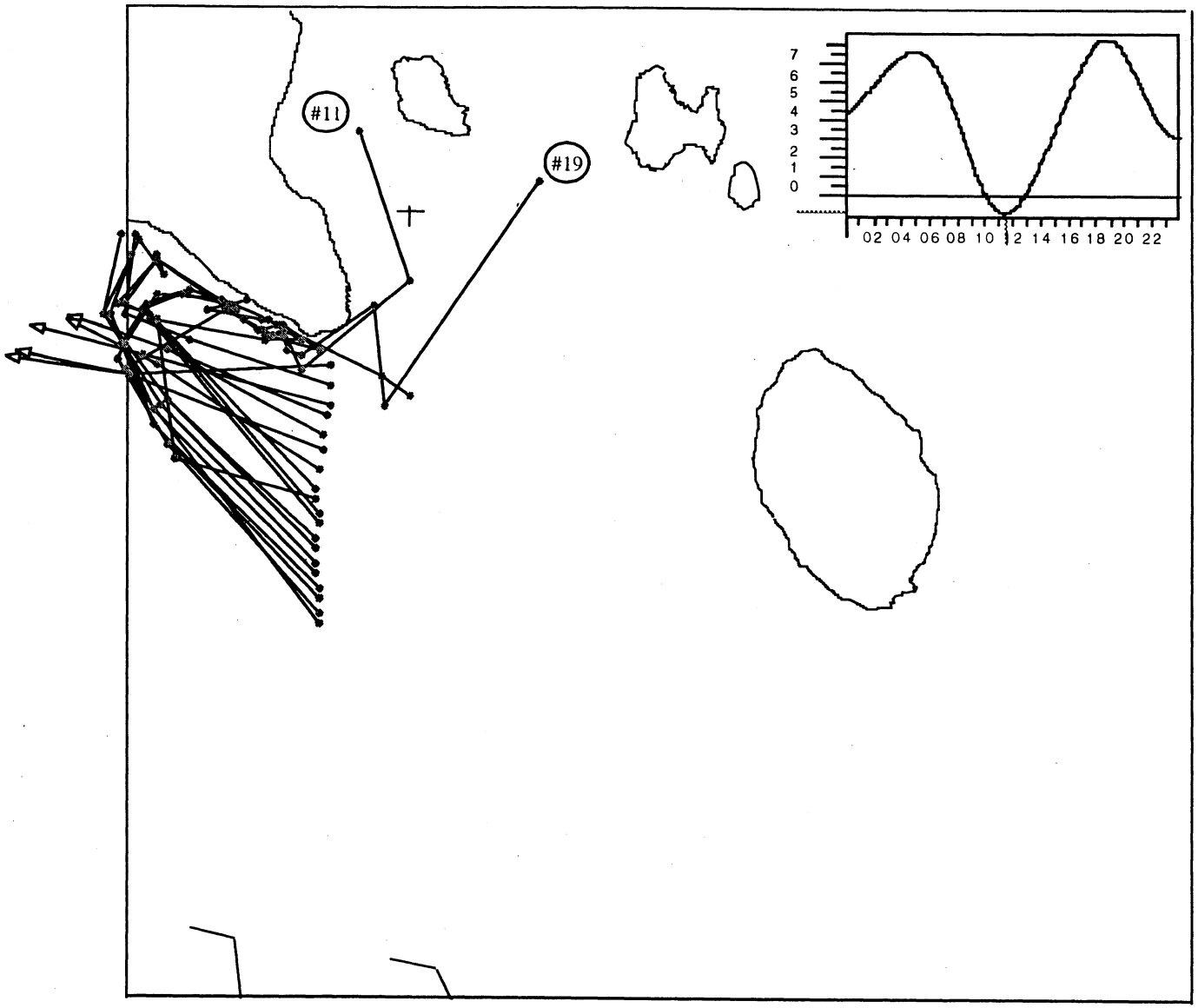


Figure 8. Movement of drift sticks #1 to #19 that were deployed closest to Guemes Island on August 18, 1993 between 11:00 and 11:15 am near the beginning of a flood tide (LLW in Guemes Channel at Anacortes was predicted for 11:27 am, HHW for 6:35 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; arrows indicate last recorded position of drift sticks moving west in Guemes Channel; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

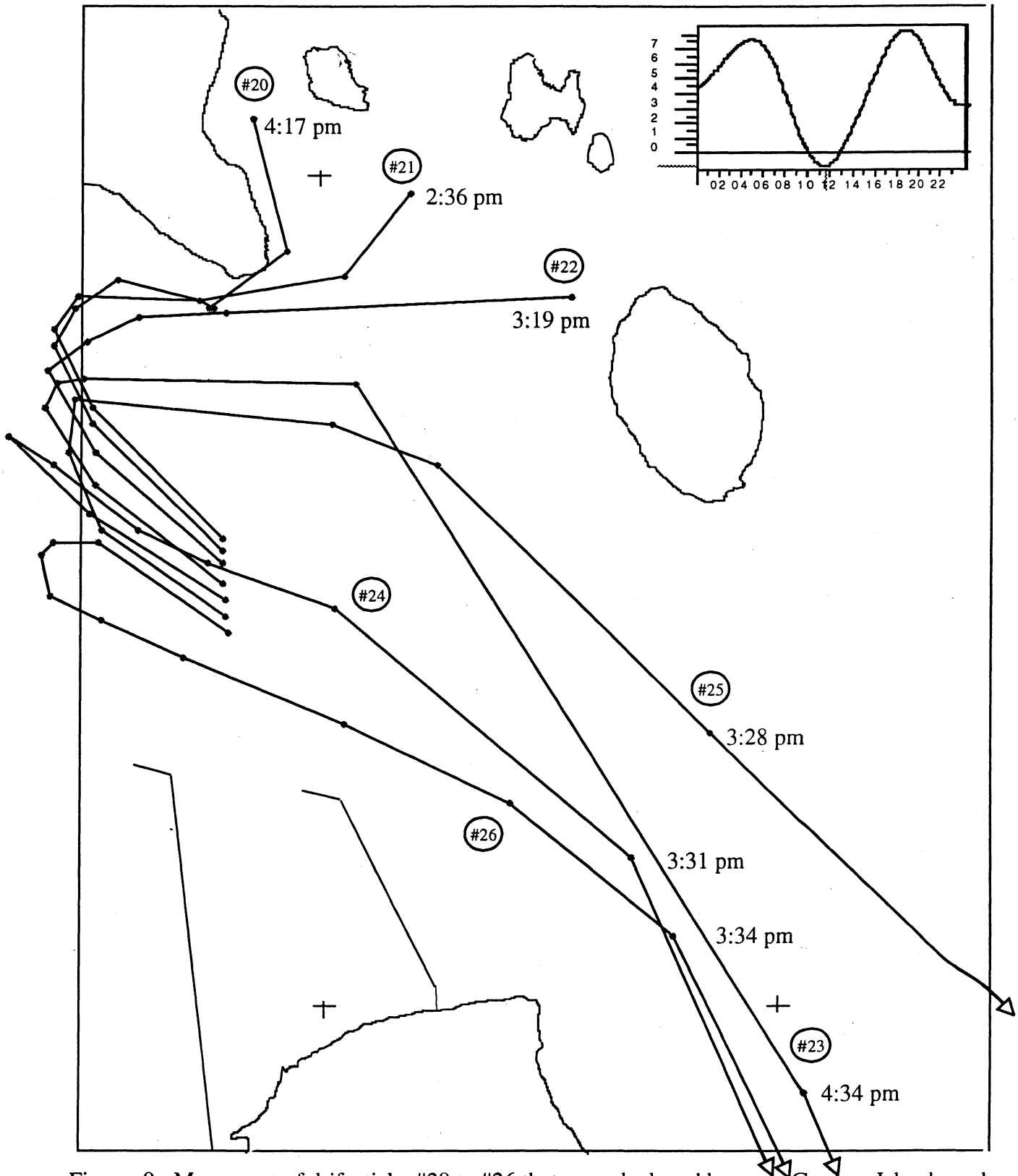


Figure 9. Movement of drift sticks #20 to #26 that were deployed between Guemes Island and March Point near the eastern end of Guemes Channel on August 18, 1993 about 11:15 am near the beginning of a flood tide (LLW in Guemes Channel at Anacortes was predicted for 11:27 am, HHW for 6:35 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

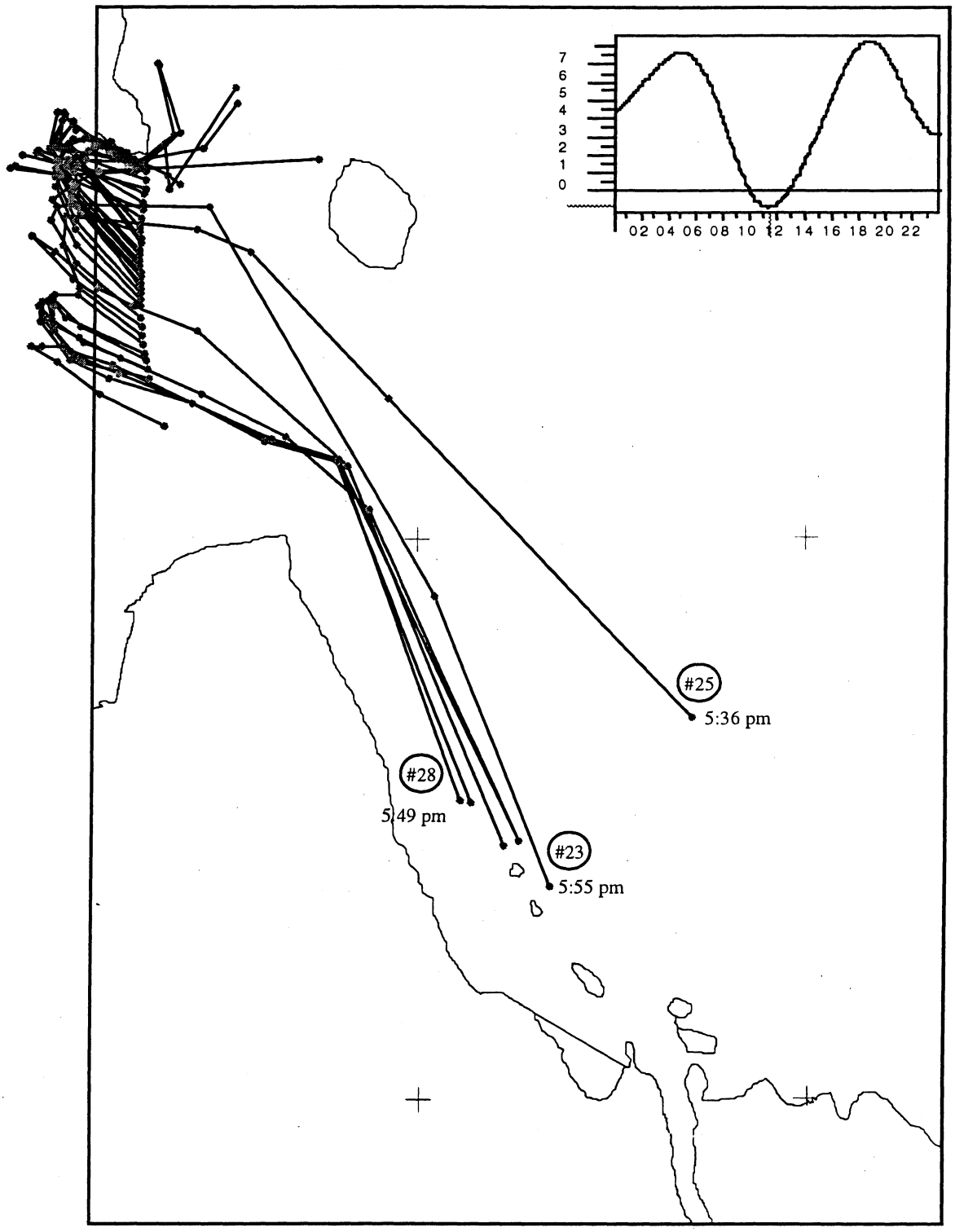


Figure 10. Movement of all drift sticks (#1to #30) that were deployed between Guemes Island and March Point on August 18, 1993 between 11:00 and 11:30 am near the beginning of a flood tide (LLW in Guemes Channel at Anacortes was predicted for 11:27 am, HHW for 6:35 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

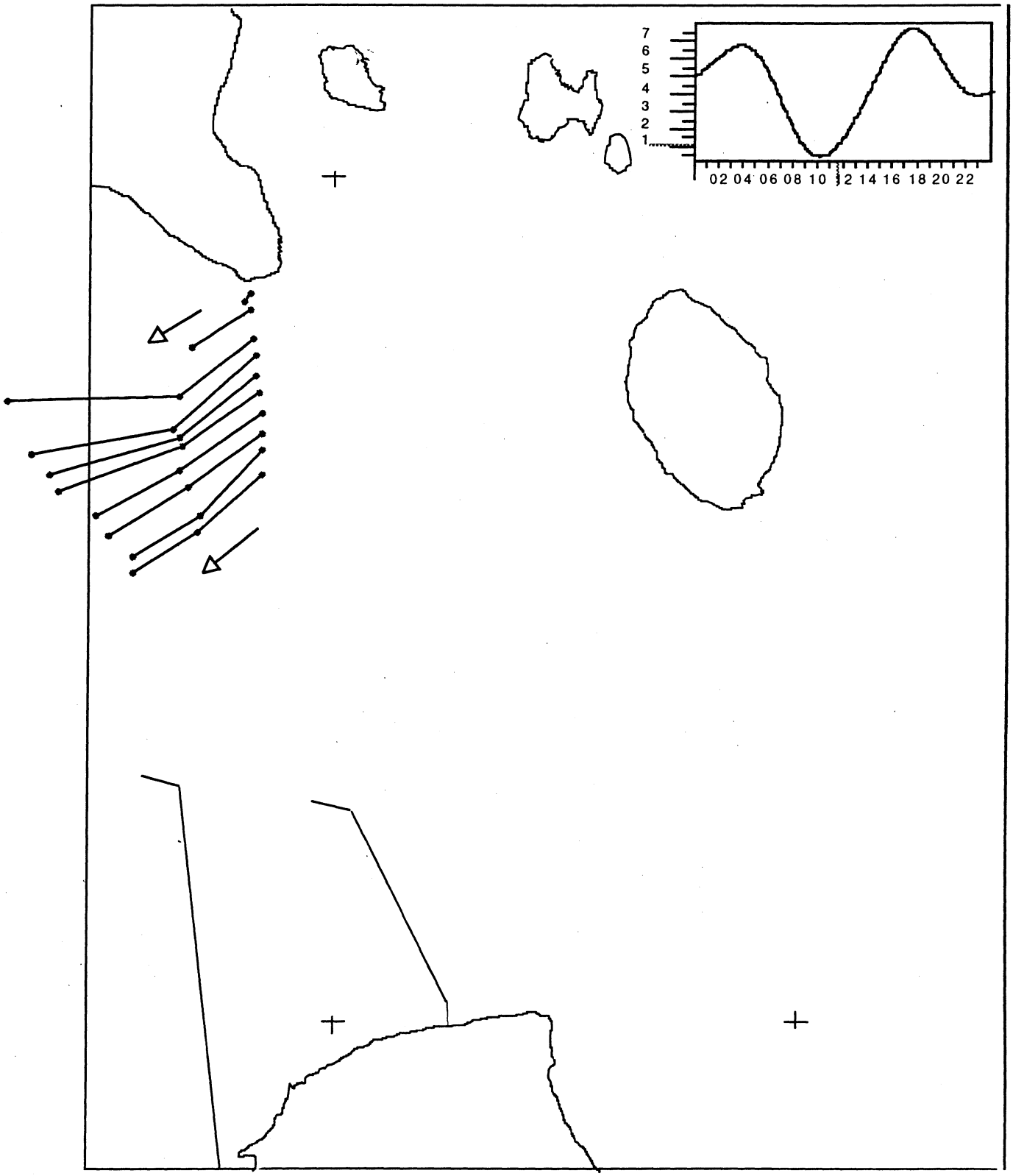


Figure 11. Movement of drift sticks that were deployed south of Southeast Point, Guemes Island on August 30, 1993 near the beginning of a flood tide (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Sticks were deployed between 11:33 and 11:37, and recovered between 12:04 and 12:10. Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

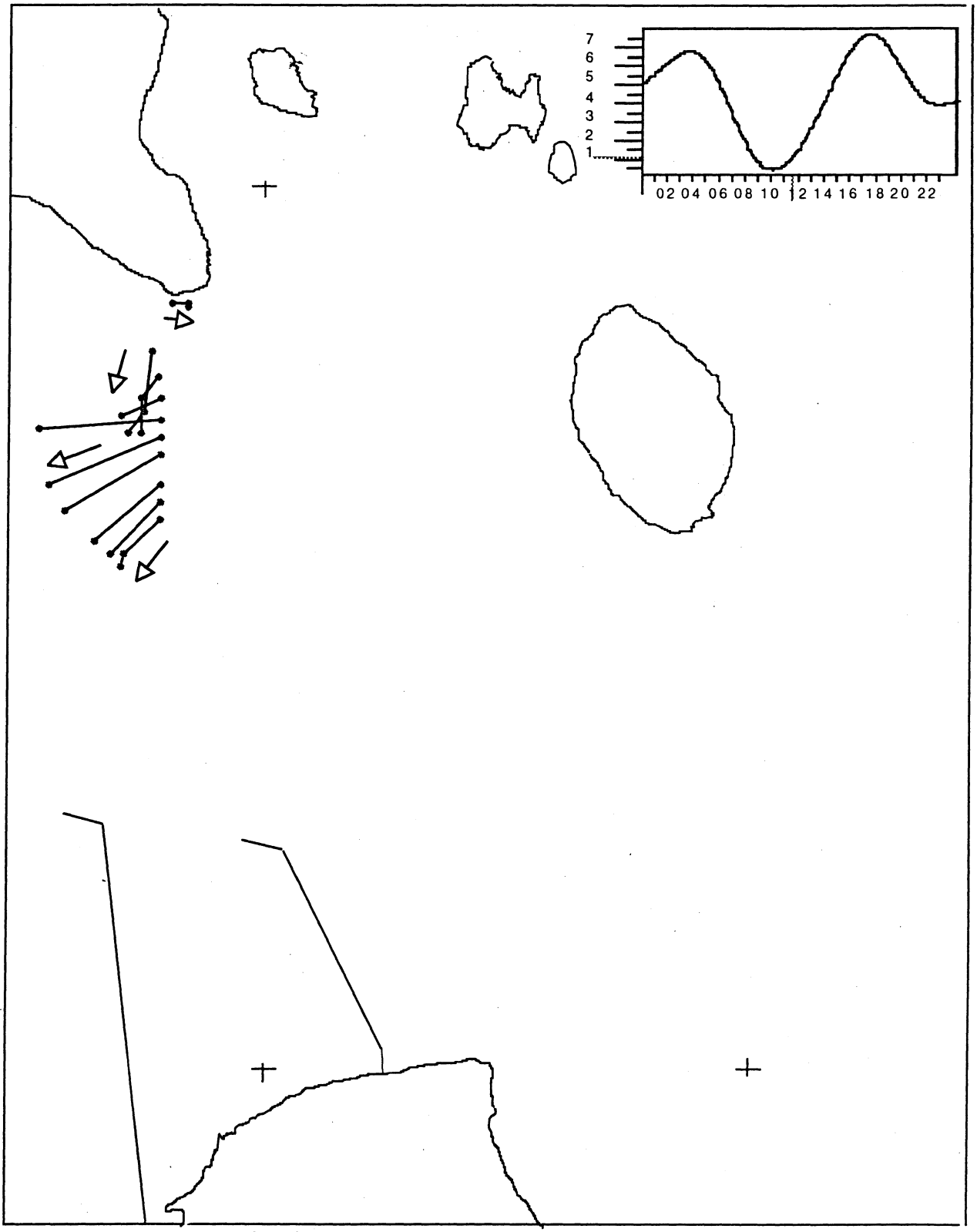


Figure 12. Movement of drift sticks that were deployed a second time south of Southeast Point, Guemes Island on August 30, 1993 near the beginning of a flood tide (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Sticks were deployed between 12:20 and 12:24, and recovered between 1242 and 12:50. Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

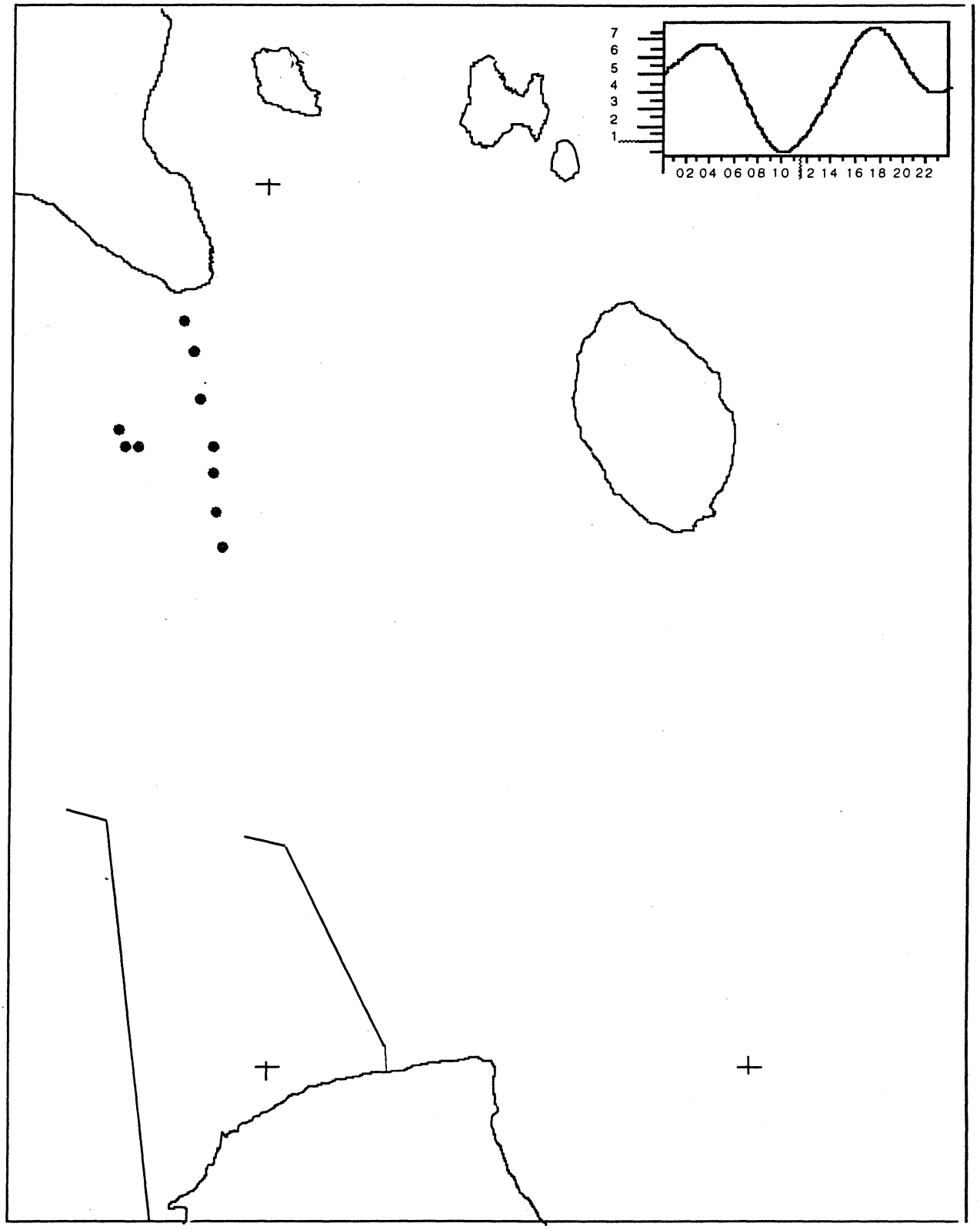


Figure 13. Locations at which drift sticks were deployed for the third time (or locations of sticks that were not redeployed) south of Southeast Point on Guemes Island on August 30, 1993 between 12:48 and 12:57 pm during early flood tide (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

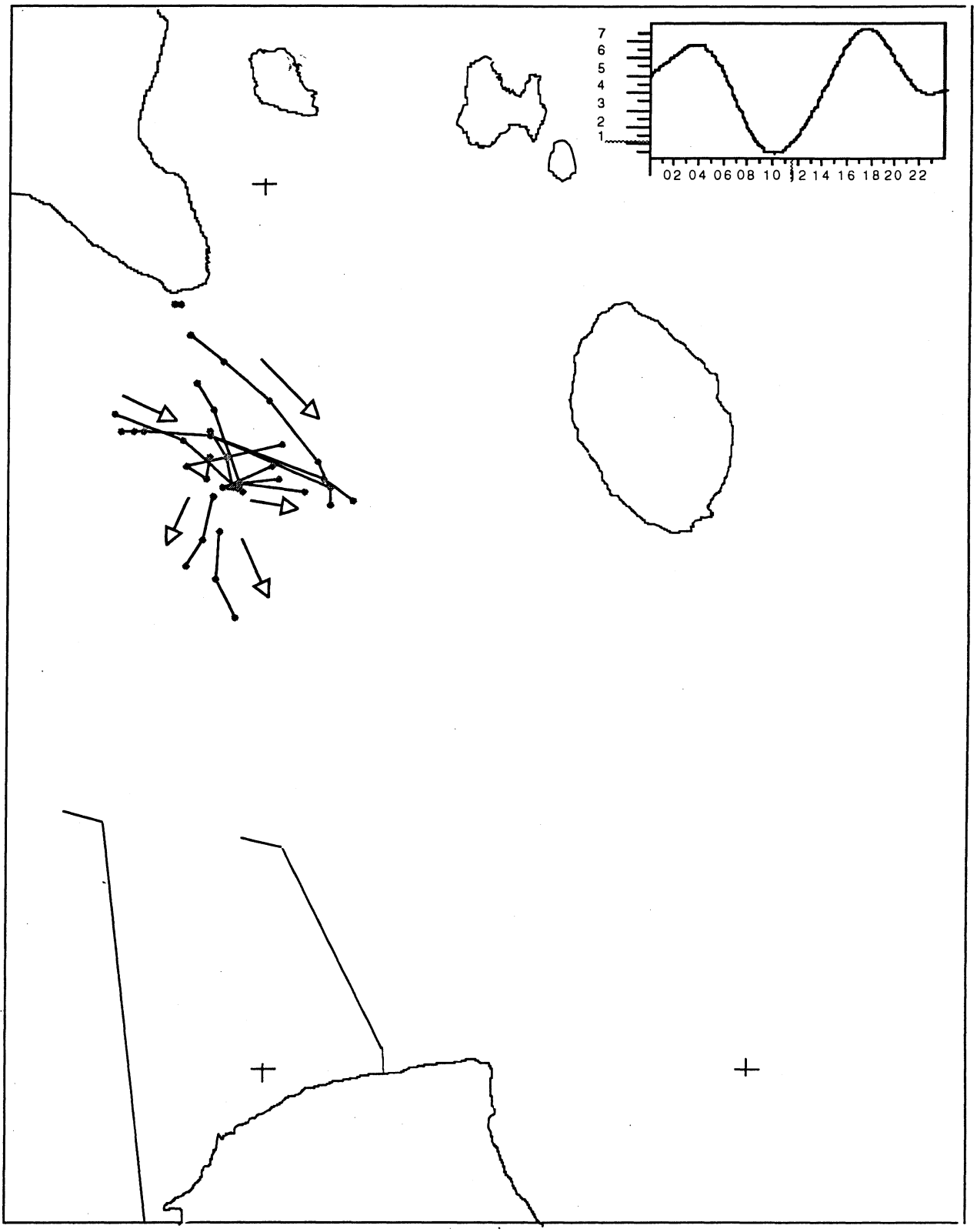


Figure 14. Movement of drift sticks during the first hour (between 12:48 and 1:43 pm) after the third deployment on August 30, 1993 (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

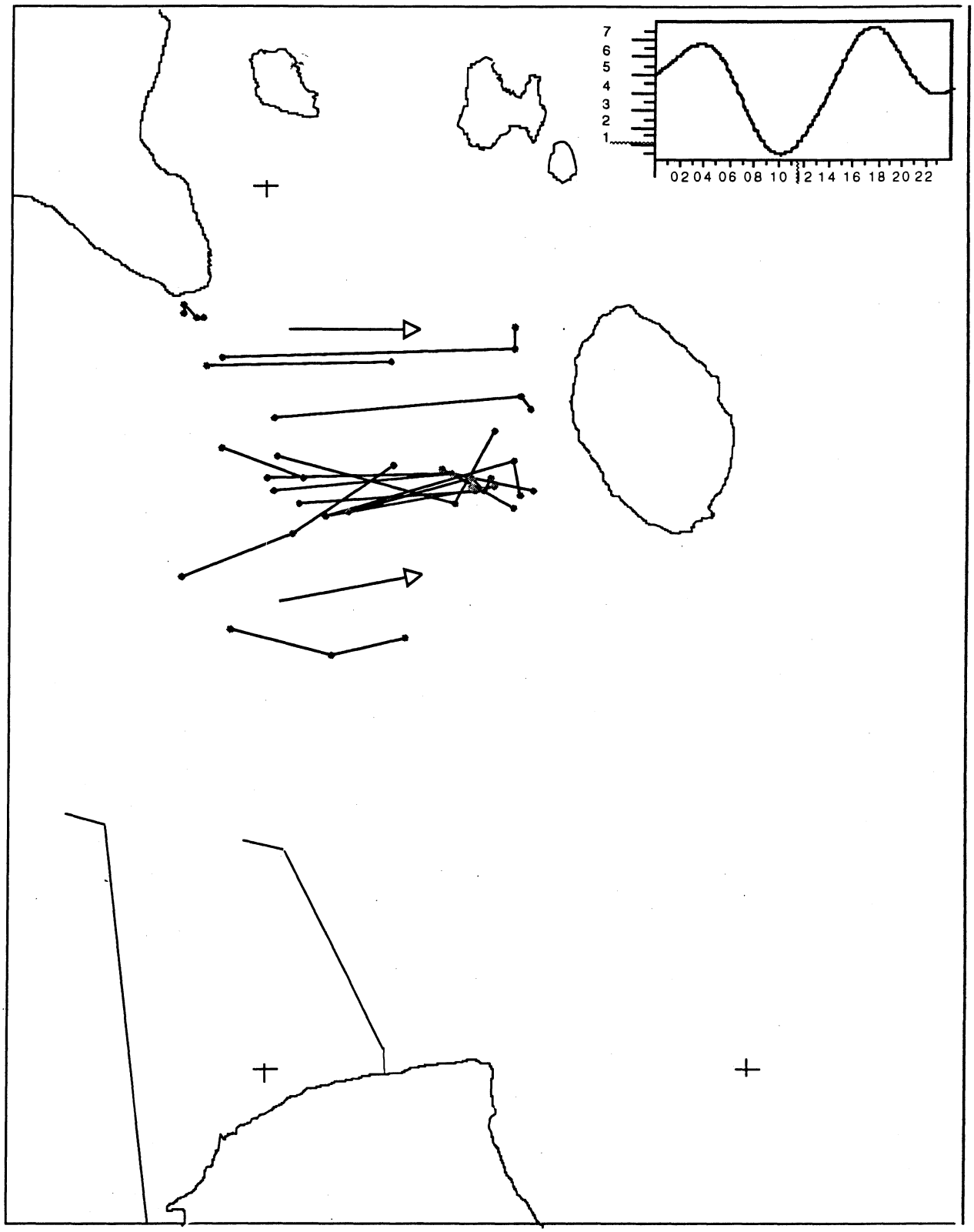


Figure 15. Movement of drift sticks between 1:36 and 3:04 pm on August 30, 1993 that had been deployed about 12:50 pm south of Southeast Point, Guemes Island (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

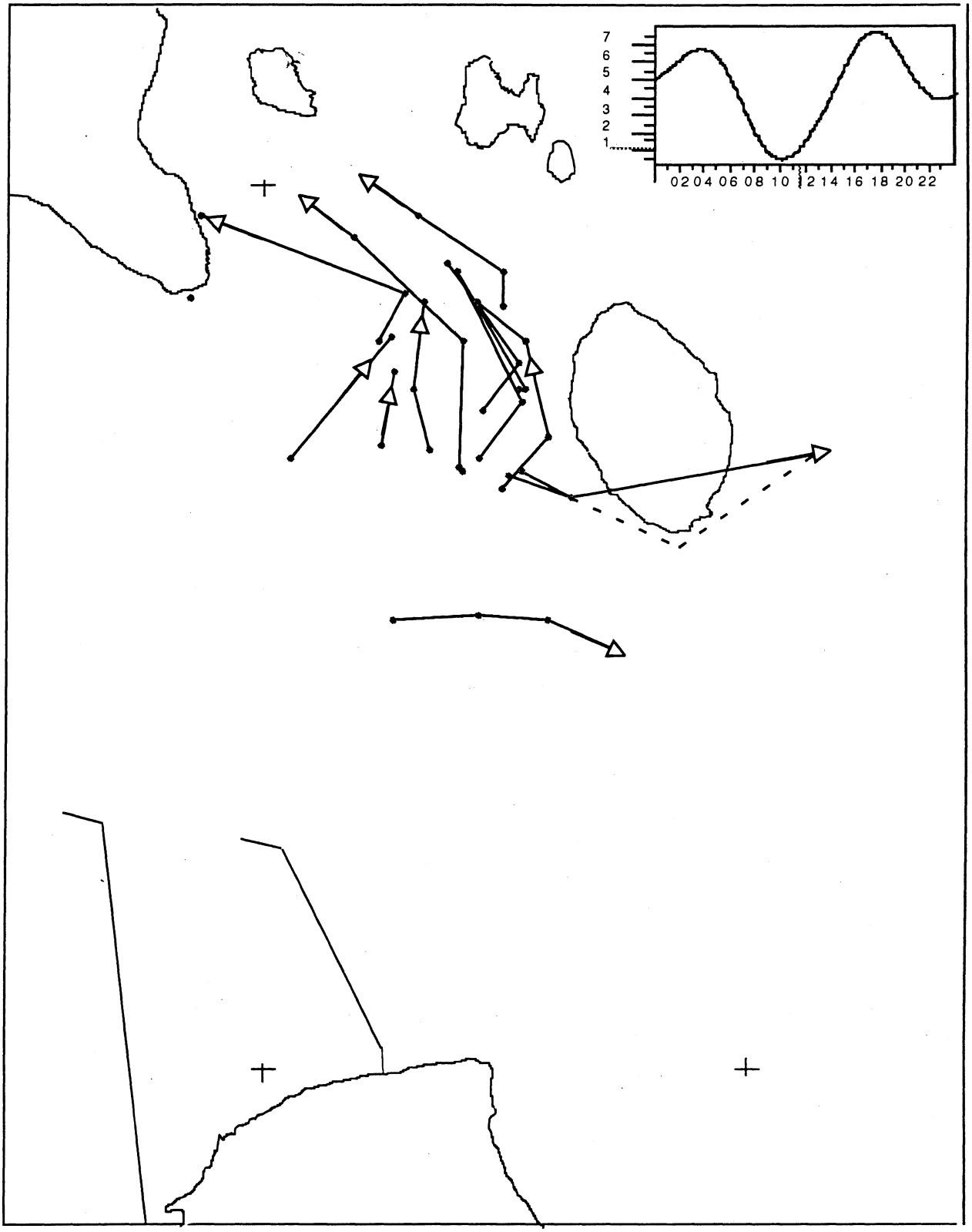


Figure 16. Movement of drift sticks between 2:41 and 4:30 pm on August 30, 1993 that had been deployed about 12:50 pm south of Southeast Point, Guemes Island during early flood tide (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

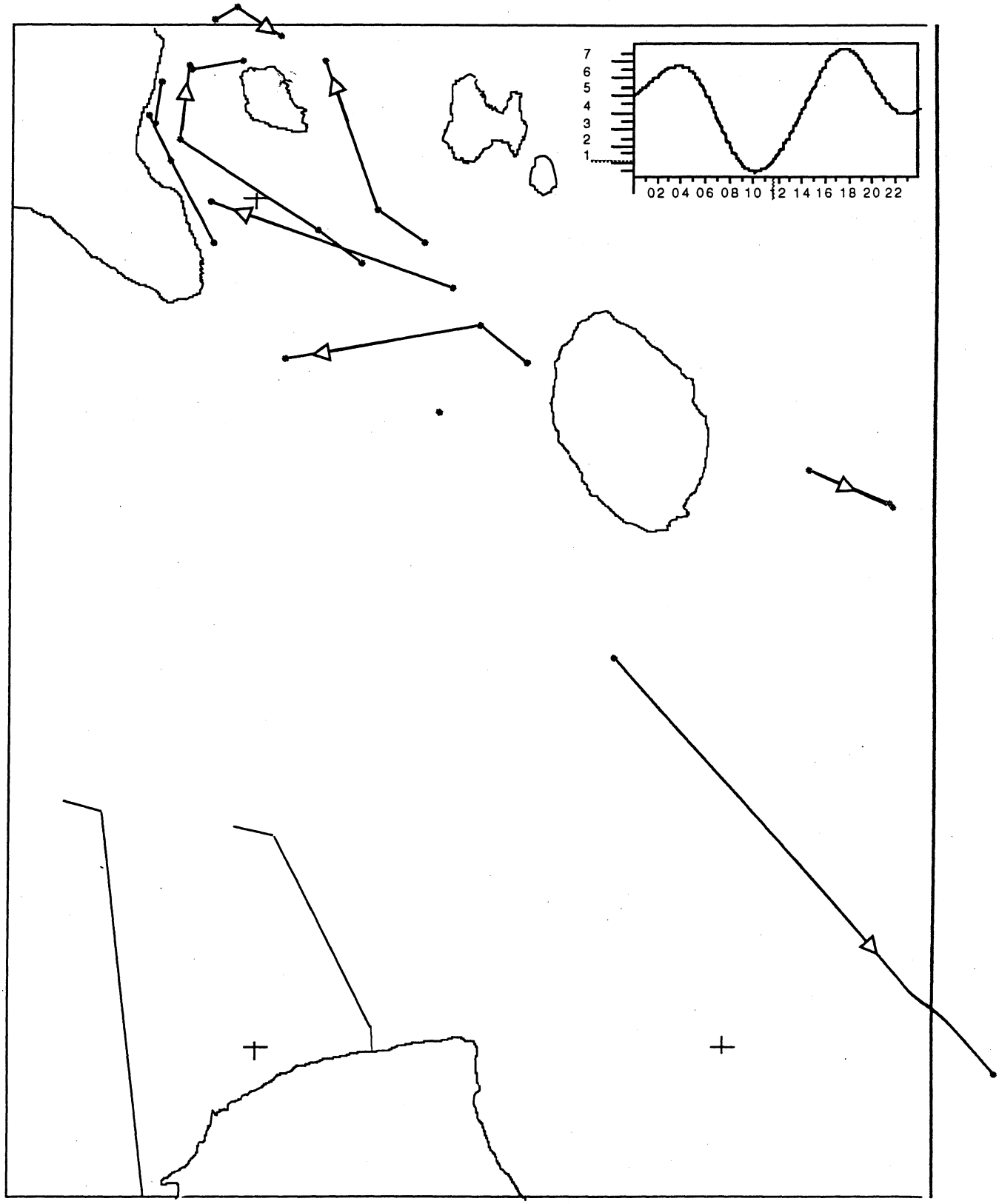


Figure 17. Movement of drift sticks between 3:51 and 6:00 pm on August 30, 1993. Sticks were deployed about 12:50 pm south of Southeast Point, Guemes Island during early flood tide (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

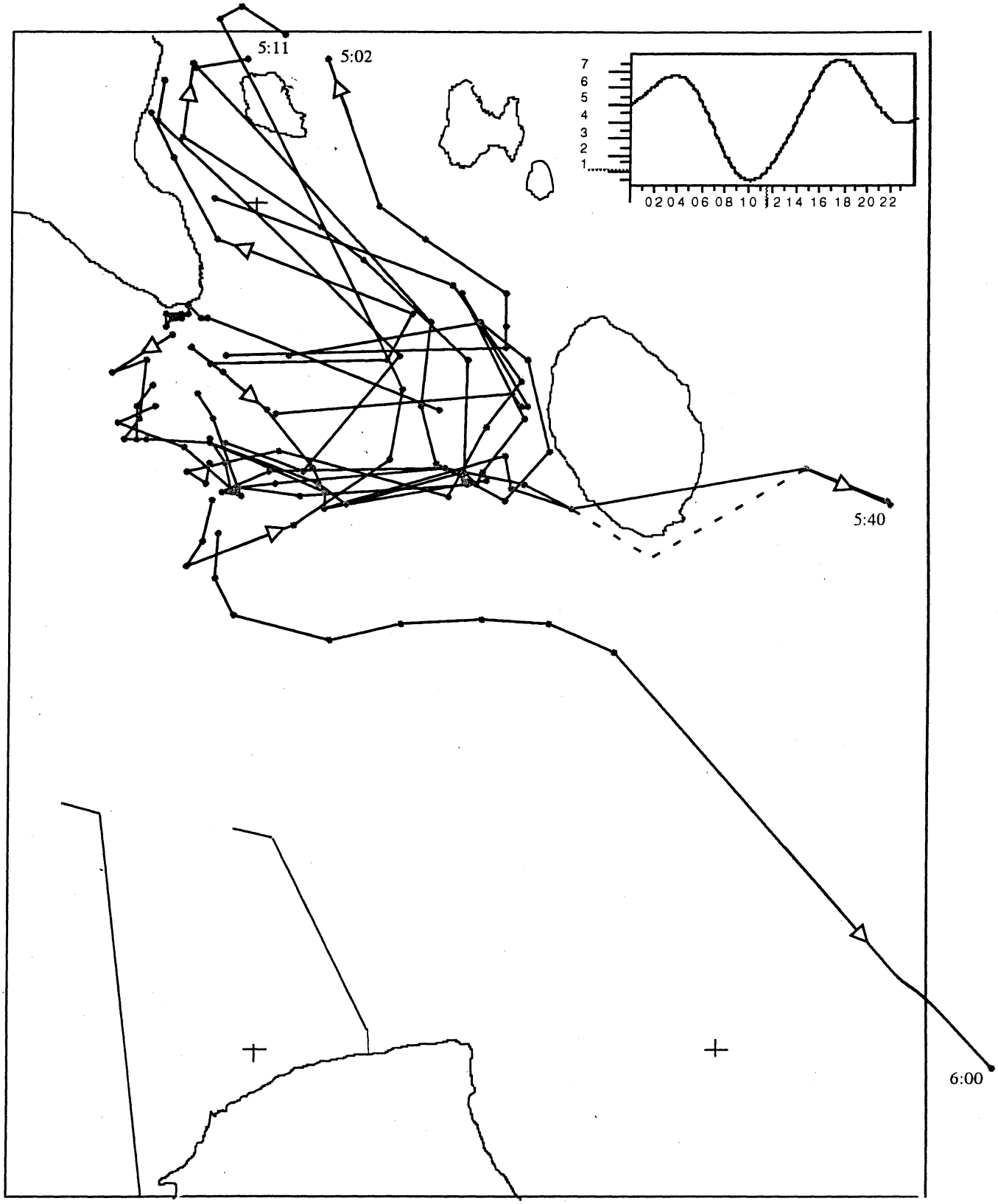


Figure 18. Movement of drift sticks from last (third) deployment until 6:00 pm on August 30, 1993. Sticks were deployed about 12:50 pm south of Southeast Point, Guemes Island during early flood tide (LLW in Guemes Channel at Anacortes was predicted for 10:10 am, HHW for 5:28 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for the day (height in feet).

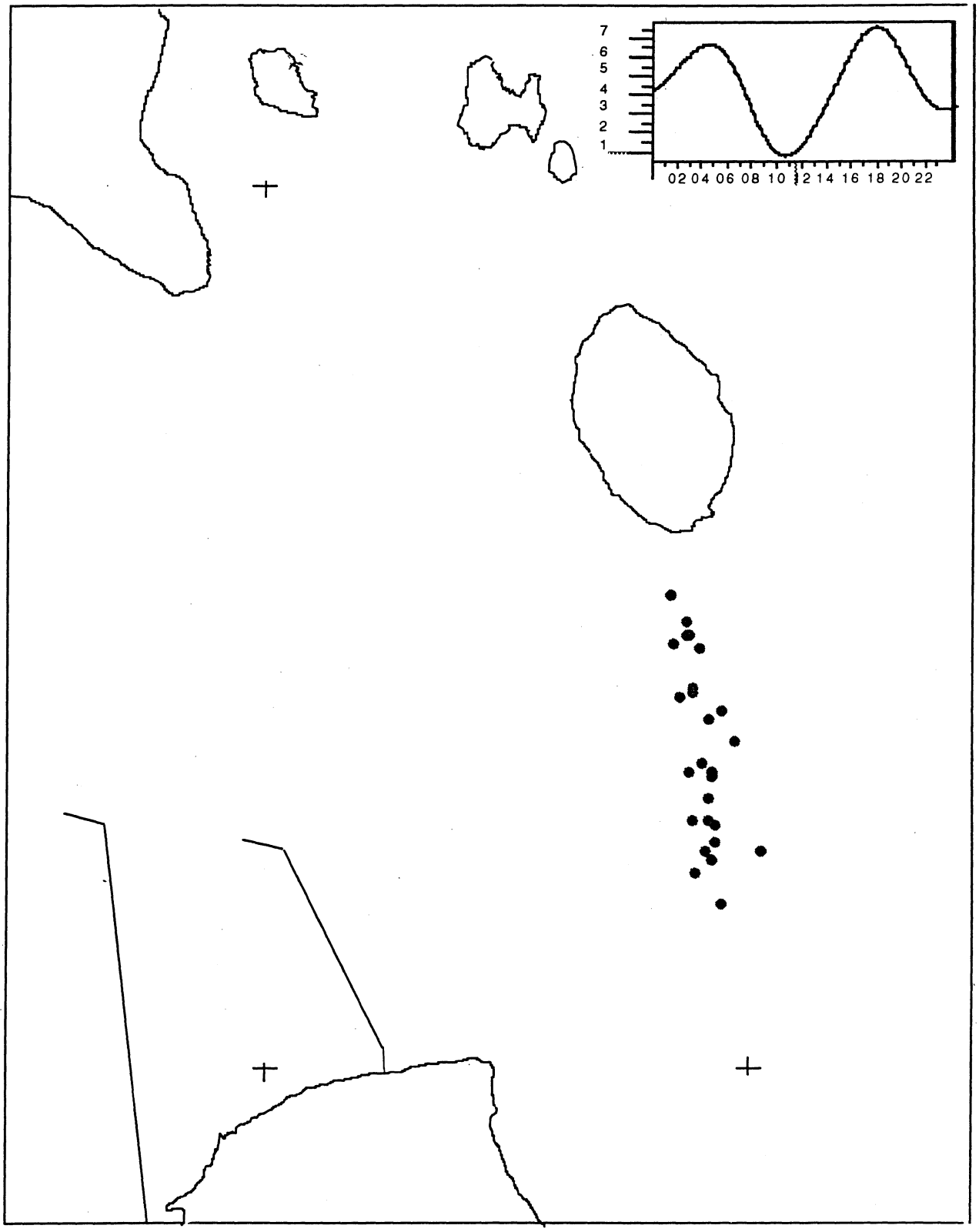


Figure 19. Locations that drift sticks were deployed during a flooding tide on August 31, 1993. At each of five sites a drift stick was released at about 10:50 am, 11:50 am, 1:00 pm, 2:00 pm, and 3:20 pm (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

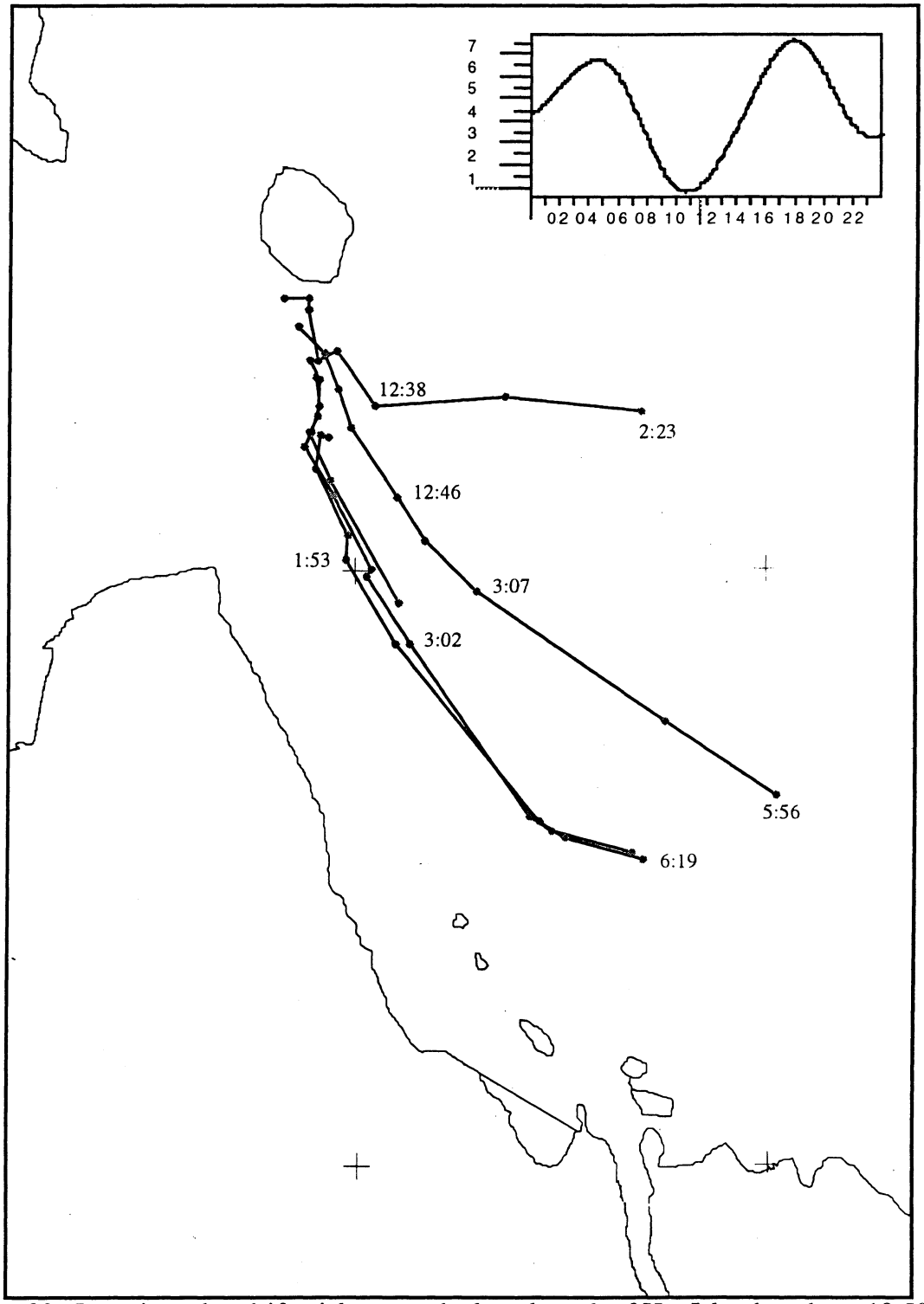


Figure 20. Locations that drift sticks were deployed south of Hat Island at about 10:50 am near the time of low water slack on August 31, 1993. (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; times (pm) indicate when each stick was last sited or retrieved; selected intermediate times are also indicated; graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

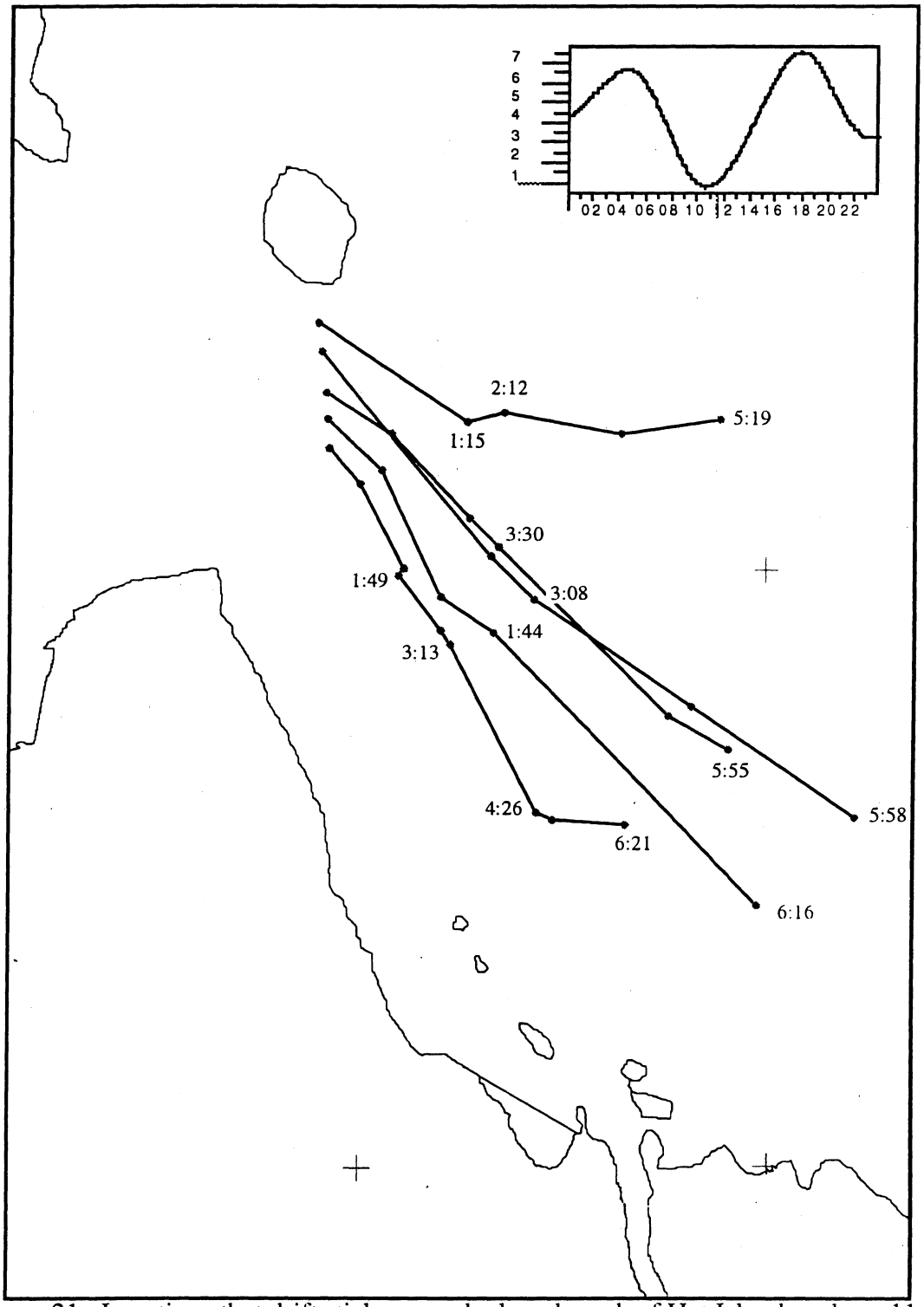


Figure 21. Locations that drift sticks were deployed south of Hat Island at about 11:50 am, approximately one hour after low water slack, on August 31, 1993. (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; times (pm) indicate when each stick was last sited or retrieved; selected intermediate times are also indicated; graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

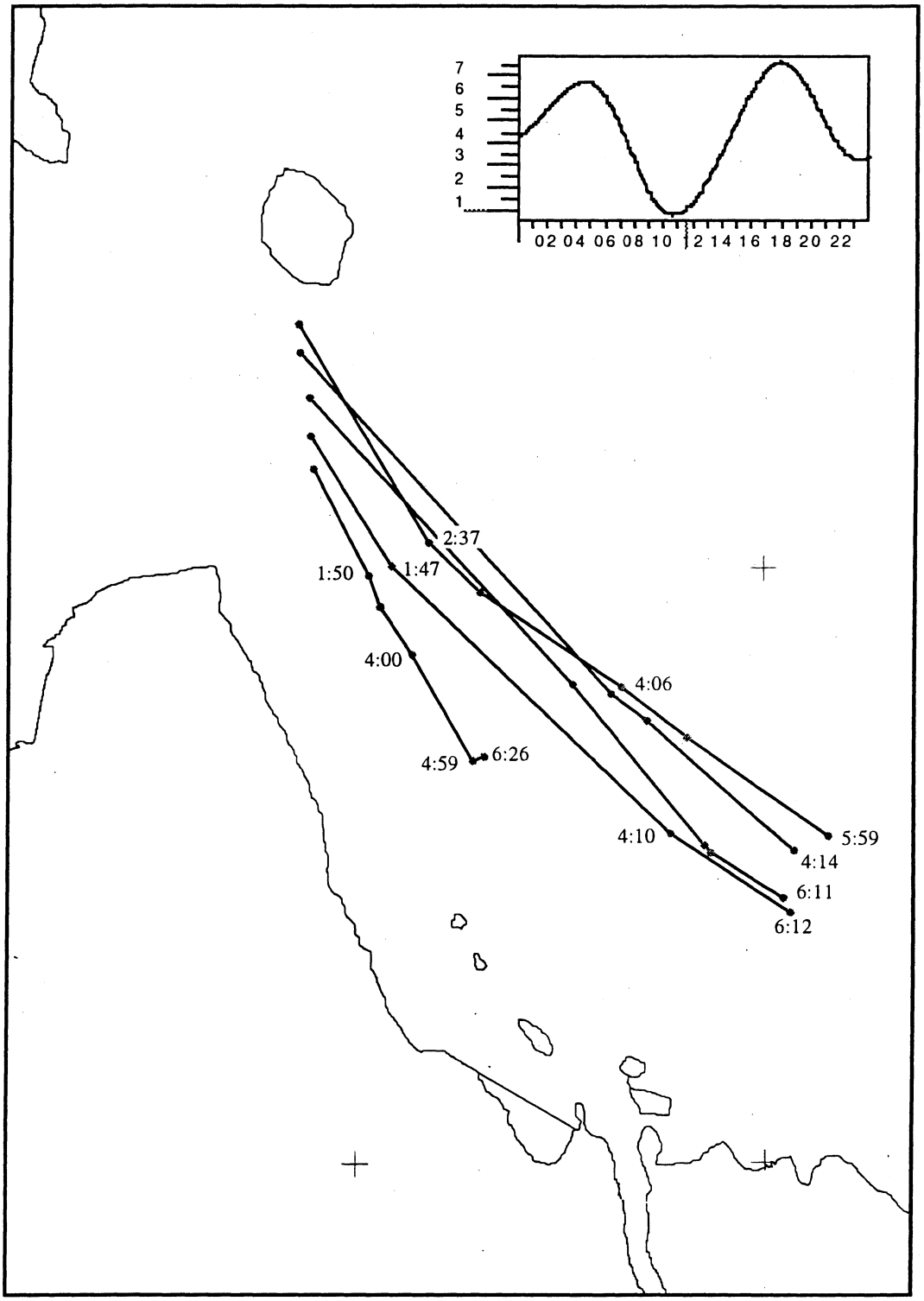


Figure 22. Locations that drift sticks were deployed south of Hat Island at about 1:00 pm, approximately two hours after low water slack, on August 31, 1993. (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; times (pm) indicate when each stick was last sited or retrieved; selected intermediate times are also indicated; graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

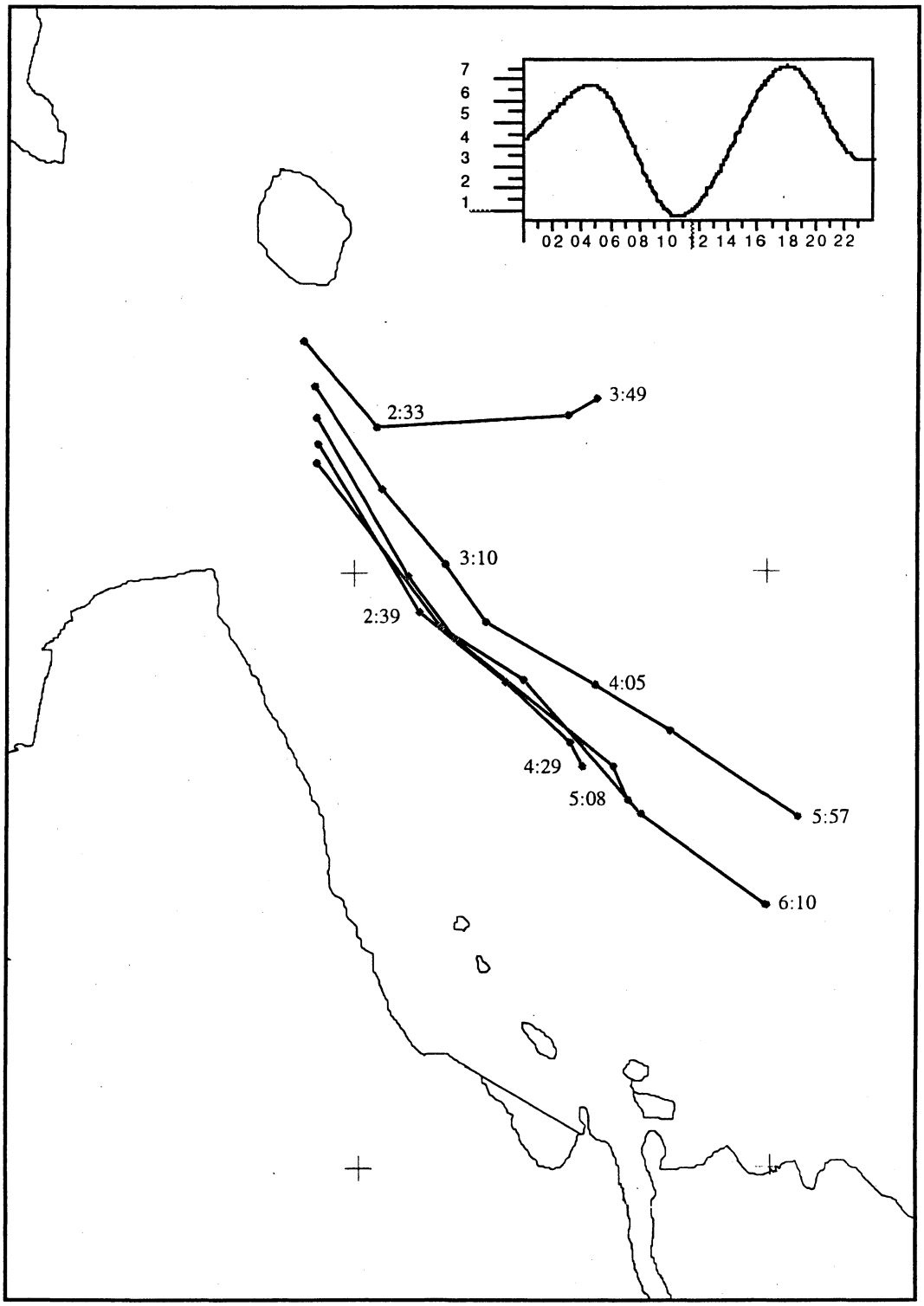


Figure 23. Locations that drift sticks were deployed south of Hat Island at about 2:00 pm, approximately three hours after low water slack, on August 31, 1993. (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; times (pm) indicate when each stick was last sited or retrieved; selected intermediate times are also indicated; graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

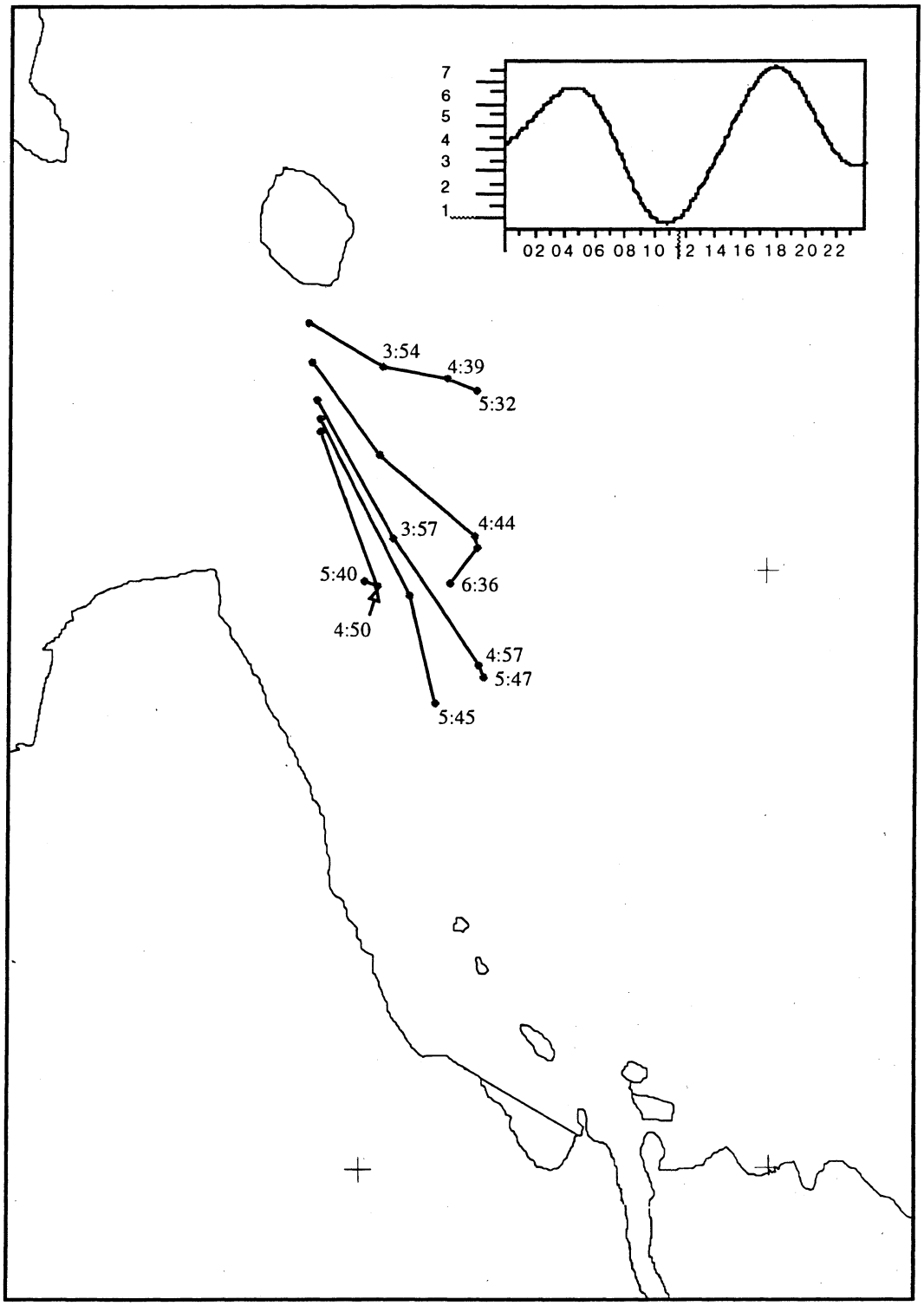


Figure 24. Locations that drift sticks were deployed south of Hat Island at about 3:20 pm, approximately four and a half hours after low water slack, on August 31, 1993. (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; times (pm) indicate when each stick was last sited or retrieved; selected intermediate times are also indicated; graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

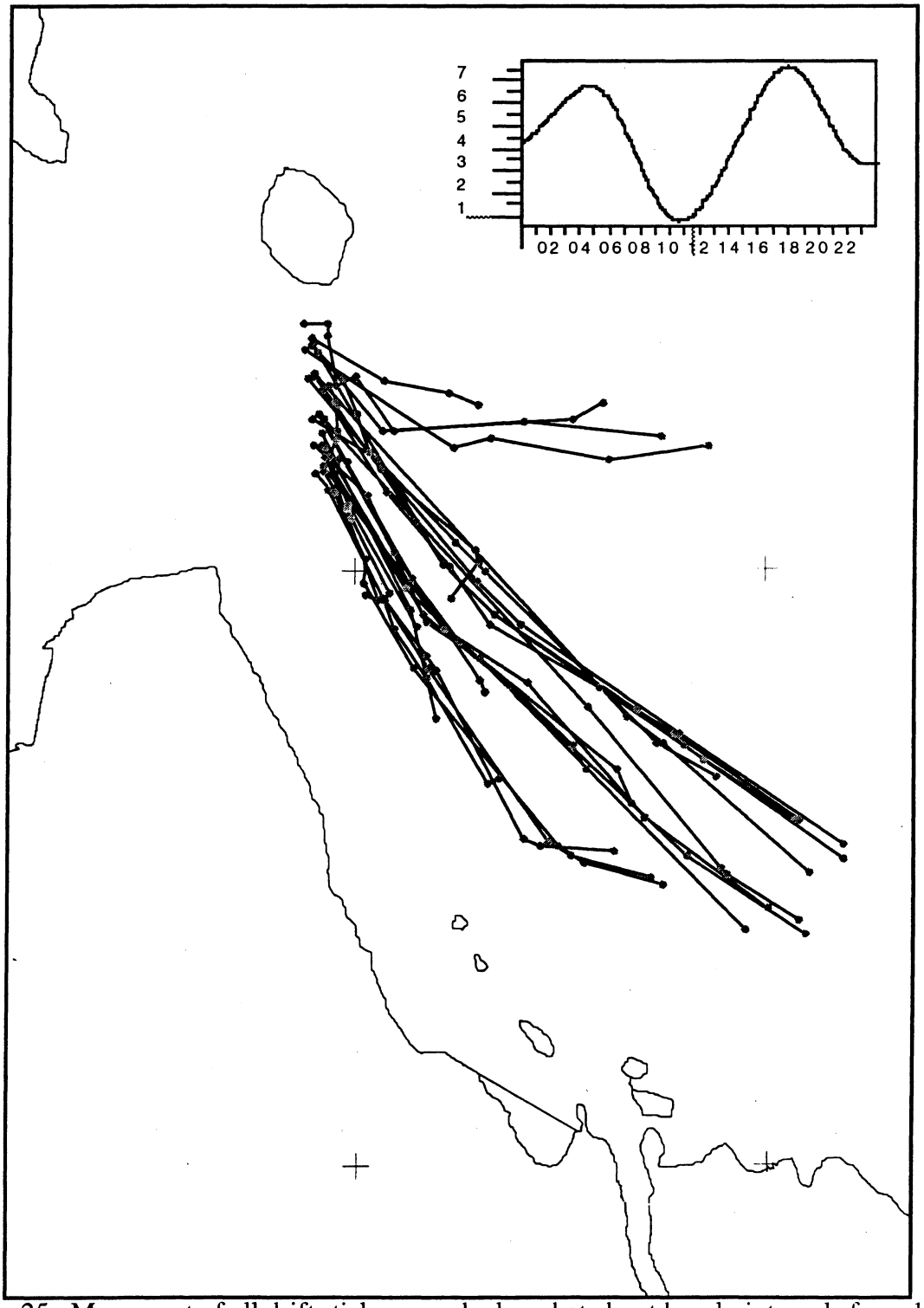


Figure 25. Movement of all drift sticks were deployed at about hourly intervals from 10:50 am to 3:20 pm south of Hat Island on August 31, 1993. (LLW in Guemes Channel at Anacortes was predicted for 10:46 am, HHW for 5:51 pm). Dots indicate where the latitude and longitude of individual drift sticks were determined; lines connect the different locations of individual drift sticks; graph in upper right indicates the predicted tidal curve at Anacortes for August 31 (height in feet).

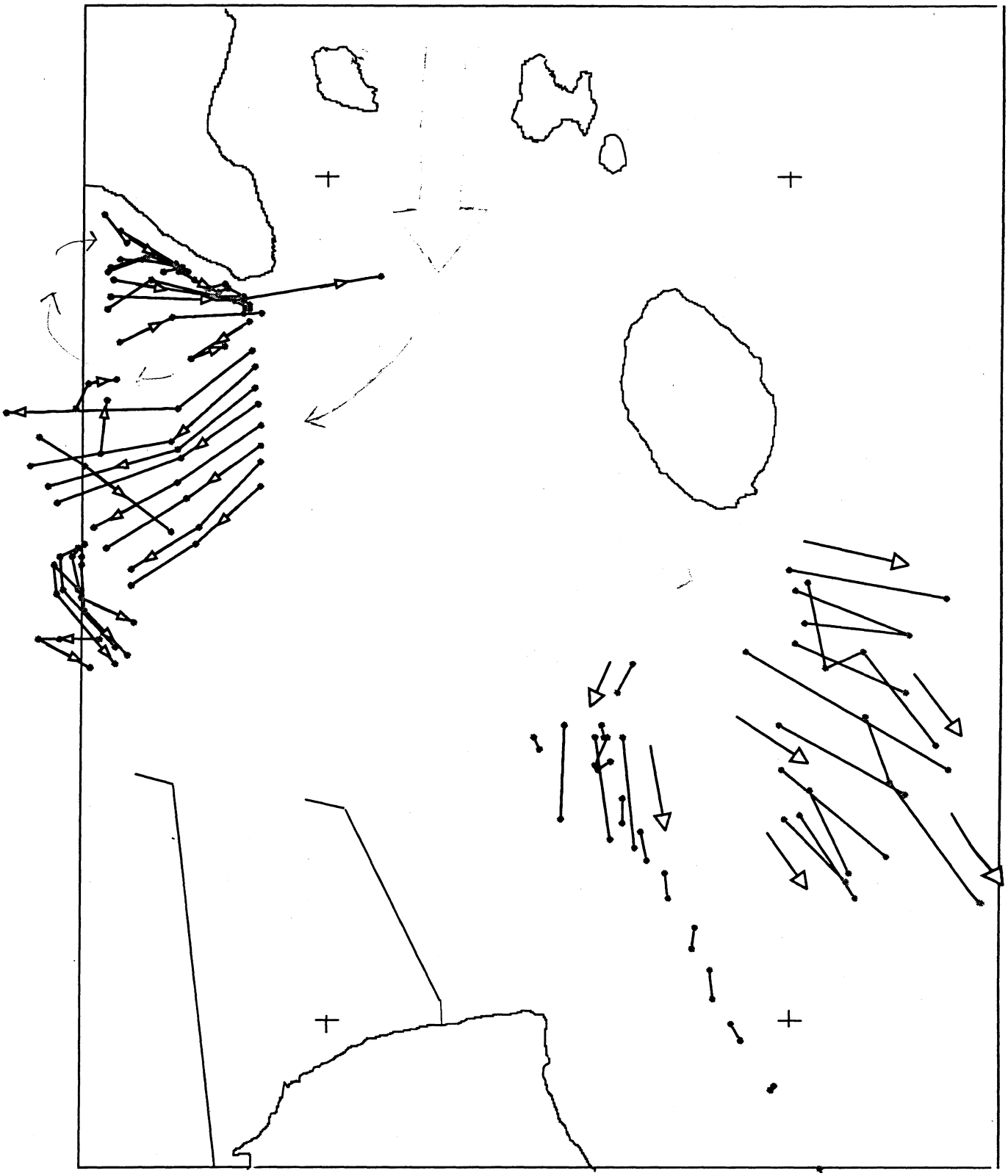


Figure 26. Movement of drift sticks during the first hour and a half after predicted lower low water in Swinomish Channel at the Padilla Bay entrance. This figure includes all drift sticks set out on July 29, August 4, 18, 30, & 31 and September 13, 1993 whose locations were recorded during the first hour and a half after predicted low water. This figure shows the movement of drift sticks in the area between Guemes Island, Hat Island and March Point; figure 28 shows the same data plus that for Swinomish Channel at a smaller scale. Inferred water movement between Saddlebag and Huckleberry Islands sketched with by hand drawn arrows.

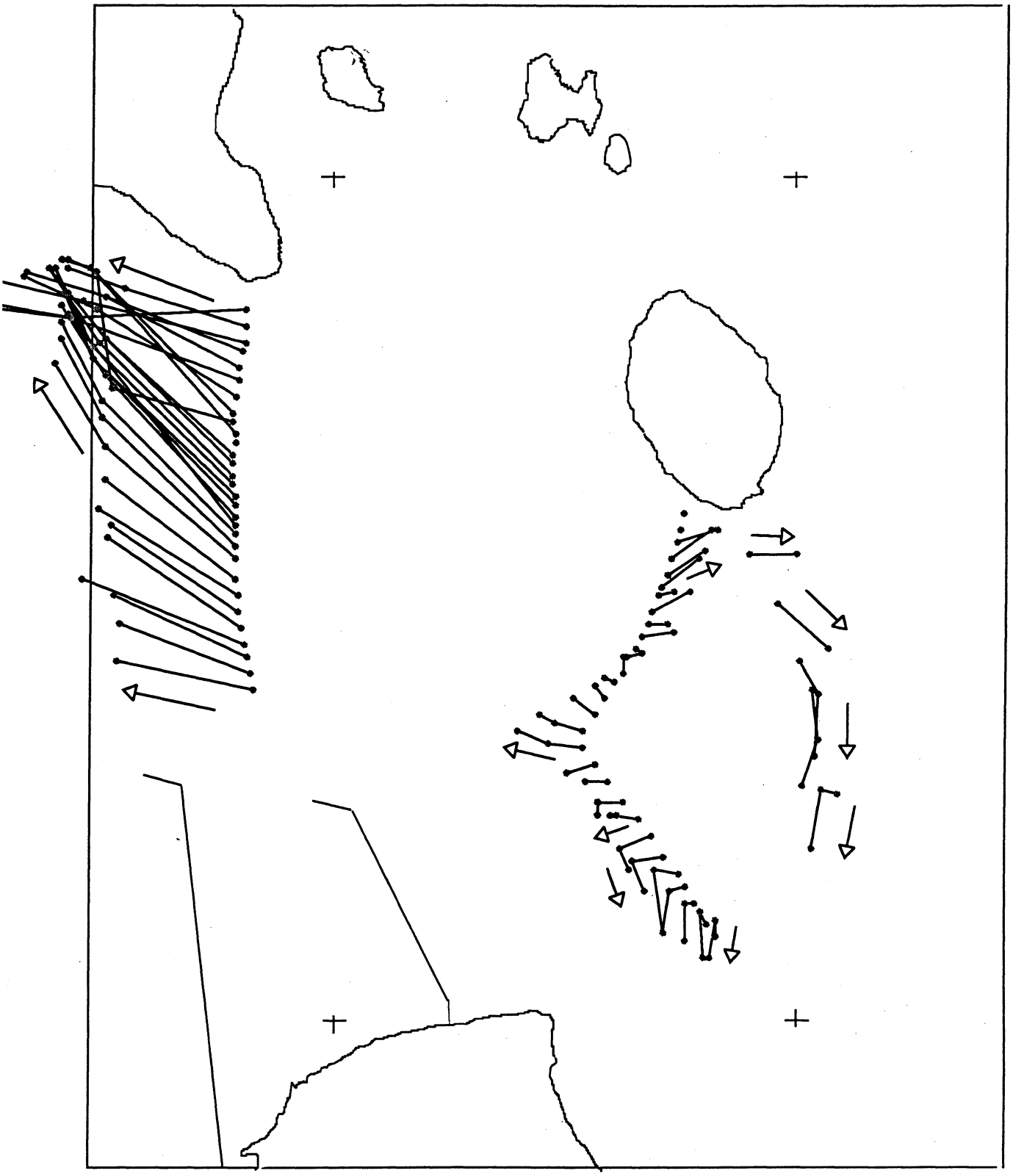


Figure 27. Movement of drift sticks during the last hour before predicted Lower Low Water in Swinomish Channel at the Padilla Bay entrance. Figure includes all drift sticks set out before predicted LLW on August 4, 18, 30 & 31.

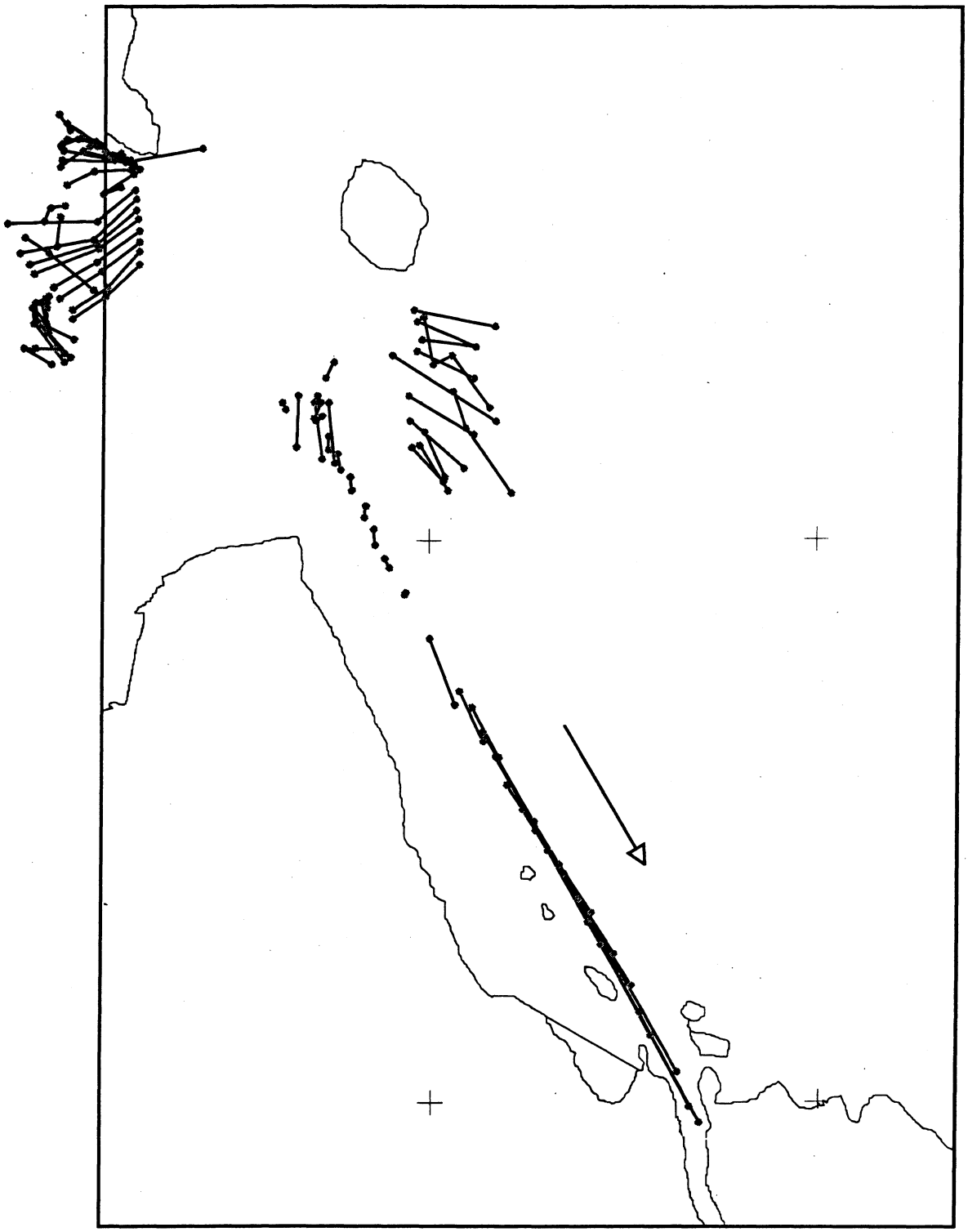


Figure 28. Movement of drift sticks during the first hour and a half after predicted lower low water in Swinomish Channel at the Padilla Bay entrance. This figure includes all drift sticks set out on July 29, August 4, 18, 30, & 31 and September 13, 1993 whose locations were recorded at least twice during the first hour and a half after predicted low water. Fig. 26 shows the same data in the area between Guemes Island, Hat Island and March Point at a larger scale.

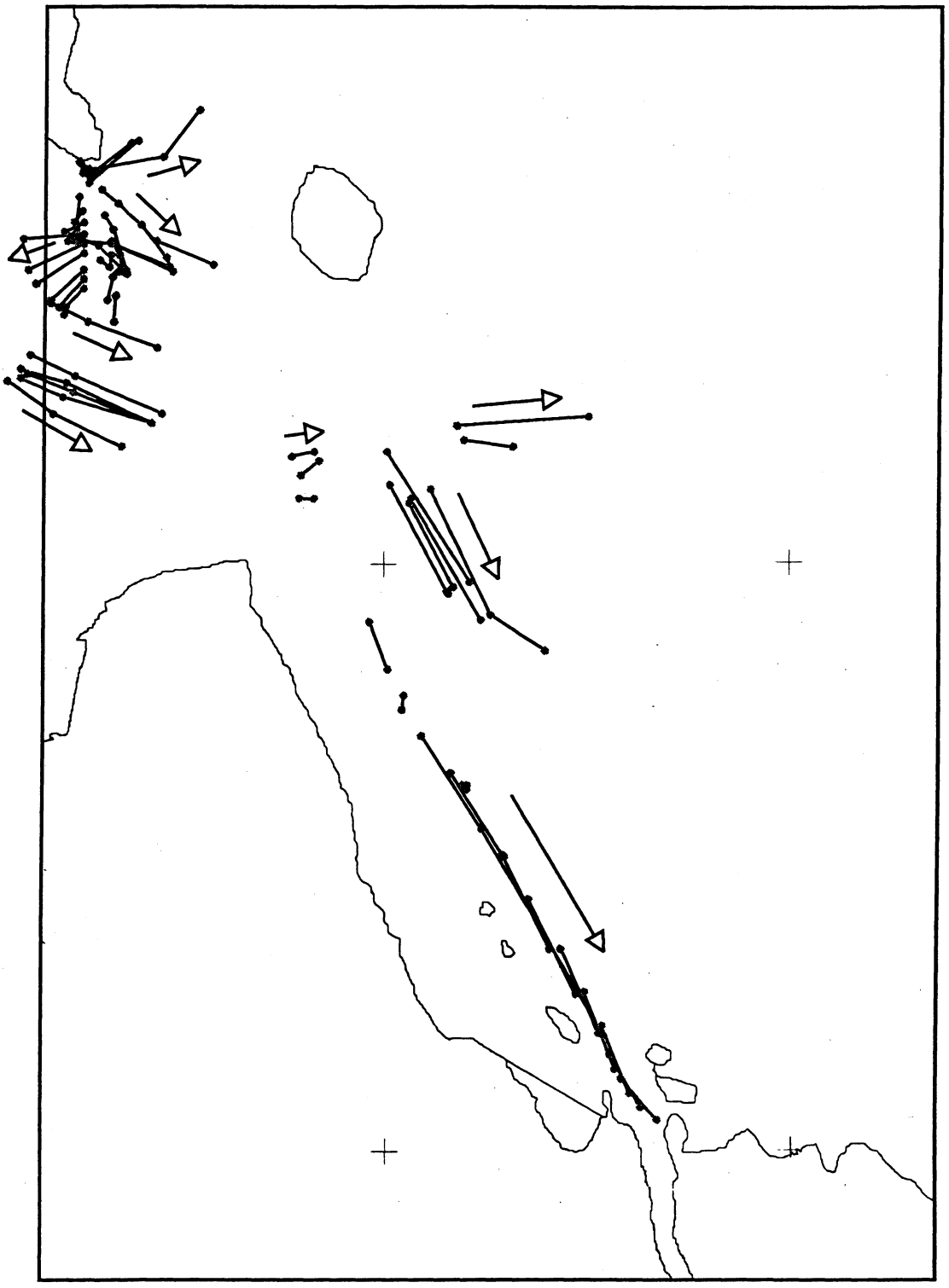


Figure 29. Movement of drift sticks from 1 hour to 2 hours 40 minutes after predicted lower low water in Swinomish Channel at the Padilla Bay entrance. This figure includes all drift sticks set out on July 29, August 4, 18, 30, & 31 and September 13,1993 whose locations were recorded at laest twice during the time between 1 hour and 2 hours 40 minutes after predicted low water.

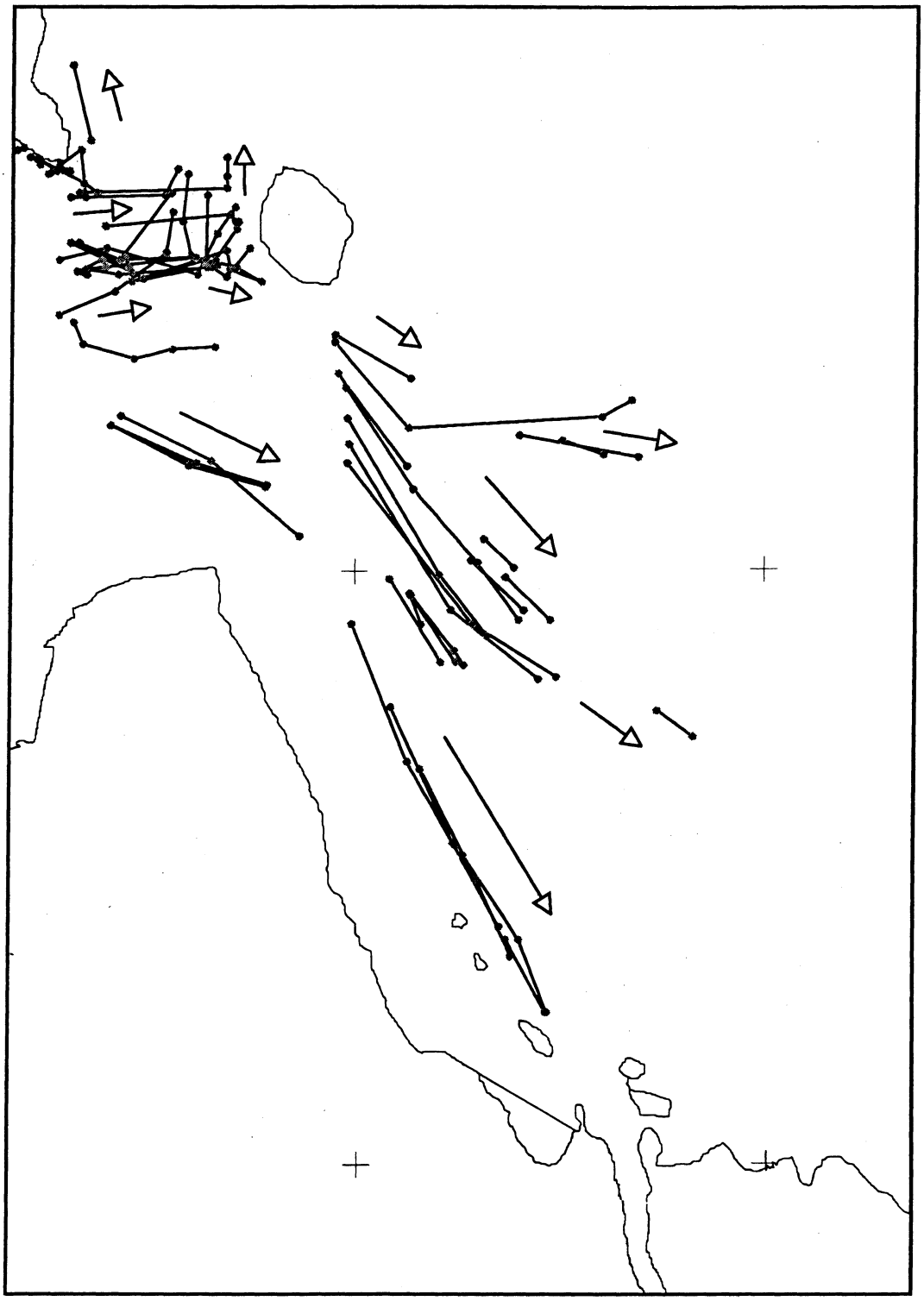


Figure 30. Movement of drift sticks during the middle third of the flood tide predicted for Swinomish Channel at the Padilla Bay entrance. This figure includes all drift sticks set out on July 29, August 4, 18, 30, & 31 and September 13, 1993 whose locations were recorded at laest twice during the time of the middle third of the flood tide.

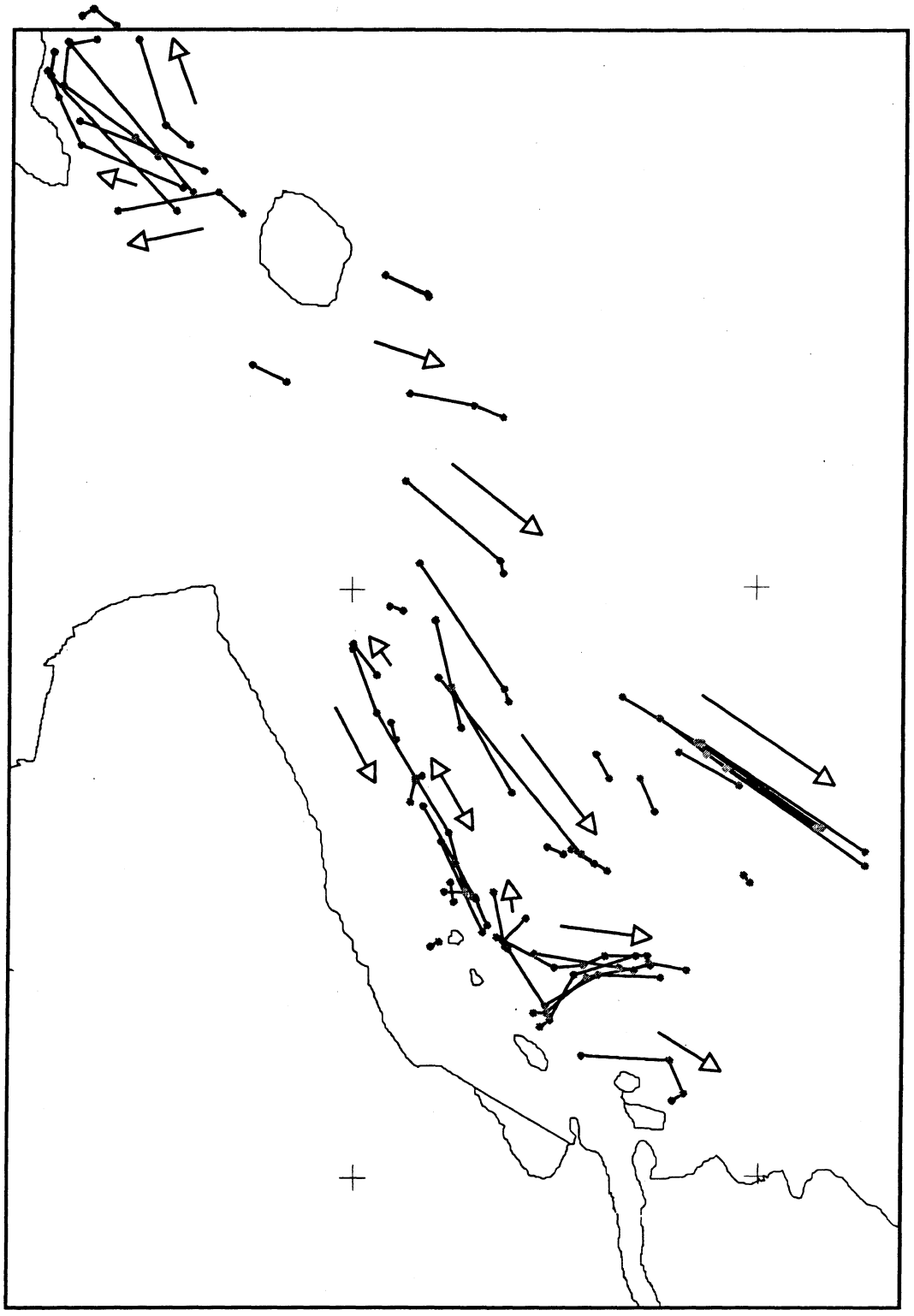


Figure 31. Movement of drift sticks during the last third of the flood tide predicted for Swinomish Channel at the Padilla Bay entrance. This figure includes all drift sticks set out on July 29, August 4, 18, 30, & 31 and September 13, 1993 whose locations were recorded at least twice during the time of the last third of the flood tide.

Appendix A. Data sheets for drift stick trials

Appendix A. Data sheets for drift stick trials

Appendix A-1. Time and location of drift sticks at deployment, relocation, and retrieval on August 4, 1993. The fifth column indicates the time relative to predicted lower low water in Swinomish Channel at the Padilla Bay entrance (positive values are hours and minutes before predicted LLW, negatives values after LLW). The last two clolumns indicate the distance and speed that the drift stick traveled from the previous location to the location on that row of the table.

drift stick #	Time	Latitude	Longitude	delta LLW (h:min)	Distance (m)	Speed (cm/s)
1	12:17 PM	30.94	33.08	0:43		
1	12:36 PM	30.99	32.96	0:24	175	15
1	1:12 PM	31.01	32.66	-0:12	374	17
1	2:23 PM	30.9	32.29	-1:23	502	12
1	7:21 PM	31.12	30.47	-6:21	2292	13
2	12:18 PM	31.03	33.03	0:42		
2	12:37 PM	31.09	32.91	0:23	186	16
2	1:10 PM	31.02	32.66	-0:10	336	17
2	2:31 PM	31.02	32.49	-1:31	211	4.3
2	5:10 PM	31.2	31	-4:10	1876	20
2	7:16 PM	31.2	30.46	-6:16	669	8.9
3	12:12 PM	30.53	33.22	0:48		
3	12:29 PM	30.53	33.29	0:31	87	8.5
3	1:49 PM	30.4	33.33	-0:49	246	5.1
3	3:13 PM	30.4	33.29	-2:13	50	1.0
3	6:30 PM	29.23	32.22	-5:30	2540	21
3	8:31 PM	29.28	32.14	-7:31	136	1.9
4	12:16 PM	30.85	33.13	0:44		
4	12:34 PM	30.84	33.11	0:26	31	2.9
4	1:05 PM	30.72	33.04	-0:05	239	13
4	3:39 PM	28.48	31.67	-2:39	4482	49
4	3:49 PM	28.18	31.43	-2:49	630	105
5	12:16 PM	30.88	33.11	0:44		
5	12:35 PM	30.89	33.01	0:25	125	11
5	1:08 PM	30.86	32.82	-0:08	242	12
5	2:10 PM	30.57	32.16	-1:10	978	26
5	2:48 PM	30.54	31.86	-1:48	376	16
5	4:18 PM	30.58	31.34	-3:18	649	12
5	4:56 PM	30.52	31.09	-3:56	329	14
5	7:08 PM	30.63	30.26	-6:08	1049	13
6	12:07 PM	30.16	32.87	0:53		
6	12:25 PM	30.2	32.87	0:35	74	6.9
6	12:46 PM	30.11	32.89	0:14	169	13
6	1:29 PM	29.69	32.74	-0:29	800	31

Appendix A-1. Continued

drift stick #	Time	Latitude	Longitude	delta LLW (h:min)	Distance (m)	Speed (cm/s)
7	12:11 PM	30.44	33.12	0:49		
7	12:28 PM	30.45	33.21	0:32	113	11
7	12:57 PM	30.45	33.19	0:03	25	1.4
7	1:37 PM	30.2	33.04	-0:37	499	21
7	6:19 PM	29.14	32.71	-5:19	2005	12
7	8:00 PM	29.25	32.48	-7:00	350	5.8
8	12:08 PM	30.24	32.94	0:52		
8	12:26 PM	30.24	32.97	0:34	37	3.4
8	12:53 PM	30.15	32.97	0:07	167	10
8	1:34 PM	29.93	32.96	-0:34	408	17
8	6:16 PM	29.11	32.8	-5:16	1532	9.1
8	8:05 PM	29.11	32.8	-7:05	0	0.0
9	12:15 PM	30.77	33.2	0:45		
9	12:33 PM	30.78	33.23	0:27	42	3.9
9	1:04 PM	30.65	33.22	-0:04	241	13
9	1:45 PM	30.38	33.18	-0:45	502	20
10	12:16 PM	30.91	33.09	0:44		
10	12:36 PM	30.91	33.03	0:24	74	6.2
10	1:09 PM	30.88	32.66	-0:09	462	23
10	2:06 PM	30.76	32.3	-1:06	498	15
11	12:14 PM	30.69	33.26	0:46		
11	12:33 PM	30.73	33.33	0:27	114	10
11	1:02 PM	30.68	33.41	-0:02	136	7.8
11	1:50 PM	30.45	33.42	-0:50	426	15
11	3:13 PM	30.4	33.29	-2:13	186	3.7
11	6:30 PM	29.23	32.17	-5:30	2573	22
11	7:01 PM	29.22	32.21	-6:01	53	2.8
12	12:17 PM	30.98	33.06	0:43		
12	12:37 PM	30.99	33.01	0:23	65	5.4
12	1:09 PM	30.93	32.63	-0:09	484	25
12	2:23 PM	30.9	32.29	-1:23	425	10
12	5:05 PM	30.96	31.05	-4:05	1541	16
14	12:12 PM	30.57	33.26	0:48		
14	12:29 PM	30.55	33.35	0:31	118	12

Appendix A-1. Continued

drift stick #	Time	Latitude	Longitude	delta LLW (h:min)	Distance (m)	Speed (cm/s)
14	6:11 PM	29.27	32.63	-5:11	2533	12
16	12:11 PM	30.48	33.17	0:49		
16	12:28 PM	30.48	33.25	0:32	99	10
16	12:58 PM	30.45	33.25	0:02	56	3.1
16	1:46 PM	30.37	33.23	-0:46	150	5.2
16	3:14 PM	30.36	33.18	-2:14	65	1.2
16	6:12 PM	29.25	32.62	-5:12	2170	20
16	8:33 PM	29.34	32.15	-7:33	606	7.2
20	12:18 PM	31.11	33	0:42		
20	12:38 PM	31.14	32.87	0:22	170	14
20	1:11 PM	31.07	32.68	-0:11	269	14
20	2:32 PM	31.05	32.5	-1:32	226	4.7
20	5:09 PM	31.18	31.08	-4:09	1776	19
20	7:19 PM	31.18	30.49	-6:19	731	9.4
21	12:16 PM	30.83	33.16	0:44		
21	12:34 PM	30.84	33.11	0:26	65	6.0
21	1:05 PM	30.72	33.04	-0:05	239	13
21	3:33 PM	29.03	32.26	-2:33	3276	37
21	6:42 PM	28.51	32.11	-5:42	981	8.7
21	6:54 PM	28.53	32.06	-5:54	72	10
22	12:15 PM	30.79	33.17	0:45		
22	12:34 PM	30.83	33.17	0:26	74	6.5
22	1:06 PM	30.72	33.08	-0:06	232	12
22	3:28 PM	29.37	32.54	-2:28	2588	30
22	8:15 PM	28.77	32.15	-7:15	1212	7.0
30	12:13 PM	30.65	33.3	0:47		
30	12:32 PM	30.67	33.39	0:28	118	10
30	12:43 PM	30.69	33.44	0:17	72	11
30	1:02 PM	30.65	33.51	-0:02	114	10
30	1:53 PM	30.62	33.49	-0:53	61	2.0
30	3:18 PM	30.1	32.99	-2:18	1145	22
30	6:14 PM	29.21	32.62	-5:14	1711	16
30	8:28 PM	29.15	32.14	-7:28	605	7.5
31	12:08 PM	30.19	32.9	0:52		

Appendix A-1. Continued

drift stick #	Time	Latitude	Longitude	delta LLW (h:min)	Distance (m)	Speed (cm/s)
31	12:25 PM	30.22	32.92	0:35	61	6.0
31	12:53 PM	30.11	32.91	0:07	204	12
31	1:31 PM	29.79	32.85	-0:31	597	26
31	6:18 PM	29.14	32.77	-5:18	1208	7.0
32	12:10 PM	30.4	33.08	0:50		
32	12:27 PM	30.37	33.18	0:33	136	13
32	12:56 PM	30.32	33.15	0:04	100	5.7
32	1:44 PM	30.34	33.22	-0:44	94	3.3
32	3:15 PM	30.34	33.17	-2:15	62	1.1
32	6:10 PM	29.35	32.66	-5:10	1939	18
32	8:30 PM	29.25	32.15	-7:30	659	7.8
33	12:10 PM	30.35	33.04	0:50		
33	12:27 PM	30.34	33.14	0:33	125	12
33	12:55 PM	30.27	33.1	0:05	139	8.3
33	1:43 PM	30.29	33.19	-0:43	118	4.1
33	3:16 PM	30.24	33.14	-2:16	111	2.0
33	6:46 PM	28.35	32.07	-5:46	3743	30
34	12:19 PM	31.14	32.99	0:41		
34	1:16 PM	31.16	32.85	-0:16	177	5.2
34	5:31 PM	31.54	31.39	-4:31	1941	13
35	12:09 PM	30.28	32.97	0:51		
35	12:26 PM	30.27	33.02	0:34	65	6.3
35	12:54 PM	30.17	33.04	0:06	187	11
35	1:36 PM	30.08	33.07	-0:36	171	6.8
37	12:18 PM	31.07	33.02	0:42		
37	12:38 PM	31.14	32.89	0:22	207	17
37	1:11 PM	31.07	32.68	-0:11	291	15
37	2:32 PM	31.07	32.49	-1:32	235	4.8
37	5:17 PM	31.24	30.92	-4:17	1971	20
37	7:21 PM	31.24	30.33	-6:21	731	10
38	12:14 PM	30.73	33.23	0:46		
38	12:33 PM	30.76	33.26	0:27	67	5.9
38	1:01 PM	30.65	33.31	-0:01	213	13
38	1:47 PM	30.4	33.26	-0:47	467	17

Appendix A-1. Continued

drift stick #	Time	Latitude	Longitude	delta LLW (h:min)	Distance (m)	Speed (cm/s)
38	3:15 PM	30.34	33.17	-2:15	157	3.0
38	6:38 PM	28.78	31.99	-5:38	3238	27
38	6:58 PM	28.7	31.97	-5:58	150	13
38	8:16 PM	28.76	32.07	-7:16	166	3.6
39	12:13 PM	30.61	33.3	0:47		
39	12:30 PM	30.62	33.41	0:30	138	13
39	12:43 PM	30.65	33.51	0:17	136	17
39	1:03 PM	30.63	33.59	-0:03	106	8.8
39	3:01 PM	30.83	33.81	-2:01	460	6.5
40	12:19 PM	31.18	32.98	0:41		
40	1:14 PM	31.17	32.79	-0:14	236	7.2
40	2:36 PM	31.18	32.66	-1:36	162	3.3
41	12:17 PM	31	33.05	0:43		
41	12:37 PM	31.07	32.93	0:23	197	16
41	1:12 PM	31.06	32.68	-0:12	310	15
41	2:28 PM	30.99	32.17	-1:28	645	14
41	7:14 PM	31.17	30.62	-6:14	1949	11
42	12:09 PM	30.31	32.99	0:51		
42	12:26 PM	30.32	33.07	0:34	101	10
42	12:54 PM	30.17	33.04	0:06	280	17
42	1:36 PM	30.11	33.09	-0:36	127	5.1

Appendix A-2. Time and location of drift sticks at deployment, relocation, and retrieval on August 18, 1993. The fifth column indicates the time relative to predicted lower low water in Guemes Channel at Anacortes (positive values are hours and minutes before predicted LLW, negatives values after LLW). The last two clolumns indicate the distance and speed that the drift stick traveled from the previous location to the location on the same row of the table.

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
1	11:03 AM	31.67	34.39	0:24		
1	11:41 AM	31.65	34.95	-0:14	695	30
1	12:01 PM	31.68	35.27	-0:34	400	33
2	11:04 AM	31.63	34.39	0:23		
2	11:38 AM	31.72	34.78	-0:11	511	25
2	11:57 AM	31.77	34.96	-0:30	242	21
2	12:30 PM	31.93	34.93	-1:03	299	15
3	11:05 AM	31.59	34.39	0:22		
3	11:40 AM	31.69	34.91	-0:13	670	32
3	12:00 PM	31.74	35.19	-0:33	359	30
4	11:05 AM	31.57	34.40	0:22		
4	11:39 AM	31.70	34.84	-0:12	596	29
4	11:59 AM	31.76	35.09	-0:32	329	27
5	11:06 AM	31.53	34.41	0:21		
5	11:39 AM	31.70	34.84	-0:12	619	31
5	11:59 AM	31.76	35.09	-0:32	329	27
6	11:06 AM	31.50	34.41	0:21		
6	11:41 AM	31.65	34.95	-0:14	725	35
6	12:01 PM	31.69	35.24	-0:34	367	31
7	11:07 AM	31.46	34.42	0:20		
7	11:40 AM	31.67	34.87	-0:13	680	34
7	12:00 PM	31.75	35.10	-0:33	321	27
8	11:07 AM	31.42	34.43	0:20		
8	11:57 AM	31.77	34.89	-0:30	863	29
8	12:04 PM	31.79	34.98	-0:37	118	28
8	12:29 PM	31.88	34.87	-1:02	215	14
8	12:51 PM	31.74	34.59	-1:24	433	33
8	1:10 PM	31.74	34.58	-1:43	12	1.1
8	1:37 PM	31.75	34.53	-2:10	65	4.0
8	2:05 PM	31.74	34.52	-2:38	22	1.3
8	3:12 PM	31.75	34.52	-3:45	19	0.5
8	3:47 PM	31.70	34.42	-4:20	155	7.4
8	4:57 PM	31.73	34.57	-5:30	194	4.6

Appendix A-2. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
9	11:07 AM	31.40	34.43	0:20		
9	11:46 AM	31.48	34.82	-0:19	505	22
9	11:56 AM	31.76	34.87	-0:29	522	87
9	12:03 PM	31.79	34.96	-0:36	125	30
9	12:29 PM	31.88	34.87	-1:02	201	13
9	12:51 PM	31.76	34.63	-1:24	371	28
9	1:10 PM	31.74	34.58	-1:43	72	6.3
9	1:37 PM	31.75	34.53	-2:10	65	4.0
9	2:05 PM	31.74	34.52	-2:38	22	1.3
9	3:12 PM	31.75	34.52	-3:45	19	0.5
9	3:46 PM	31.73	34.52	-4:19	37	1.8
9	5:00 PM	31.73	34.57	-5:33	62	1.4
10	11:08 AM	31.37	34.42	0:19		
10	11:57 AM	31.77	34.89	-0:30	942	32
10	12:04 PM	31.79	34.98	-0:37	118	28
10	12:29 PM	31.88	34.87	-1:02	215	14
10	12:50 PM	31.78	34.65	-1:23	330	26
10	1:08 PM	31.79	34.67	-1:41	31	2.9
11	11:08 AM	31.35	34.42	0:19		
11	12:22 PM	31.76	34.89	-0:55	957	22
11	12:52 PM	31.72	34.57	-1:25	403	22
11	1:11 PM	31.72	34.47	-1:44	124	11
11	1:36 PM	31.74	34.52	-2:09	72	4.8
11	2:06 PM	31.66	34.47	-2:39	161	8.9
11	2:35 PM	31.84	34.17	-3:08	499	29
11	4:17 PM	32.14	34.31	-4:50	582	10
12	11:08 AM	31.32	34.43	0:19		
12	11:42 AM	31.60	34.84	-0:15	726	36
12	12:04 PM	31.77	35.02	-0:37	386	29
12	12:30 PM	31.92	34.92	-1:03	304	20
12	12:48 PM	31.85	34.85	-1:21	156	14
12	4:46 PM	31.89	34.87	-5:19	78	0.6
13	11:09 AM	31.30	34.43	0:18		
13	11:42 AM	31.60	34.84	-0:15	753	38
13	12:04 PM	31.77	35.02	-0:37	386	29
14	11:09 AM	31.27	34.43	0:18		
14	11:43 AM	31.59	34.86	-0:16	797	39

Appendix A-2. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
14	12:06 PM	31.77	35.02	-0:39	388	28
14	12:31 PM	31.93	34.97	-1:04	303	20
15	11:09 AM	31.25	34.43	0:18		
15	11:44 AM	31.58	34.88	-0:17	827	39
15	12:07 PM	31.77	35.00	-0:40	382	28
15	12:29 PM	31.89	34.94	-1:02	234	18
16	11:10 AM	31.22	34.42	0:17		
16	11:44 AM	31.55	34.88	-0:17	836	41
16	12:08 PM	31.71	34.96	-0:41	312	22
16	12:33 PM	31.81	34.87	-1:06	216	14
16	12:50 PM	31.80	34.69	-1:23	224	22
16	2:04 PM	31.76	34.56	-2:37	177	4.0
16	3:12 PM	31.75	34.54	-3:45	31	0.8
16	3:56 PM	31.65	34.25	-4:29	404	15
16	4:26 PM	31.61	34.17	-4:59	124	6.9
17	11:10 AM	31.20	34.42	0:17		
17	11:44 AM	31.55	34.88	-0:17	863	42
17	12:07 PM	31.71	34.97	-0:40	317	23
17	12:33 PM	31.79	34.90	-1:06	172	11
17	12:49 PM	31.82	34.78	-1:22	159	17
17	1:08 PM	31.79	34.67	-1:41	147	13
17	3:09 PM	31.79	34.66	-3:42	12	0.2
17	4:54 PM	31.80	34.62	-5:27	53	0.8
18	11:10 AM	31.17	34.42	0:17		
18	11:45 AM	31.51	34.84	-0:18	817	39
18	12:08 PM	31.68	34.98	-0:41	359	26
18	12:33 PM	31.78	34.91	-1:06	205	14
18	12:48 PM	31.81	34.80	-1:21	147	16
18	1:08 PM	31.79	34.67	-1:41	165	14
18	1:35 PM	31.78	34.73	-2:08	77	4.7
18	3:11 PM	31.76	34.58	-3:44	190	3.3
18	3:44 PM	31.76	34.58	-4:17	0	0.0
19	11:11 AM	31.15	34.42	0:16		
19	12:09 PM	31.66	34.96	-0:42	1158	33
19	12:50 PM	31.78	34.68	-1:23	412	17
19	1:10 PM	31.73	34.55	-1:43	186	15
19	1:37 PM	31.74	34.52	-2:10	42	2.6
19	2:06 PM	31.70	34.51	-2:39	75	4.3

Appendix A-2. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
19	2:33 PM	31.69	34.47	-3:06	53	3.3
19	3:14 PM	31.79	34.27	-3:47	309	13
19	3:55 PM	31.59	34.24	-4:28	372	15
19	5:15 PM	32.04	33.81	-5:48	989	21
20	11:11 AM	31.13	34.42	0:16		
20	11:46 AM	31.45	34.85	-0:19	797	38
20	12:10 PM	31.64	34.98	-0:43	387	27
20	12:34 PM	31.72	34.90	-1:07	178	12
20	1:11 PM	31.71	34.50	-1:44	496	22
20	1:38 PM	31.69	34.45	-2:11	72	4.5
20	2:07 PM	31.69	34.47	-2:40	25	1.4
20	2:34 PM	31.83	34.21	-3:07	414	26
20	4:17 PM	32.15	34.32	-4:50	608	10
21	11:11 AM	31.10	34.42	0:16		
21	11:47 AM	31.41	34.85	-0:20	783	36
21	12:10 PM	31.60	34.98	-0:43	387	28
21	12:34 PM	31.69	34.91	-1:07	188	13
21	12:54 PM	31.76	34.77	-1:27	217	18
21	1:11 PM	31.71	34.50	-1:44	347	34
21	1:40 PM	31.77	34.02	-2:13	605	35
21	2:36 PM	31.97	33.80	-3:09	460	14
22	11:12 AM	31.07	34.42	0:15		
22	11:47 AM	31.34	34.84	-0:20	722	34
22	12:11 PM	31.54	35.00	-0:44	420	29
22	12:35 PM	31.61	34.87	-1:08	207	14
22	12:53 PM	31.67	34.70	-1:26	238	22
22	1:12 PM	31.68	34.41	-1:45	360	32
22	3:19 PM	31.72	33.27	-3:52	1415	19
23	11:13 AM	31.02	34.42	0:14		
23	11:48 AM	31.26	34.84	-0:21	684	33
23	12:12 PM	31.45	35.01	-0:45	410	28
23	12:36 PM	31.51	34.97	-1:09	122	8.5
23	12:57 PM	31.52	34.88	-1:30	113	9.0
23	2:09 PM	31.51	33.98	-2:42	1115	26
23	4:34 PM	29.79	32.50	-5:07	3676	42
23	5:55 PM	28.51	31.75	-6:28	2546	52
24	11:13 AM	30.98	34.41	0:14		
24	11:49 AM	31.19	34.86	-0:22	680	31

Appendix A-2. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
24	12:14 PM	31.38	35.13	-0:47	486	32
24	12:44 PM	31.38	35.13	-1:17	0	0.0
24	12:58 PM	31.31	34.98	-1:31	227	27
24	1:32 PM	31.15	34.70	-2:05	456	22
24	1:49 PM	31.07	34.47	-2:22	321	31
24	2:20 PM	30.96	34.05	-2:53	559	30
24	3:31 PM	30.36	33.07	-4:04	1646	39
24	5:52 PM	28.69	32.05	-6:25	3341	39
25	11:14 AM	30.94	34.41	0:13		
25	11:50 AM	31.15	34.82	-0:23	640	30
25	12:13 PM	31.34	34.93	-0:46	377	27
25	12:37 PM	31.47	34.91	-1:10	242	17
25	1:44 PM	31.41	34.06	-2:17	1059	26
25	2:11 PM	31.31	33.71	-2:44	472	29
25	3:28 PM	30.66	32.81	-4:01	1641	36
25	5:36 PM	29.26	30.84	-6:09	3561	46
26	11:14 AM	30.90	34.40	0:13		
26	11:50 AM	31.12	34.83	-0:23	671	31
26	12:16 PM	31.12	34.98	-0:49	186	12
26	12:41 PM	31.09	35.02	-1:14	74	5.0
26	12:59 PM	30.99	34.99	-1:32	189	17
26	1:28 PM	30.93	34.82	-2:01	238	14
26	1:50 PM	30.84	34.55	-2:23	374	28
26	2:27 PM	30.68	34.02	-3:00	721	32
26	3:00 PM	30.49	33.47	-3:33	767	39
26	3:34 PM	30.17	32.93	-4:07	894	44
26	5:53 PM	28.71	31.95	-6:26	2964	36
27	11:15 AM	30.86	34.39	0:12		
27	11:51 AM	31.02	34.91	-0:24	709	33
27	12:17 PM	31.09	34.99	-0:50	163	10
27	12:40 PM	31.07	34.99	-1:13	37	2.7
27	1:03 PM	30.96	34.98	-1:36	204	15
27	1:29 PM	30.85	34.84	-2:02	268	17
27	1:52 PM	30.77	34.56	-2:25	377	27
27	2:26 PM	30.64	34.08	-2:59	642	31
27	2:59 PM	30.48	33.56	-3:32	709	36
27	3:30 PM	30.39	33.13	-4:03	558	30
27	5:53 PM	28.71	31.95	-6:26	3438	40
28	11:15 AM	30.83	34.38	0:12		

Appendix A-2. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
28	11:51 AM	30.98	34.81	-0:24	601	28
28	12:17 PM	31.11	35.00	-0:50	337	22
28	12:41 PM	31.09	35.06	-1:14	83	5.8
28	1:00 PM	31.01	35.05	-1:33	149	13
28	1:29 PM	30.87	34.88	-2:02	334	19
28	1:50 PM	30.81	34.60	-2:23	364	29
28	2:26 PM	30.64	34.08	-2:59	717	33
28	2:59 PM	30.48	33.59	-3:32	676	34
28	3:30 PM	30.39	33.13	-4:03	594	32
28	5:49 PM	28.89	32.33	-6:22	2950	35
29	11:16 AM	30.79	34.37	0:11		
29	11:52 AM	30.91	34.79	-0:25	566	26
29	12:18 PM	31.01	35.00	-0:51	319	20
29	12:41 PM	31.07	35.08	-1:14	149	11
29	1:00 PM	31.00	35.07	-1:33	130	11
29	1:30 PM	30.83	34.88	-2:03	393	22
29	1:51 PM	30.75	34.62	-2:24	355	28
29	2:26 PM	30.64	34.08	-2:59	699	33
29	2:58 PM	30.47	33.61	-3:31	662	34
29	3:32 PM	30.38	33.14	-4:05	606	30
29	5:50 PM	28.88	32.26	-6:23	2984	36
30	11:16 AM	30.75	34.36	0:11		
30	11:52 AM	30.82	34.80	-0:25	560	26
30	12:18 PM	30.89	34.93	-0:51	207	13
30	12:42 PM	30.89	35.06	-1:15	161	11
30	1:02 PM	30.89	35.13	-1:35	87	7.2
30	1:30 PM	30.82	34.96	-2:03	247	15
30	1:54 PM	30.68	34.68	-2:27	433	30
30	2:25 PM	30.54	34.26	-2:58	581	31

Appendix A-3. Time and location of drift sticks at deployment, relocation, and retrieval on August 30, 1993. The fifth column indicates the time relative to predicted lower low water (LLW) in Guemes Channel at Anacortes (negative values are hours and minutes after predicted LLW). The last two clolumns indicate the distance and speed that the drift stick traveled from the previous location to the location on the same row of the table. Drift sticks were deployed three times on August 30 and most of them retrieved after the first two times and redeployed.

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
First deployment on August 30, 1993						
33	11:34 AM	31.59	34.44	-1:24		
33	11:45 AM	31.45	34.68	-1:35	395	60
33	12:10 PM	31.44	35.24	-2:00	694	46
34	11:35 AM	31.55	34.43	-1:25		
34	11:48 AM	31.37	34.7	-1:38	472	61
34	12:09 PM	31.31	35.16	-1:59	581	46
35	11:35 AM	31.5	34.43	-1:25		
35	11:47 AM	31.35	34.68	-1:37	416	58
35	12:08 PM	31.26	35.1	-1:58	546	43
36	11:35 AM	31.46	34.42	-1:25		
36	11:47 AM	31.33	34.67	-1:37	392	54
36	12:08 PM	31.22	35.07	-1:58	536	43
37	11:36 AM	31.41	34.41	-1:26		
37	11:49 AM	31.27	34.68	-1:39	423	54
37	12:06 PM	31.16	34.95	-1:56	392	38
38	11:36 AM	31.36	34.41	-1:26		
38	11:49 AM	31.23	34.65	-1:39	383	49
38	12:05 PM	31.11	34.91	-1:55	391	41
39	11:36 AM	31.32	34.41	-1:26		
39	11:50 AM	31.16	34.61	-1:40	386	46
39	12:04 PM	31.06	34.83	-1:54	330	39
40	11:37 AM	31.26	34.41	-1:27		
40	11:50 AM	31.12	34.62	-1:40	367	47
40	12:04 PM	31.02	34.83	-1:54	319	38

Appendix A-3. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
Second deployment on August 30, 1993						
35	12:22 PM	31.44	34.50	-2:12		
35	12:45 PM	31.42	34.87	-2:35	460	33
36	12:22 PM	31.40	34.50	-2:12		
36	12:44 PM	31.29	34.84	-2:34	468	35
37	12:23 PM	31.36	34.50	-2:13		
37	12:44 PM	31.23	34.79	-2:34	433	34
38	12:23 PM	31.29	34.50	-2:13		
38	12:43 PM	31.16	34.70	-2:33	346	29
39	12:24 PM	31.25	34.50	-2:14		
39	12:42 PM	31.13	34.65	-2:32	290	27
40	12:24 PM	31.21	34.50	-2:14		
40	12:38 PM	31.13	34.61	-2:28	201	24
40	12:42 PM	31.10	34.62	-2:32	57	24
Last deployment on August 30, 1993						
31	11:33 AM	31.70	34.45	-1:23		
31	11:43 AM	31.68	34.47	-1:33	45	7.4
31	12:18 PM	31.71	34.47	-2:08	56	2.6
31	12:33 PM	31.71	34.42	-2:23	62	6.9
31	12:50 PM	31.70	34.42	-2:40	19	1.8
31	1:17 PM	31.70	34.44	-3:07	25	1.5
31	1:46 PM	31.71	34.40	-3:36	53	3.0
31	2:19 PM	31.73	34.40	-4:09	37	1.9
31	2:36 PM	31.70	34.36	-4:26	74	7.3
31	3:00 PM	31.70	34.34	-4:50	25	1.7
31	5:53 PM	31.48	33.59	-7:43	1015	10
32	11:34 AM	31.66	34.45	-1:24		
32	11:45 AM	31.57	34.64	-1:35	288	44
32	12:20 PM	31.60	34.53	-2:10	146	7.0
32	12:37 PM	31.46	34.55	-2:27	260	26
32	12:48 PM	31.41	34.60	-2:38	111	17
32	1:05 PM	31.41	34.53	-2:55	87	8.5
32	1:16 PM	31.40	34.33	-3:06	249	38
32	1:30 PM	31.30	33.98	-3:20	472	56
32	1:40 PM	31.25	33.89	-3:30	145	24
32	2:25 PM	31.33	33.51	-4:15	494	18
32	2:27 PM	31.30	33.47	-4:17	74	62
32	2:53 PM	31.33	33.45	-4:43	61	3.9

Appendix A-3. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
32	3:16 PM	31.46	33.32	-5:06	290	21
32	3:56 PM	31.76	33.52	-5:46	608	25
33	12:21 PM	31.54	34.51	-2:11		
33	12:36 PM	31.49	34.56	-2:26	111	12
33	12:49 PM	31.41	34.56	-2:39	148	19
33	1:05 PM	31.41	34.53	-2:55	37	3.9
33	1:16 PM	31.40	34.33	-3:06	249	38
33	1:31 PM	31.28	33.96	-3:21	510	57
33	1:39 PM	31.24	33.96	-3:29	74	15
33	2:27 PM	31.31	33.44	-4:17	657	23
33	2:50 PM	31.30	33.50	-4:40	77	5.6
33	2:54 PM	31.31	33.51	-4:44	22	9.3
33	3:27 PM	31.60	33.50	-5:17	537	27
33	4:00 PM	31.84	33.84	-5:50	612	31
33	4:11 PM	31.92	33.98	-6:01	228	35
33	4:47 PM	32.14	34.42	-6:37	681	32
33	5:14 PM	32.32	34.39	-7:04	335	21
34	12:22 PM	31.49	34.50	-2:12		
34	12:48 PM	31.45	34.62	-2:38	165	11
34	1:03 PM	31.39	34.41	-2:53	283	31
34	1:14 PM	31.28	34.25	-3:04	284	43
34	1:27 PM	31.29	34.24	-3:17	22	2.9
34	1:41 PM	31.27	34.04	-3:31	251	30
34	2:26 PM	31.30	33.47	-4:16	709	26
34	2:49 PM	31.35	33.60	-4:39	186	13
34	3:06 PM	31.49	33.65	-4:56	267	26
34	3:26 PM	31.69	33.62	-5:16	372	31
34	4:52 PM	32.31	34.38	-6:42	1485	29
34	5:08 PM	32.33	34.22	-6:58	202	21
35	1:48 PM	31.61	34.28	-3:38		
35	2:32 PM	31.63	33.38	-4:22	1116	42
35	2:57 PM	31.68	33.38	-4:47	93	6.2
35	3:19 PM	31.76	33.38	-5:09	148	11
35	3:58 PM	31.89	33.64	-5:48	402	17
35	4:13 PM	31.97	33.79	-6:03	238	26
35	5:02 PM	32.33	33.96	-6:52	699	24
36	1:49 PM	31.47	34.12	-3:39		
36	2:31 PM	31.52	33.36	-4:21	946	38
36	2:56 PM	31.49	33.33	-4:46	67	4.5
36	3:16 PM	31.49	33.31	-5:06	25	2.1
36	3:56 PM	31.76	33.52	-5:46	564	23

Appendix A-3. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
37	12:57 PM	31.41	34.33	-2:47		
37	1:02 PM	31.35	34.28	-2:52	127	42
37	1:14 PM	31.28	34.26	-3:04	132	18
37	1:27 PM	31.29	34.24	-3:17	31	4.0
37	1:42 PM	31.30	34.12	-3:32	150	17
37	2:25 PM	31.34	33.57	-4:15	686	27
37	2:52 PM	31.30	33.32	-4:42	319	20
37	3:13 PM	31.24	33.17	-5:03	217	17
37	4:30 PM	31.34	32.42	-6:20	948	21
37	5:40 PM	31.26	32.16	-7:30	355	8.4
38	12:56 PM	31.35	34.33	-2:46		
38	1:02 PM	31.30	34.34	-2:52	93	26
38	1:28 PM	31.33	34.40	-3:18	93	6.0
38	1:43 PM	31.38	34.11	-3:33	371	41
38	2:28 PM	31.27	33.56	-4:18	711	26
38	2:55 PM	31.44	33.44	-4:45	348	21
38	3:17 PM	31.55	33.33	-5:07	245	19
38	3:57 PM	31.78	33.55	-5:47	506	21
38	5:22 PM	31.99	34.32	-7:12	1030	20
39	12:55 PM	31.26	34.32	-2:45		
39	1:09 PM	31.16	34.35	-2:59	189	22
39	1:36 PM	31.10	34.40	-3:26	127	7.9
39	2:16 PM	31.20	34.06	-4:06	460	19
39	2:49 PM	31.36	33.75	-4:39	485	25
39	3:07 PM	31.53	33.71	-4:57	319	30
39	4:53 PM	32.43	34.31	-6:43	1825	29
39	5:00 PM	32.46	34.24	-6:50	103	25
39	5:11 PM	32.39	34.10	-7:01	217	33
40	12:54 PM	31.18	34.30	-2:44		
40	1:09 PM	31.07	34.31	-2:59	204	23
40	1:38 PM	30.98	34.25	-3:28	183	10
40	2:14 PM	30.92	33.94	-4:04	400	19
40	2:41 PM	30.96	33.71	-4:31	294	18
40	3:10 PM	30.97	33.45	-5:00	323	19
40	3:30 PM	30.96	33.24	-5:20	261	22
40	3:51 PM	30.89	33.03	-5:41	291	23
40	6:00 PM	29.89	31.86	-7:50	2352	30
41	12:52 PM	31.63	34.39	-2:42		
41	12:58 PM	31.57	34.29	-2:48	166	46
41	1:06 PM	31.48	34.15	-2:56	241	50
41	1:21 PM	31.34	34.00	-3:11	319	35
41	1:31 PM	31.28	33.96	-3:21	122	20

Appendix A-3. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
41	1:39 PM	31.24	33.96	-3:29	74	15
41	2:29 PM	31.37	33.38	-4:19	758	25
41	2:51 PM	31.29	33.36	-4:41	150	11
41	3:13 PM	31.24	33.17	-5:03	253	19
41	4:30 PM	31.34	32.42	-6:20	948	21
41	5:38 PM	31.25	32.15	-7:28	374	9.2
42	12:52 PM	31.52	34.37	-2:42		
42	12:57 PM	31.46	34.32	-2:47	127	42
42	1:13 PM	31.27	34.23	-3:03	369	38
42	1:28 PM	31.28	34.29	-3:18	77	8.5
42	1:43 PM	31.33	34.14	-3:33	208	23
42	2:25 PM	31.34	33.57	-4:15	707	28
42	2:51 PM	31.26	33.38	-4:41	278	18
42	3:15 PM	31.38	33.24	-5:05	282	20
42	3:55 PM	31.60	33.31	-5:45	417	17
42	4:17 PM	31.69	33.46	-6:07	250	19
42	5:25 PM	31.61	34.08	-7:15	782	19
43	2:38 PM	31.59	34.33	-4:28		
43	3:04 PM	31.60	33.76	-4:54	707	45
43	3:25 PM	31.71	33.68	-5:15	227	18
43	4:03 PM	31.89	34.31	-5:53	849	37
43	4:48 PM	32.09	34.45	-6:38	409	15
43	5:18 PM	32.20	34.52	-7:08	221	12
44	2:39 PM	31.40	34.28	-4:29		
44	2:48 PM	31.33	34.03	-4:38	336	62
44	3:25 PM	31.61	33.72	-5:15	645	29
44	4:45 PM	32.18	34.50	-6:35	1431	30
44	5:16 PM	32.28	34.48	-7:06	187	10

Appendix A-4. Time and location of drift sticks at deployment, relocation, and retrieval on August 31, 1993. The fifth column indicates the time relative to predicted lower low water (LLW) in Guemes Channel at Anacortes (negative values are hours and minutes after predicted LLW). The last two clolumns indicate the distance and speed that the drift stick traveled from the previous location (recorded on the row above) to the location on the same row.

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
40	10:49 AM	31.08	32.77	-0:03		
40	11:06 AM	31.08	32.62	-0:20	186	18
40	11:32 AM	31.03	32.62	-0:46	93	5.9
40	11:45 AM	30.82	32.56	-0:59	396	51
40	12:00 PM	30.86	32.44	-1:14	166	18
40	12:38 PM	30.63	32.2	-1:52	520	23
40	1:17 PM	30.67	31.4	-2:31	994	42
40	2:23 PM	30.61	30.56	-3:37	1047	26
41	10:50 AM	30.96	32.68	-0:04		
41	11:11 AM	30.85	32.52	-0:25	284	23
41	11:31 AM	30.7	32.43	-0:45	299	25
41	11:58 AM	30.54	32.35	-1:12	312	19
41	12:46 PM	30.25	32.06	-2:00	646	22
41	2:37 PM	30.07	31.89	-3:51	394	5.9
41	3:07 PM	29.86	31.57	-4:21	555	31
41	4:32 PM	29.32	30.41	-5:46	1751	34
41	5:56 PM	29.01	29.73	-7:10	1020	20
42	10:51 AM	30.82	32.61	-0:05		
42	11:13 AM	30.74	32.55	-0:27	166	13
42	11:29 AM	30.59	32.56	-0:43	278	29
42	11:55 AM	30.52	32.61	-1:09	144	9.2
42	12:30 PM	30.32	32.48	-1:44	404	19
42	1:28 PM	29.81	32.05	-2:42	1084	31
43	10:52 AM	30.75	32.57	-0:06		
43	11:14 AM	30.63	32.55	-0:28	224	17
43	11:28 AM	30.52	32.6	-0:42	213	25
43	11:56 AM	30.46	32.64	-1:10	122	7.2
43	12:28 PM	30.26	32.46	-1:42	432	23
43	1:26 PM	29.95	32.22	-2:40	647	19
43	1:49 PM	29.92	32.25	-3:03	67	4.8
43	3:02 PM	29.64	31.98	-4:16	617	14
43	4:27 PM	28.92	31.24	-5:41	1618	32
43	5:06 PM	28.86	31.1	-6:20	206	8.8
43	6:19 PM	28.77	30.61	-7:33	630	14

Appendix A-4. Continued

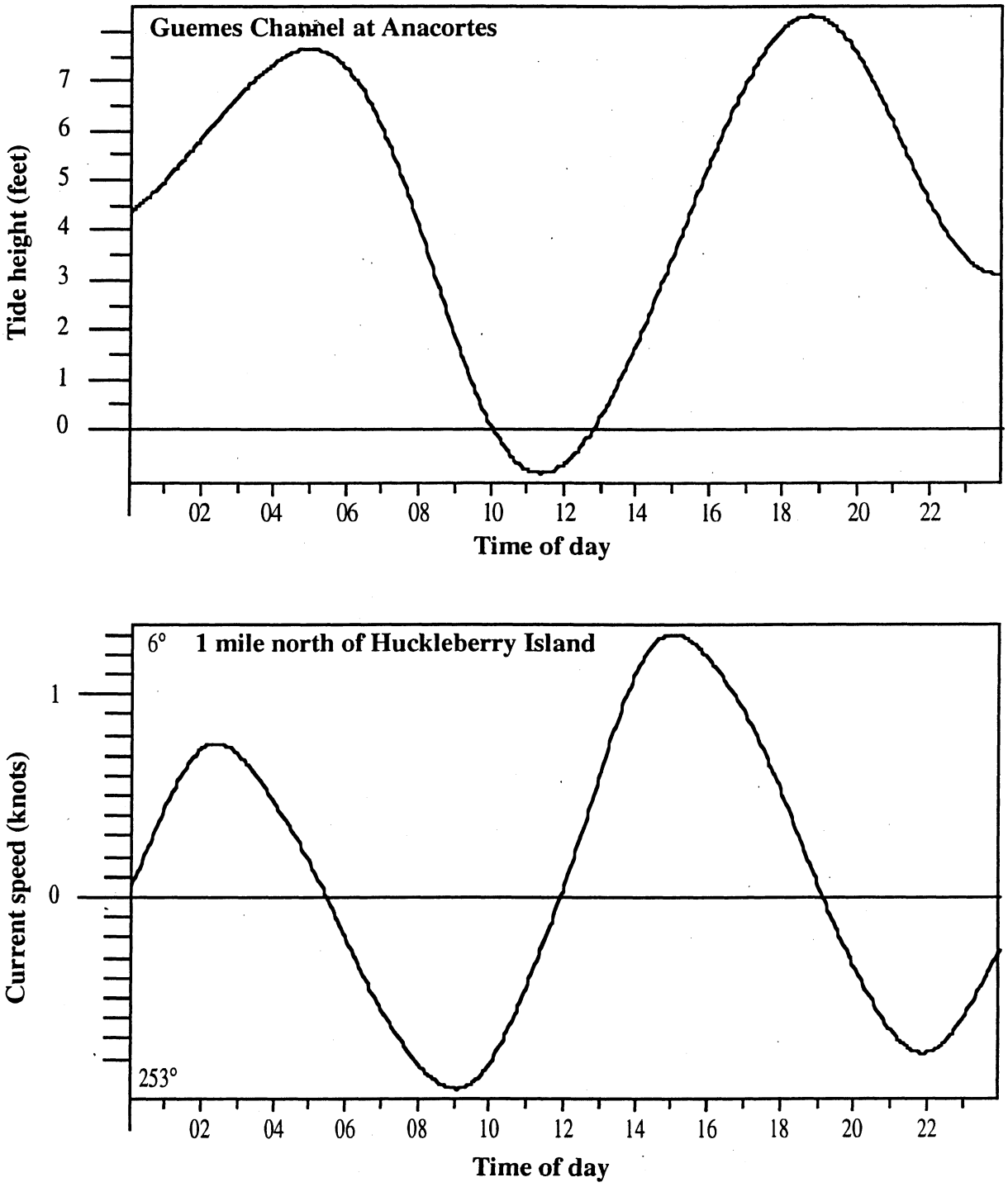
drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
44	10:53 AM	30.5	32.49	-0:07		
44	11:16 AM	30.51	32.54	-0:30	65	4.7
44	11:28 AM	30.37	32.57	-0:42	262	36
44	12:22 PM	30.09	32.37	-1:36	575	18
44	1:53 PM	29.99	32.38	-3:07	186	3.4
44	3:04 PM	29.64	32.07	-4:18	753	18
44	4:27 PM	28.9	31.18	-5:41	1759	35
44	5:06 PM	28.83	31.02	-6:20	237	10
44	6:18 PM	28.74	30.54	-7:32	618	14
45	11:48 AM	30.45	32.69	-1:02		
45	12:32 PM	30.3	32.49	-1:46	372	14
45	1:26 PM	29.95	32.22	-2:40	729	23
45	1:49 PM	29.92	32.25	-3:03	67	4.8
45	3:01 PM	29.69	31.99	-4:15	534	12
45	3:13 PM	29.63	31.93	-4:27	134	19
45	4:26 PM	28.93	31.39	-5:40	1459	33
45	5:05 PM	28.9	31.29	-6:19	136	5.8
45	6:21 PM	28.88	30.84	-7:35	559	12
46	11:49 AM	30.57	32.7	-1:03		
46	12:34 PM	30.36	32.36	-1:48	573	21
46	1:29 PM	29.83	31.99	-2:43	1083	33
46	1:44 PM	29.68	31.66	-2:58	494	55
46	6:16 PM	28.55	30.03	-7:30	2909	18
47	11:50 AM	30.68	32.71	-1:04		
47	12:37 PM	30.51	32.3	-1:51	598	21
47	2:36 PM	30.16	31.81	-3:50	888	12
47	3:30 PM	30.04	31.63	-4:44	315	10
47	5:10 PM	29.33	30.58	-6:24	1850	31
47	5:55 PM	29.19	30.21	-7:09	527	20
48	11:51 AM	30.85	32.74	-1:05		
48	2:41 PM	30	31.68	-3:55	2050	20
48	3:08 PM	29.82	31.41	-4:22	472	29
48	4:07 PM	29.37	30.44	-5:21	1463	41
48	5:58 PM	28.91	29.43	-7:12	1514	23
49	11:51 AM	30.97	32.76	-1:05		
49	1:15 PM	30.56	31.83	-2:29	1380	27
49	2:12 PM	30.6	31.6	-3:26	294	8.6
49	3:47 PM	30.51	30.88	-5:01	908	16

Appendix A-4. Continued

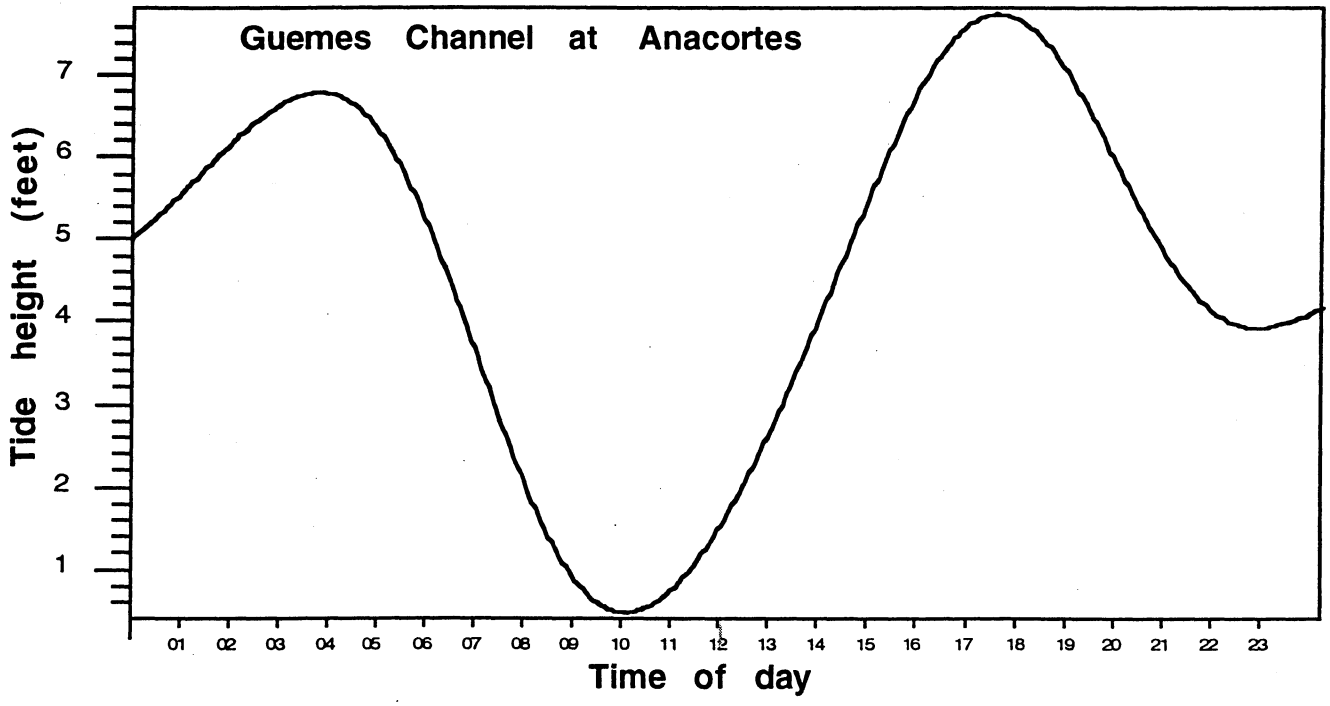
drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
49	5:19 PM	30.57	30.27	-6:33	764	14
50	12:55 PM	30.38	32.61	-2:09		
50	1:50 PM	29.93	32.26	-3:04	940	28
50	3:12 PM	29.8	32.19	-4:26	256	5.2
50	4:00 PM	29.6	31.99	-5:14	446	15
50	4:59 PM	29.16	31.61	-6:13	941	27
50	6:26 PM	29.18	31.54	-7:40	94	1.8
51	12:57 PM	30.52	32.63	-2:11		
51	1:47 PM	29.97	32.12	-3:01	1199	40
51	4:10 PM	28.86	30.39	-5:24	2970	35
51	6:12 PM	28.53	29.66	-7:26	1092	15
52	12:59 PM	30.68	32.64	-2:13		
52	2:44 PM	29.48	31	-3:58	3011	48
52	4:11 PM	28.81	30.18	-5:25	1604	31
52	4:22 PM	28.78	30.14	-5:36	74	11
52	6:11 PM	28.59	29.7	-7:25	649	10
53	1:01 PM	30.87	32.7	-2:15		
53	2:45 PM	29.44	30.76	-3:59	3577	57
53	2:54 PM	29.33	30.54	-4:08	340	63
53	4:14 PM	28.79	29.64	-5:28	1498	31
54	1:02 PM	30.99	32.71	-2:16		
54	2:37 PM	30.07	31.89	-3:51	1984	35
54	3:07 PM	29.86	31.57	-4:21	555	31
54	4:06 PM	29.47	30.7	-5:20	1298	37
54	4:32 PM	29.26	30.29	-5:46	640	41
54	5:59 PM	28.85	29.43	-7:13	1309	25
55	2:00 PM	30.48	32.64	-3:14		
55	2:40 PM	29.8	31.88	-3:54	1573	66
55	2:57 PM	29.58	31.37	-4:11	752	74
55	4:09 PM	29.02	30.65	-5:23	1368	32
55	6:10 PM	28.64	29.89	-7:24	1176	16
56	2:01 PM	30.56	32.63	-3:15		
56	2:39 PM	29.86	32.01	-3:53	1507	66
56	2:58 PM	29.57	31.48	-4:12	848	74
56	4:04 PM	29.32	31.09	-5:18	669	17
56	4:29 PM	29.22	31.01	-5:43	210	14

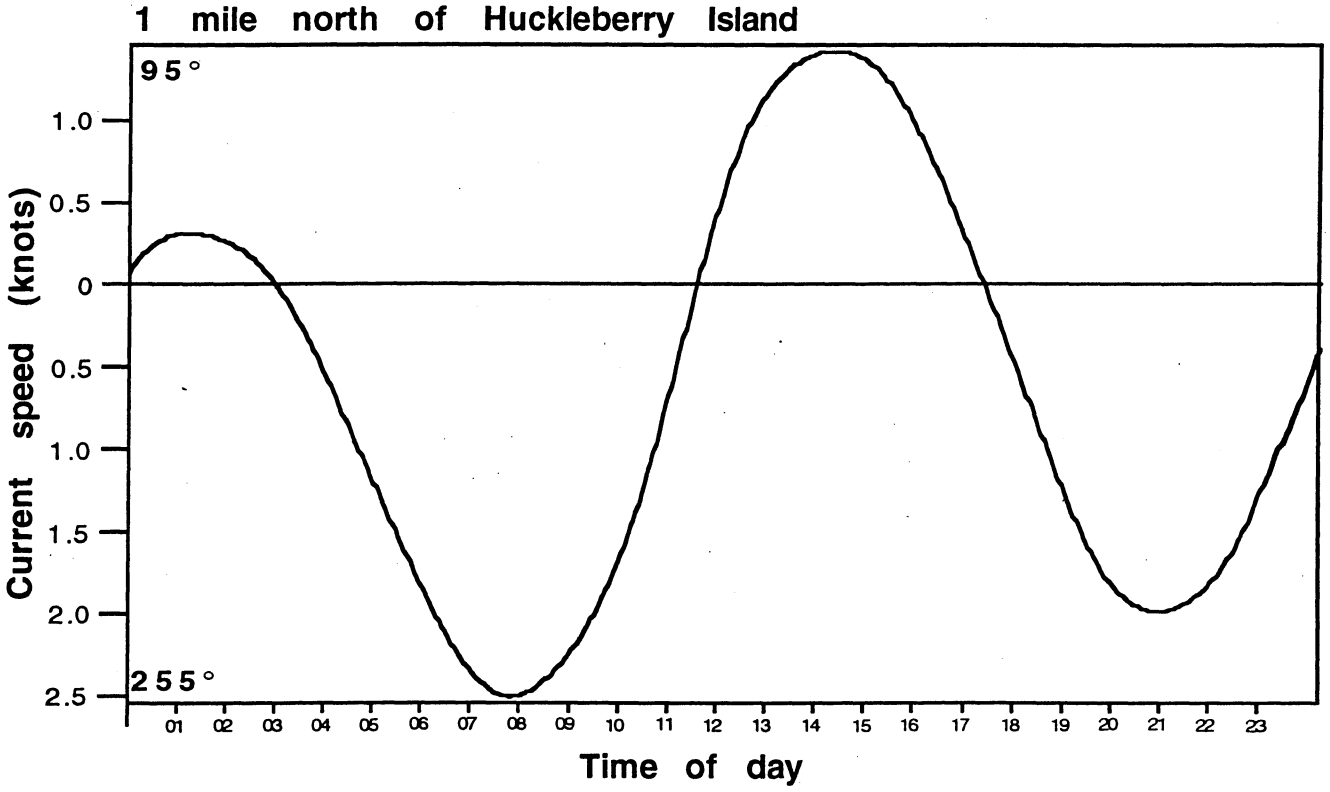
Appendix A-4. Continued

drift stick #	Time	Latitude	Longitude	delta LLW	Distance (m)	Speed (cm/s)
57	2:01 PM	30.67	32.64	-3:15		
57	2:37 PM	30.01	32.08	-3:51	1406	65
57	3:06 PM	29.75	31.79	-4:20	601	35
57	4:29 PM	29.22	30.82	-5:43	1552	31
57	5:08 PM	29.08	30.73	-6:22	282	12
58	2:02 PM	30.8	32.65	-3:16		
58	2:32 PM	30.37	32.24	-3:46	945	52
58	3:10 PM	30.06	31.85	-4:24	750	33
58	3:29 PM	29.82	31.6	-4:43	542	48
58	4:05 PM	29.56	30.93	-5:19	960	44
58	4:31 PM	29.37	30.47	-5:45	670	43
58	5:57 PM	29.01	29.7	-7:11	1164	23
59	2:03 PM	30.99	32.72	-3:17		
59	2:33 PM	30.63	32.27	-3:47	869	48
59	3:35 PM	30.68	31.1	-4:49	1453	39
59	3:49 PM	30.75	30.92	-5:03	258	31
25	3:20 PM	30.57	32.65	-4:34		
25	4:50 PM	29.92	32.29	-6:04	1284	24
25	5:40 PM	29.94	32.37	-6:54	106	3.5
26	3:21 PM	30.62	32.65	-4:35		
26	3:58 PM	29.88	32.09	-5:12	1536	69
26	5:45 PM	29.43	31.93	-6:59	857	13
27	3:21 PM	30.7	32.67	-4:35		
27	3:57 PM	30.12	32.19	-5:11	1228	57
27	4:57 PM	29.59	31.66	-6:11	1181	33
27	5:47 PM	29.54	31.63	-7:01	100	3.3
28	3:22 PM	30.86	32.7	-4:36		
28	3:52 PM	30.47	32.28	-5:06	890	49
28	4:44 PM	30.13	31.69	-5:58	965	31
28	4:55 PM	30.08	31.67	-6:09	96	15
28	6:36 PM	29.93	31.84	-7:50	349	5.8
29	3:23 PM	31.02	32.72	-4:37		
29	3:54 PM	30.84	32.26	-5:08	660	36
29	4:39 PM	30.79	31.86	-5:53	504	19
29	5:32 PM	30.74	31.68	-6:46	242	7.6



Appendix A-5. Predicted tide height in Guemes Channel at Anacortes and predicted current speed one mile north of Huckleberry Island on August 18, 1993 when drift sticks were released between Southeast Point and March Point.





Appendix A-6. Predicted tide height in Guemes Channel at Anacortes and predicted current speed one mile north of Huckleberry Island on August 30, 1993 when drift sticks were released between Southeast Point and March Point.

Appendix B. Excerpts from unpublished studies that refer to currents and current studies in Guemes Channel

Appendix B has not been included in this printing of the report. A copy of the full report including Appendix B can be seen at Padilla Bay National Estuarine Research Reserve Rod Mack Library.