W00056 - W00057

NOAA FORM 76-35A

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

OUTSIDE SOURCE DATA

Type of Survey AIRBORNE LIDAR

Field No.

Registry No. W00056, W00057

LOCALITY

State HAWAII

General Locality KAWAIHAE BAY

Sublocality KAWAIHAE BAY AND HARBOR

2000

SOURCE

U.S. Naval Oceanographic Office

LIBRARY & ARCHIVES

DATE

TABLE OF CONTENTS FOR W00056 AND W00057

1. Approval Memorandum

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF COAST SURVEY
Pacific Hydrographic Branch
Seattle, Washington 98115-6349

25 May 2005

MEMORANDUM FOR: Captain James C. Gardner, NOAA
Chief, Marine Chart Division

THROUGH: W. Michael Gibson
Chief, Hydrographic Surveys Division

FROM: Commander Donald W. Haines, NOAA
Chief, Pacific Hydrographic Branch

SUBJECT: Approval Memorandum for W00056 & W00057

Pacific Hydrographic Branch has completed an evaluation and chart application of Outside Source Data from the Naval Oceanographic Office (W00056 & W00057). I have reviewed the data, reports and compilation to the chart. Data are suitable for nautical charting except where specifically recommended in the Evaluation and Quality Assurance Memorandum and Chart Application Memorandum.

Kawaihae Harbor and Bay are currently listed as "critical" in the NOAA Hydrographic Survey Priorities (NHSP). This area should be considered surveyed adequately enough to be removed from the critical area in the NHSP, since LIDAR provided adequate depth information. However, additional fieldwork including side-scan and/or multibeam surveys of Kawaihae Harbor and Approaches is recommended next time a survey asset is at this location in order to complete bottom search and object detection requirements. Therefore, it is recommended that this area be reclassified as "Priority 1".

This survey area should be classified as Category of Zones of Confidence (CATZOC) "B" if used to update ENC's (Full seafloor coverage not achieved; uncharted features, hazardous to surface navigation are not expected but may exist. Controlled, systematic survey to standard accuracy).

cc: Chief HSD Operations Branch N/CS31

2. Memorandum of Chart Application

May 23, 2005

MEMORANDUM TO: Commander Donald W. Haines, NOAA
Chief, Pacific Hydrographic Branch

Russ Davies

FROM: Russ Davies
Cartographer, Pacific Hydrographic Branch

SUBJECT: Application of Outside Source Data Surveys, W00056-W00057 U.S. Naval Oceanographic Office / SHOALS 400 LIDAR Kawaihae Bay and Harbor, Hawaii

I concur with all recommendations by the reviewer, Lt. E.J.Van Den Ameele.

Summary of compilation:

- soundings, curves and features applied
- no wrecks, rocks, shoals, obstructions or foul areas were superseded
- shoreline was retained as charted
- bottom samples were retained as charted
- recommend aids to navigation be updated with latest information
- no additional Dangers to Navigation were found during compilation

It is recommended that OSD surveys W00056 and W00057, supersede charted information within the common area and applied to chart 19327, 11th Edition and chart 19330, 11th Edition.

Record of Application to Charts is attached.

Reviewed and Approved Gary C. Nelson 5/23/2005

Gary Nelson, Cartographic Team Leader
Pacific Hydrographic Branch

Kyle R. Ward

Digitally signed by Kyle R. Ward
DN: CN = Kyle R. Ward, C = US, O = HSD, OU = OPS
Reason: AWOIS and SURF check
Date: 2005.06.01 10:04:14 -04'00'

3. Memorandum of Evaluation and Quality Assurance Checklist

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF COAST SURVEY
Pacific Hydrographic Branch
Seattle, Washington 98115-6349

May 23, 2005

MEMORANDUM TO: Commander Donald W. Haines, NOAA
Chief, Pacific Hydrographic Branch

E. J. Van Den Ameele

FROM: Lieutenant Edward J. Van Den Ameele, NOAA
Hydrographic Team Leader

SUBJECT: Review of Outside Source Data Surveys W00056-W00057
U.S. Naval Oceanographic Office / SHOALS 400 LIDAR
Kawaihae Bay and Harbor, Hawaii

I have reviewed outside source hydrographic surveys W00056 and W00057 with regard to data integrity and completeness of the data submission package, survey field procedures, data processing and quality assurance methods, and overall data accuracy and data quality. Surveys W00056 and W00057 comply with specifications and requirements set forth in the NOS Hydrographic Surveys Specifications and Deliverables Manual (HSSDM), with the following exceptions:

- SHOALS 400 LIDAR data acquired in these survey areas do not meet NOAA HSSDM requirements (equivalent to IHO Order 1) for object detection. The capability of LIDAR to meet NOAA object detection requirements is still unproven and questionable, and item investigations to either disprove charted features or acquire definitive least depths were not conducted. These data do meet NOAA HSSDM requirements for depth and position accuracy.

I have performed the following additional processing of this survey in conjunction with this evaluation:

- Additional soundings not depicted on the NAVOCEANO smooth sheets at the entrance channel to the small boat harbor south of Kawaihae Harbor have been selected in order the depict the center of the natural entrance channel to this basin. Refer to the Outside Source Data Quality Review Checklist for a listing of these soundings. These soundings should be charted to depict the natural channel at the entrance to this harbor.

Special attention should be given to:

- A number of fliers were noted inside the Kawaihae Harbor Turning Basin. These fliers are depicted on the NAVOCEANO smooth sheets and should not be charted. A listing and description of these fliers is in the Outside Source Data Quality Review Checklist.
- Refer to the Outside Source Data Quality Review Checklist for additional specific charting recommendations.
- A U.S. Army Corps of Engineers (USACE) survey was conducted in June 2003 in the entrance channel and turning basing in Kawaihae Harbor. Data from these surveys were compared with depths from the USACE survey, and while they compared within one to two feet, LIDAR depths from W00056 and W00057 were generally shoaler. Although the LIDAR survey (2000) predates the USACE survey (2003), depths from W00056 and W00057 should supersede the USACE survey since LIDAR has greater bottom coverage than the single-beam USACE survey and is more likely to detect shoaler soundings. I contacted the USACE Honolulu District and confirmed that dredging has not occurred in the harbor since 1972. The correspondence is attached to this memo.

Final Recommendations:

- These data should be used to chart soundings and depth curves representing general bathymetric trends, and new shoals and features not depicted on the current editions of NOAA charts 19327 and 19330. Data meet NOAA HSSDM requirements for depth and position accuracy.
- These data should not be used to supersede charted shoals, wrecks, rocks, obstructions, or foul areas. Data do not meet NOAA HSSDM requirements for bottom search and object detection.
- The charted shoreline should be retained as charted.
- Bottom samples were not acquired and should be retained as charted.
- Aids to navigation were not investigated and should be retained as charted.
- Kawaihae Harbor and Bay are currently listed as "critical" in the NOAA Hydrographic Survey Priorities. This area should be considered surveyed adequately enough to be removed from the critical area in the NHSP since LIDAR provided adequate depth information. However, additional fieldwork including side-scan sonar and/or multibeam surveys of Kawaihae Harbor and Approaches is recommended the next time a survey asset is at this location in order to complete bottom search requirements. Therefore, it is recommended that this area be reclassified as "Priority 1."
- This survey area should be classified as Category of Zones of Confidence (CATZOC) "B" if used to update ENC's (Full seafloor coverage not achieved; uncharted features, hazardous to surface navigation are not expected but may exist. Controlled, systematic survey to standard accuracy.).

SURVEY REGISTRY NUMBER(S): _________W00056-W00057___________________________

OSD SUPPLIER __U.S. Naval Oceanographic Office (NAVO)________________________________

SURVEYOR: ____ U.S. Naval Oceanographic Office, SHOALS / JALBTCX________________

SURVEY AREA: ____Kawaihae Bay, West Coast of Island of Hawaii

DATES OF SURVEY: __August 1 – December 20, 2000____________

REVIEW DATE:__May 2005___________________**REVIEWER:**__VanDenAmeele ______

I. DATA INVENTORY

A. Reports

____x____ Descriptive Report or equivalent _x_Digital __Hardcopy

Document Title: _Hawaii LIDAR Report of Survey (ROS)__14-Sept-2004___

____x____Data Acquisition and Processing Report or equivalent _x_Digital __Hardcopy

Document Title: ___Hawaii LIDAR Report of Survey (ROS)__14-Sept-2004 (Comment 1)___

_________Horizontal and Vertical Control Report or equivalent __Digital __Hardcopy

Document Title: ____

_________ Systems Certification Report or Equivalent __Digital __Hardcopy

Document Title: ____

_________ Digital and hardcopy versions of all documents match and are in the prescribed format.

_________ Other: ____________________________________ __Digital __Hardcopy

B. Data

____x____ Smooth sheets / sounding plots _x_Digital _xHardcopy

File name(s)	Description	Format
01x.dgn	Smooth Sheet 1:25000	Microstation DGN
01x_land.dgn	Shoreline 1:25000	Microstation DGN
01A.dgn	Smooth Sheet 1:5000	Microstation DGN
01A_land.dgn	Shoreline 1:5000	Microstation DGN

___x_____ ASCII XYZ Files: Full density _x__ Decimated: __x_

File name(s)	Description	Format
01_25000.asc	Full density XYZ soundings	ASCII
01A_5000.asc	Full density XYZ soundings	ASCII
01x_10213_5000.pfm.crs	Smooth sheet XYZ soundings	ASCII
01x_10213_10000.pfm.crs	Smooth Sheet XYZ soundings	ASCII

__________ Shallow-water multibeam data ___ Raw ___ Processed

___ DTM ____ BASE / Navigation Surface ____ PFM

Format(s): ____

__________ Side-Scan Sonar Data ___ Raw ___ Processed

____ Mosaic

Format(s): ____

___x_____ LIDAR ___ Raw ___ Processed

Format(s): _SHOALS 400 / Fledermaus PFM______________

__________ Single-Beam Data ___ Raw ___ Processed

Format(s): ____

__________ Detached Position / Point Features ___ Raw ___ Processed

Format(s): ____

__________ GPS Data (e.g. kinematic / static) ___ Raw ___ Processed

Format(s):____

____x____ Other Data ___ Raw ___ Processed

Format(s): ___Fledermaus PFM________

01x_102103.pfm	Full density XYZ soundings	PFM

____x____ All data open correctly and without error (MBES lines, SSS lines, VBES, Crosslines, Fieldsheets, Smooth Sheets, Sessions, DTM's, BASE grids, Mosaics, and DP's).

Comments:

1. Original HAWAII LIDAR ROS submitted 31- Jan – 2002. Revised ROS submitted 14- Sept – 2004.

II. DATA ACQUISITION AND PROCESSING

A. Horizontal Positioning

____x_____ Positioning equipment and methodology are capable of meeting NOAA HSSDM Specifications

Equipment / method used: __ASHTECH Z-12 L1/L2 GPS receivers, Fugro OmniStar DPGS Satellite Beacons.____

____x____ The surveyor has conducted adequate quality control of horizontal positioning data

____x____ A review of the data reveals no positioning errors exceeding NOAA specifications

B. Water Levels

____x____ Water level measuring equipment and methods are consistent with NOAA equipment and methods and are capable of meeting specifications

Equipment / method used: ___NOAA CO-OPS NWLON stations

____x____ Water level correctors applied to sounding data

_x__ Verified ___ Observed ___ Predicted

_x__ Zoned: __x_ NOAA Zoning ____ Other zoning

Comment 1 Water level error estimate provided by CO-OPS

Water level / zoning error estimate: __0.179m_____

C. Sensors

____N/A__ Echosounder(s) used are capable of meeting NOAA HSSDM accuracy and object detection requirements

Echsounder(s) used: ____

____N/A__ Side-Scan sonar(s) used are capable of meeting NOAA HSSDM object detection requirements

Side-scan sonar(s) used: _____________________________________

__Comment 2_ LIDAR used is capable of meeting NOAA HSSDM accuracy and object detection requirements

LIDAR(s) used: ___SHOALS 400______________________________ ___x_____ Motion sensor used is capable of meeting NOAA HSSDM accuracy requirements

Motion sensor(s) used: _Applanix POS/AV______

____x____ Gyro / heading sensor used is capable of meeting NOAA HSSDM accuracy requirements

Gyro / heading sensor used: __Applanix POS/AV______

__N/A____ Sound velocity equipment used is capable of meeting NOAA HSSDM accuracy requirements

SV sensor(s) used: ____

__N/A____ Other sensors used are capable of meeting NOAA HSSDM accuracy requirements

Other sensor(s) used: ____

D. System Calibrations and/or Certifications

comment 3 A sensor offset and alignment survey was conducted to NOAA HSSDM requirements

____ Offset values provided

__N/A_____ Patch tests were conducted for shallow-water multibeam systems

____ Alignment bias and latency values provided

___N/A___ Draft determinations were conducted and provided

____ Static Draft ____ Dynamic Draft ____ Loading

____ Draft values were provided

______x___ Sensors were calibrated in accordance with manufacturer requirements and NOAA specifications

____ Calibration reports provided

E. Survey Methodology

___No____ Bottom coverage and object detection requirements (per NOAA HSSDM) have been met:

__No_ System(s) and field procedures used are capable of meeting object detection requirements

_N/A__ Range scales or ping rates used were consistent with meeting requirements

_N/A_ Vessel speed was limited with regard to range scale and depth of water

__N/A____ DTM, BASE surface, and/or mosaics indicate that seafloor coverage and object detection requirements were met.

Comment 4 No significant coverage holidays exist

Comment 5 All least depths over shoals, wrecks, rocks, obstructions, and other features have been determined

Comment 5 Least depths have been retained in the data

__N/A____ Sound velocity sampling regime in accordance with NOAA HSSDM requirements

F. Corrections to Echosoundings

Comment 6 All data corrector files have been supplied and appear valid

____x____ All data have (as applicable):

_n/a_ SV applied _x_ Tides Applied _x_ Offsets and ~~Draft~~ applied

____x____ No tide errors exceeding NOAA HSSDM requirements are observable in the data

___N/A___ No SV errors exceeding NOAA HSSDM accuracy standards are observable

G. Data Processing and Quality Control

____x____ An adequate description of data processing and quality control methods is provided in documentation.

____x____ Data processing methodology is consistent with procedures required to provide a dataset suitable for charting.

Comment 7 Full resolution data was provided in order to gauge the adequacy of cleaning and/or processing of the data.

Comment 8 No anomalous data (fliers, noise, etc) were apparent in the BASE surface, DTM, and/or selected sounding set.

Comment 8 All shoals are valid (no fliers) and the proper least depth has been retained.

____x____ A 10% sample of subsets have been reviewed and data are cleaned appropriately with no noise, fliers, or systematic errors noted.

Comments:

1. While CO-OPS did not provide a zoning error estimate, NAVO completed an estimate by installing backup tide gauges and comparing water level data from NOAA stations, zoned using NOAA CO-OPS zoning, with water levels measured directly at the NAVO stations. The differences had a standard deviation of 0.179 meters, with a maximum difference of 0.35 meters and a mean difference of 0.15 meters.

2. At this time NOAA does not have sufficient experience or empirical test results confirming that the SHOALS 400 system is capable of meeting NOAA HSSDM object detection requirements. These data should not be considered to meet object detection requirements. According to the ROS, the system is theoretically capable of meeting IHO Order 1 object detection requirements in depths of 7 to 20 meters; however, more empirical testing is needed to confirm this.

3. The ROS indicates that "The laser system and motion sensors are optically aligned and the offsets measured with respect to the phase center of the GPS antenna. This is done at every system or component installation. The measured offsets are contained in what is called the "STATIC" file. This file is written to the survey plan and, during initialization of the data collection system, written to the daily data tape." It is not known if this results in measurements which meet NOAA accuracy standards.

4. A few small coverage holidays exist in deeper waters. Inside Kawaihae Harbor, numerous data gaps exist, presumably due to turbidity and/or anchored or moored vessels. See figure 1.

5. Least depths over all bathymetric features such as pinnacles, rock outcrops, and coral heads detected by this survey have been verified through visual examination in Fledermaus. Definitive least depths over existing charted wrecks, rocks, and obstructions were not obtained due to limitations of LIDAR. Additionally, discreet item investigations to disprove or fully develop features were not conducted.

6. Tide corrector files were not provided with the deliverables. The Hawaii LIDAR ROS states "NAVOCEANO's processing system handles tide correction by creating a tide file for each zone by applying zonal corrections to the reference gauge tides. The processing software identifies in which zone a sounding falls and applies that zone's tide to the sounding. Tide correctors are applied during post processing, just prior to data editing and validation." These individual zonal corrector files were not provided and could not be QA'ed. Tide application errors were noted in the ROS (section 7.8.2) yet were also noted as resolved. Redundant data were acquired for this survey on several days and no tide errors were noted; internal data consistency was good (see figures 2 and 3).

7. All accepted and rejected LIDAR data points were provided. Laser waveform information was not provided. Full resolution data were examined in Fledermaus. The data cleaning has removed all fliers (other than exceptions specifically addressed in this evaluation), and selected soundings represent a shoal-biased data set.

8. Fliers were noted inside Kawaihae Harbor. These fliers all exist at the outer edge of the LIDAR swath and are directly adjacent to gaps in coverage. Since the holidays are believed to be from turbidity and/or moored vessels, these fliers are also believed to be from the same causes. LIDAR soundings at the following positions are noted as fliers and should not be charted (see figures 4 and 5 as well):

4.8 fathoms	20º 02' 09.7" N	155º 49' 46.9" W
4.9 fathoms	20º 02' 07.6" N	155º 49' 45.3" W
5.6 fathoms	20º 02' 06.1" N	155º 49' 44.2" W
5.4 fathoms	20º 02' 04.1" N	155º 49' 42.8" W
5.1 fathoms	20º 02' 01.9" N	155º 49' 38.7" W

III. DATA QUALITY AND RESULTS

A. Internal Data Consistency

____x____ The Hydrographer has conducted the required quantity of cross lines, or acquired sufficient redundant data, in accordance with the HSSDM, to assess internal data consistency.

____x____ Crossline agreement or redundant data overlap has been visually inspected and no disagreements exceeding NOAA HSSDM tolerances have been noted.

__N/A____ Where multiple systems, platforms, and/or sensors were used, junctioning or overlapping data agree within NOAA HSSDM tolerance between platforms.

____x____ Any statistical assessment of the data (e.g. BASE standard deviation, QC reports, etc) indicate that data agree within NOAA HSSDM tolerances.

Comments:

All data points were inspected visually using the PFM files submitted in Fledermaus. Most areas had overlapping data of redundant coverage (200% or greater) and all data were internally consistent within NOAA accuracy requirements. A standard deviation grid was generated in Fledermaus and no areas were noted as having an SD greater than NOAA HSSDM accuracy requirements, other than small areas over steep and irregular bathymetric features, such as rock outcrops. See figures 2 and 3.

B. Error Budget Analysis

____x____ An error budget analysis was provided by the surveyor

__x__ The error budget analysis indicates that data are capable of meeting NOAA HSSDM standards

___x_ The evaluator concurs with the provided error budget analysis

___No____ The evaluator has conducted an error budget analysis

_____ The error budget analysis indicates that data are capable of meeting NOAA HSSDM standards

C. Chart Comparison

____x____ The chart comparison contains no significant discrepancies which cannot be sufficiently explained

___No____ All significant shoals, wrecks, rocks, and obstructions have significant coverage to confirm or disprove.

Chart Comparison Comments:

These surveys were compared with charts 19327 and 19330

1. Soundings from W00056 and W00057 generally compare within one fathom of charted soundings, with greater discrepancies occurring around bathymetric features which may not have been detected with the prior single-beam survey. Numerous features

resembling coral heads or rock outcrops were detected with LIDAR and resulting in soundings shoaler than those charted. These shoaler sounding should supersede charted data.

2. Charted wrecks, rocks, obstructions, foul areas, submerged features, and shoals should be retained and not superseded with data from this survey. No item investigations were conducted and the object detection capability of LIDAR is insufficient to definitively disprove charted features.

3. New shoals from this survey should supersede deeper charted data.

4. The natural deep channel at the entrance to the small boat harbor located near 20º 01' 39.3N 155º 49' 43.0" W is reflected in the full resolution LIDAR data but not in the selected sounding set on the NAVO smooth sheets. The following deeper soundings taken from the center of the deep channel can be used to supplement smooth sheet soundings and chart this natural deep channel (depths are in meters):

Record	Subrecord	File	Line	Easting	Northing	Lon	Lat	Depth
8956	0	66	66	204118.8	2216955.1	-155°49.6887'	20°1.6112'	-5.00
50807	0	17	17	204063.9	2216882.0	-155°49.7194'	20°1.5711'	-5.17
5562	0	16	16	204111.9	2216990.7	-155°49.6930'	20°1.6304'	-5.17
51697	0	49	49	204078.7	2216897.5	-155°49.7112'	20°1.5796'	-5.21
51563	0	91	91	204039.1	2216840.0	-155°49.7333'	20°1.5481'	-6.41
8923	0	50	50	203983.4	2216811.0	-155°49.7649'	20°1.5319'	-7.38

D. Automated Wreck and Obstruction Information System (AWOIS) Items

___No____ AWOIS Items are located within the limits of the survey.

___N/A___ AWOIS Items can be sufficiently confirmed or disproved using data from this survey (Attach AWOIS pages to the certification memorandum.).

E. Dangers to Navigation

__No_____ Dangers to Navigation (DTONs) were selected and submitted by the surveyor / data provider

___N/A___ DTONs have been verified by the office evaluator.

__Yes____ Additional DTONs were noted during office evaluation and submitted

Comments:

Six Dangers to Navigation were selected and submitted on May 17, 2005. A copy of the DTON letter is attached.

F. Aids to Navigation

___No____ Aids to Navigation (ATONs) were positioned during this survey

__________ New ATONS were positioned during this survey

__________ Survey positions match charted positions

__________ The surveyor / data provider issued DTONs or notified the USCG for any ATON discrepancies

__________ ATON discrepancies were noted during office evaluation and submitted as DTONs.

Comments:

G. Shoreline

See comments The shoreline (MHW and/or MLLW lines) were included as part of this survey

__________ Surveyed shoreline matches charted shoreline

__________ Surveyed shoreline compares with NGS/RSD source data

__________ Surveyed shoreline should be used to revise nautical charts

__________ Shoreline features were positioned during this survey

__________ Surveyed features match charted shoreline

__________ Surveyed features compares with NGS/RSD source data

__________ Surveyed features should be used to revise nautical charts

Comments:

LIDAR is capable of providing an approximate Mean High Water and Mean Lower-Low Water shoreline. The surveyed shoreline from surveys W00056 and W00057 compares well with charted shoreline and confirms the positions of charted MHW features such as breakwaters and wharves. The charted shoreline should be retained.

H. Bottom Samples

__________ Bottom samples were acquired during this survey

__________ Bottom sample spacing was in accordance with NOAA HSSDM requirements

__________ Bottom samples should be used to update NOAA charts

Comments:

Bottom samples were not acquired. Retain as charted.

IV. ADDITIONAL DATA PROCESSING

_N/A_____ Final tide application at processing branch:
Date:___________________ Applied By:________________________
Type:___________________ Zoning:_____________________________

__N/A____ Final sounding set decimation conducted at PHB

__N/A____ Additional submerged features noted by reviewer (flagged as outstanding)

__N/A____ Final BASE Surfaces created by reviewer

__No____ Smooth sheet created at PHB

Additional Verification Comments:

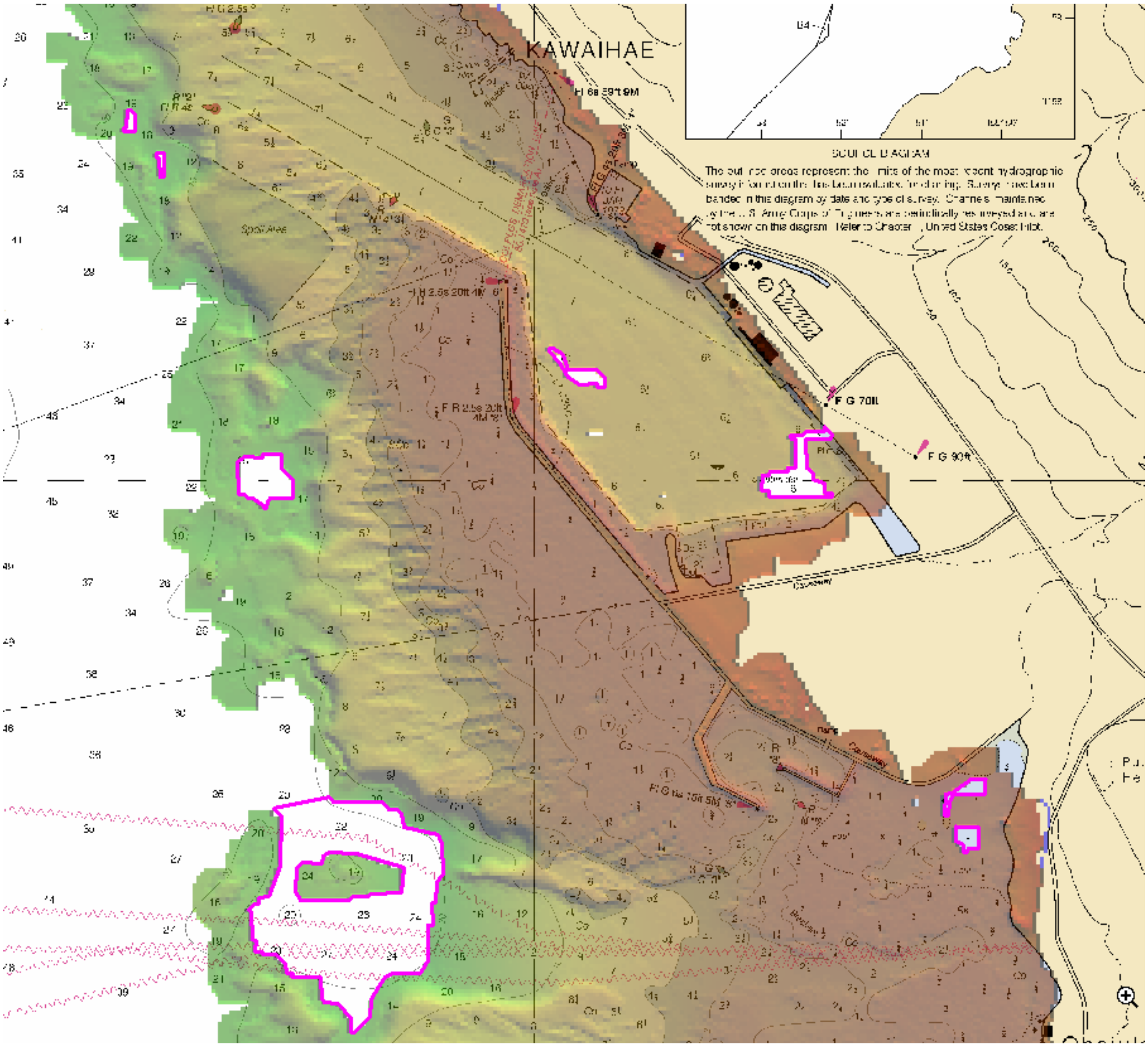


Figure 1: *Holidays in coverage in surveys W00056 and W00057*

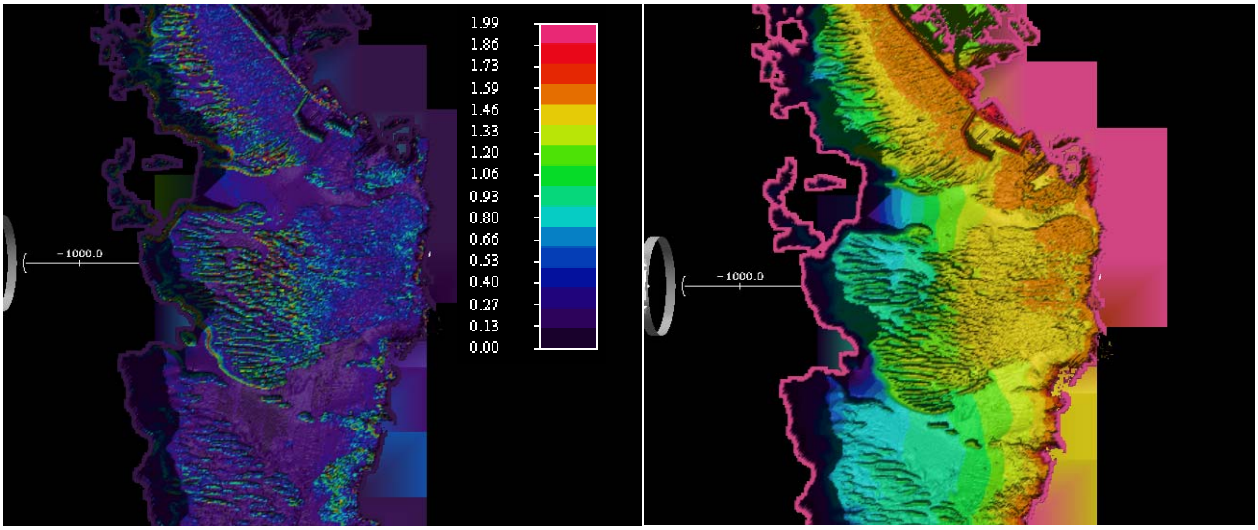


Figure 2: Standard deviation and depth grids for a section of surveys W00056 and W00057

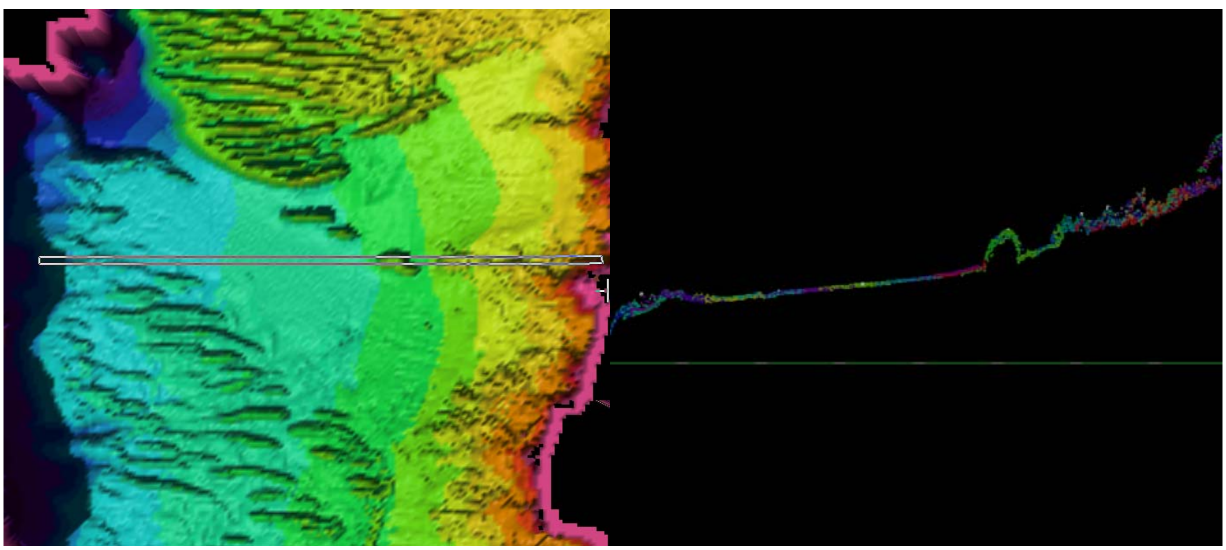


Figure 3: A cross section of data reveals good internal data consistency among redundant data and shows no tide errors.

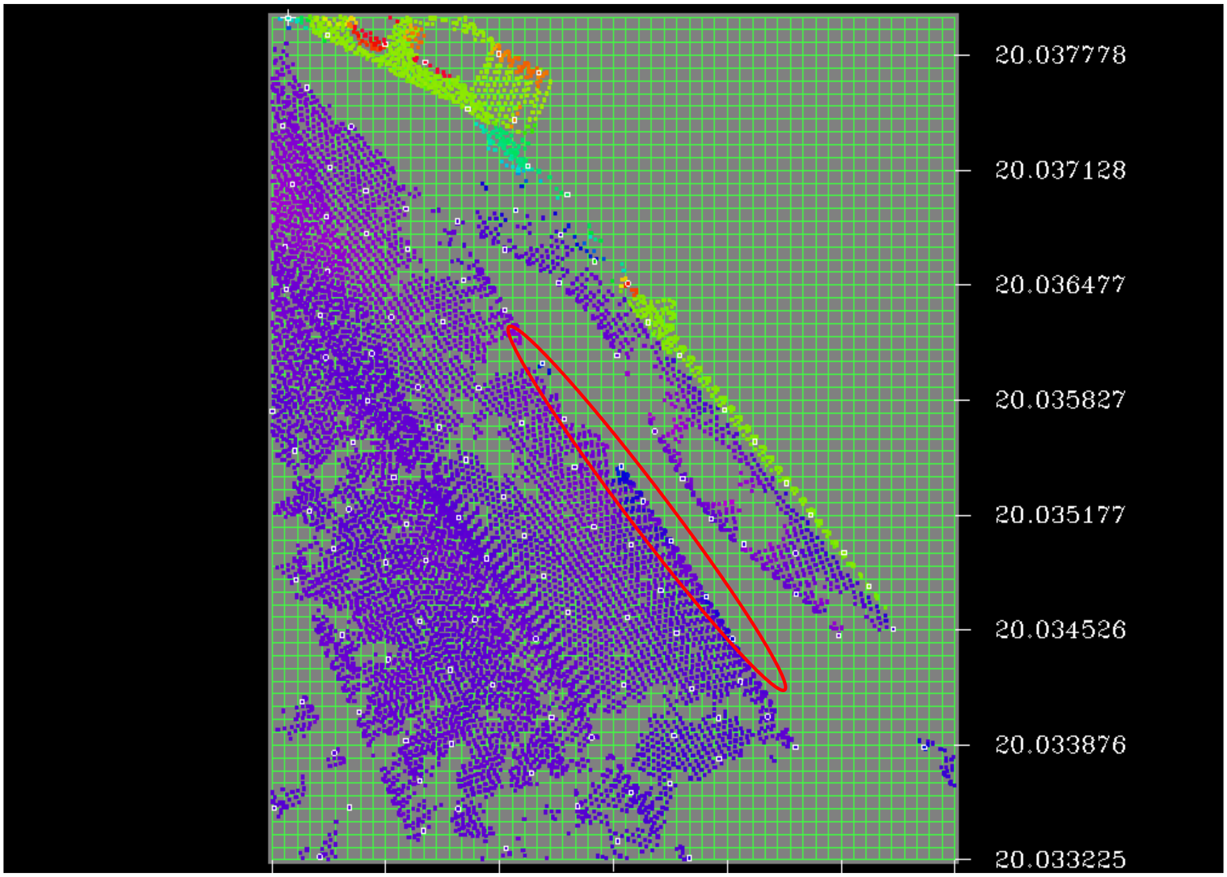


Figure 4: Shoal soundings along the outer edge of the LIDAR swath in Kawaihae Harbor are fliers.The white boxes indicate selected soundings depicted on the smooth sheet.

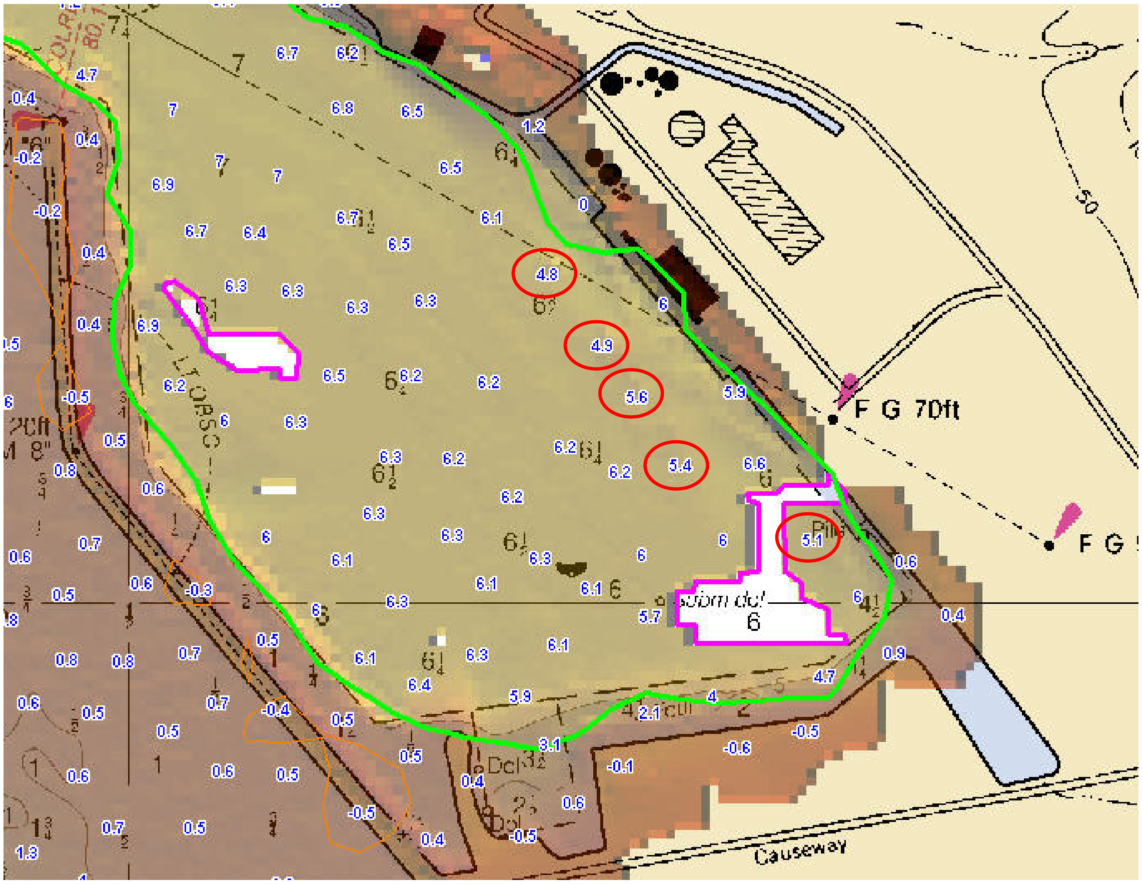


Figure 5: Circled soundings in Kawaihae Harbor are fliers and should not be charted.

4. Danger to Navigation Report

Danger to Navigation Report

Hydrographic Survey Registry Number: W00056 and W00057

Survey Title: **State: Hawaii**
Locality: Island of Hawaii

Sub-locality: Kawaihae Bay

Survey Dates: August 1 – December 20, 2000

Depths are reduced to Mean Lower Low Water using verified tides.
Positions are based on the NAD83 horizontal datum.

CHARTS AFFECTED:

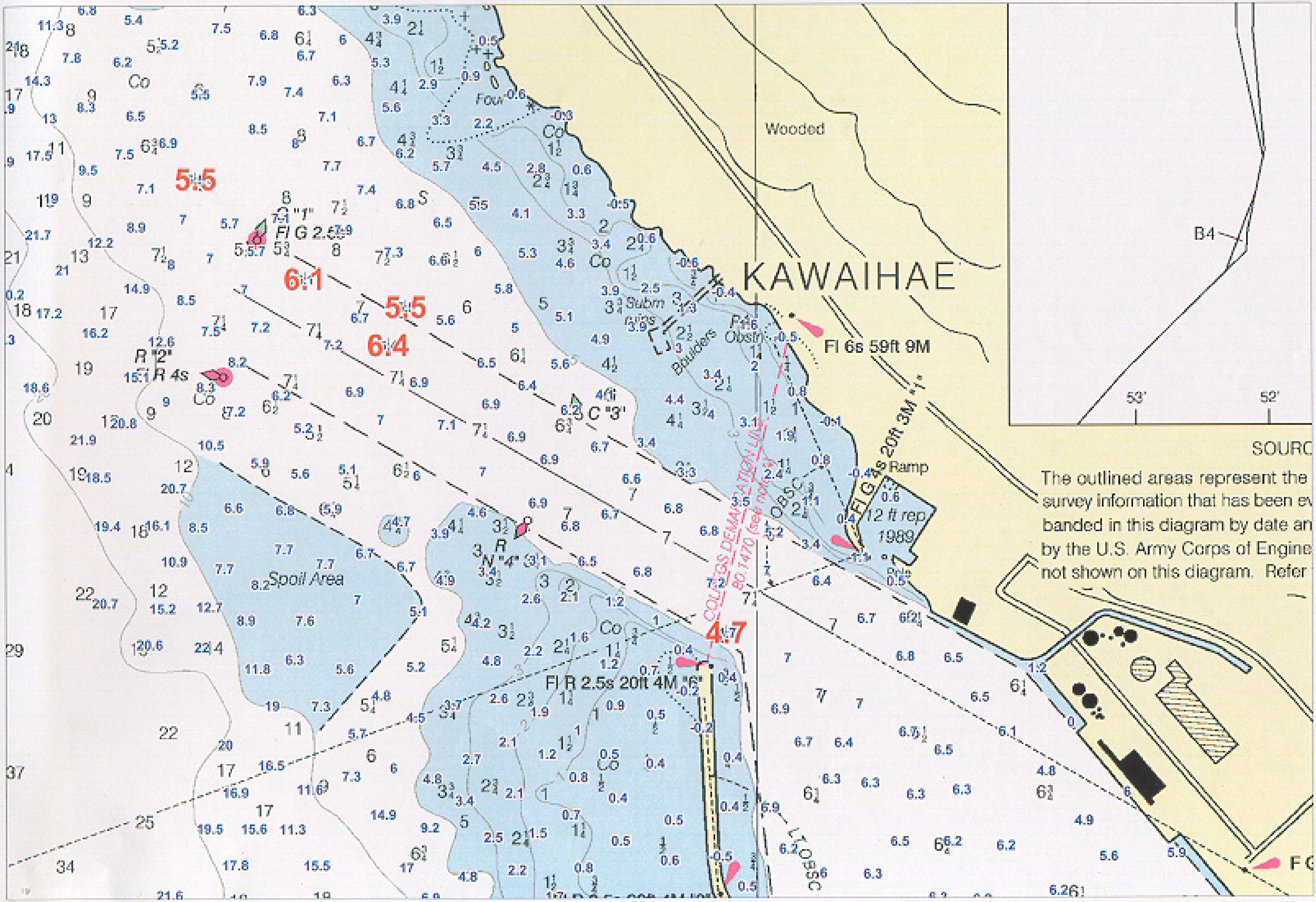
Chart	Scale	Edition	Date
19330	1:10,000	10^{th}	12/2003
19327	1:80,000	10^{th}	12/6/1997

DANGERS:

Feature	Depth(ft or fms)	Latitude	Longitude
Sounding	5 ½ fms	20º 02' 29.47" N	155º 50' 15.72" W
Sounding	5 ½ fms	20º 02' 34.91" N	155º 50' 25.17" W
Sounding	4 ½ fms	20º 02' 15.61" N	155º 50' 01.31" W
Sounding	6 fms	20º 02' 30.67" N	155º 50' 20.26" W
Sounding	6 ¼ fms	20º 02' 27.85" N	155º 50' 16.51" W

COMMENTS: Soundings are from LIDAR data acquired by the US Naval Oceanographic Office.

Questions concerning this report should be directed to the Chief, Pacific Hydrographic Branch at *(206) 526-6835*


KAWAIHAE
Wooded
Fl 6s 59ft 9M
F G 4s 20ft 3M "1"
Ramp
12 ft rep 1989
Subm ruins
Boulders
Obstn
OBSC
COLREGS DEMARCATION LINE 80.1470 (see note A)
Fl G 2.5s "1"
Fl R 4s R "2"
C "3"
R N "4"
Fl R 2.5s 20ft 4M "6"
Spoil Area
LT OBSC
B4
53'
52'
SOURC
The outlined areas represent the
survey information that has been e
banded in this diagram by date an
by the U.S. Army Corps of Engine
not shown on this diagram. Refer

5. Supplemental Correspondence

Subject: RE: Kawaihae Harbor DTONs
From: "Tom, Patrick Y POH" <Patrick.Y.Tom@poh01.usace.army.mil>
Date: Fri, 6 May 2005 13:46:01 -1000
To: "Edward J Van Den Ameele" <Edward.J.Vandenameele@noaa.gov>
CC: "Lyn Preston" <Lyn.Preston@noaa.gov>, "Don Haines" <Don.Haines@noaa.gov>, "Russ Davies" <Russ.Davies@noaa.gov>, "Gerry Wheaton" <Gerry.Wheaton@noaa.gov>

hi ej~
you are correct, we last dredged kawaihae ddh in 1972. our most recent hydrosurvey was done by our portland district in june 2003. no deepening or dredging work has been done since 1972, no less june 2003. you can always call me, if you need more information.

aloha,
pat
phone: (808)438-8874

-----Original Message-----
From: Gerry Wheaton [mailto:Gerry.Wheaton@noaa.gov]
Sent: Friday, May 06, 2005 11:31 AM
To: Tom, Patrick Y POH
Cc: Edward J Van Den Ameele; Lyn Preston; Don Haines; Russ Davies
Subject: Re: Kawaihae Harbor DTONs

Pat,

EJ Van Den Ameele is currently processing NAVO LIDAR data gathered at Kawaihae Harbor on the Big Island. The survey shows Dangers to Navigation. Our records show that harbor was dredged by USACE in 1972 and last surveyed in 2003. Before going forth with these DTON's, NOAA would like to know if USACE has dredged since the June 2003 survey. Additional info is provided below.
Please respond to EJ at his email address above.

Thanks Pat, it is always a pleasure to work with USACE Honolulu.
Gerry

Edward J Van Den Ameele wrote:

> Lyn and Gerry,
>
> PHB is working on evaluating and compiling the NAVO LIDAR data around the Hawaiian Islands. We have started with the surveys around Kawaihae Harbor on the Big Island of Hawaii to meet MCD's deadline to publish new editions of charts 19330 and 19327. We have located a few Dangers to Navigation in the approach channel to the harbor. The attached graphic shows these DTON's. (Dton's in red, all data in blue)
>
> We did a little bit of research on this channel. It was last dredged by the USACE in 1972. In June 2003, a single-beam survey of the channel was completed by the Corps (Portland District did the survey). The DTON's we have selected match the latest Corps survey within a foot or two, the difference could easily be explained by tide control or the better bottom coverage obtained with LIDAR vs. single-beam. our DTON's are shoaler.
>
> Additionally, in late 2003, the Corps, Honolulu District, appears to have initiated a proposal (public comment period) to deepen the channel and turning basin.
>
> The latest edition of chart 19330 is 12/03 (10th edition)

Before we go forward with these DTON's, we have a couple of questions:

Lyn: Was the latest USACE survey (June 2003) applied to chart 19330? It does not appear to have been, but we would like to confirm before submitting the DTONs.

Gerry: Do you have any USACE contacts at the Honolulu district who can confirm or deny if any deepening or dredging work has occurred since the June 2003 survey?

Thanks,
EJ

[Image]

6. Source Documents

FILE: HAWAII LIDAR ROS.DOC
UPDATED: 14 Sept 2004
BY: Scott Ebrite SNR

NAVAL OCEANOGRAPHIC OFFICE

Stennis Space Center, Mississippi

REPORT OF SURVEY

LIDAR

HAWAII

Vessel: SHOALS AIRCRAFT

Detachment: SHOALS PROJECT

Country: U. S.

Dates of Survey: 01 AUGUST - 20 DECEMBER 2000

Archive Number: 00US16

Areas: Hawaiian Islands
Oahu
- Makua Training Area, Pokai Bay, leeward coast; Kaena Pt. to Barbers Pt.
- Kaneohe Bay
- MCBH Kaneohe
- Bellows AFS - Waimanalo Bay and Bellows Beach
- Kahuku
- Pearl Harbor/Approach
- Waialua Bay

Kauai
- PMRF - Barking Sands, Majors Bay, Waimea Bay
- Port Allen

Molokai
- Kaunakakai area and south coast, other areas

Hawaii
- Kawaihae Harbor and approach, other areas

Maui
Lanai

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REPORT OF SURVEY CONTENTS

1.0 Introduction

1.1 Purpose of Survey

The Hydrographic Survey Specification for the aforementioned areas was generated at the request of the primary Functional Customer (CINCPACFLT) in response to a DoD/US Navy initiative. This initiative is to support present and future increased naval activity and usage in WESTPAC as follows.

1.1.1 Seal Delivery Team One (SDVT-1) has requested SHOALS surveys of several training areas within Hawaii and the WESTPAC areas of Guam, Saipan, Tinian and Farallon de Medinilla (FDM). The requirement is not simply to update existing nautical charts, but to create unique high-density digital bathymetric datasets that can be used by SDVT-1 to improve the safety of their SDV training operations. SDVT-1 uses commercial GIS packages (ESRI ArcView with Spatial Analyst) to produce tailored products for their operations, including 3D perspectives of their target and training areas. Additionally, SDVT-1 has, or will be, requesting STOIC's (Special Tactical Operational Information Charts) for their training areas.

1.1.2 Pearl Harbor and Approaches. Pearl Harbor and its approaches are a safe haven for major surface and sub-surface Fleet units. The survey is required for updating charts 19AHA19366, 19AHA19362, 19AHA19369 and 19AHA19364. CINCPACFLT recently removed Limited Distribution restrictions on hydrographic data in Pearl Harbor and the approach. This effectively transfers the responsibility of charts for Pearl Harbor from NIMA to NOAA NOS. CINCPACFLT also intends to cancel chart 19AHA19369 following NOS publication of new editions of 19AHA19362 and 19AHA19369 with necessary approach data for Pearl Harbor. CINCPACFLT would like to create a complete baseline dataset of unclassified hydrographic and topographic data for use by NOAA NOS in updating Pearl Harbor charts. These data will provide a complete bathymetric model of Pearl Harbor that will be suitable for a variety of uses, including SDVT-1 training, geospatial product prototyping, high- resolution DNC, environmental impact modeling, and harbor defenses. USACOE has recently completed a standard survey of Pearl Harbor in support of normal dredging operations and these data have been forwarded to NIMA and NOAA NOS.

1.1.3 Pacific Missile Range Facility (PMRF) Kauai. PMRF desires detailed bathymetric data inshore of the Silas Bent survey of 1995. Their test and evaluation clientele are increasingly interested in very shallow water operations. Barking Sands, the PMRF beach north of the airfield, is also used for various amphibious training operations, including major exercises (RIMPAC). Majors Bay, south of the airfield, is a major amphibious and SOF training area. SDVT-1 also requires data in Waimea Bay, between PMRF and Port Allen, and Port Allen to support training operations. Data will be used for updating NOAA NOS charts 19ACO19381, 19BHA19382 and 19XHA19386 and NIMA charts COMBT808528 and COMBT801253.

1.1.4 Bellows Air Force Station - Waimanalo Bay Bellows Beach is one of the three primary beaches in the Hawaiian Islands used for amphibious exercises including RIMPAC. Lack of high-density data for the approach to the beach presents problems for both safety and environmental protection. High-density data will improve the margin of safety in using this beach for future exercises. Data will be used to update NIMA chart COMBT800744 and NOAA NOS chart 19AHA19358. Data will also be used for future STOIC production.

1.1.5 Makua Training Area including Pokai Bay and leeward coast from Kaena Pt. to Barbers Pt.
Makua Military Reservation is a live fire facility. Data are required to support SDVT-1 and ASDS and amphibious landing exercises at Makua Beach. Data will be used to update NIMA chart COMBT805647 and NOAA NOS chart 19ACO19357.

1.1.6 Kahuku
Data are required to support SDVT-1 training operations. Data will be used to update NOAA NOS chart 19ACO19357.

1.1.7 Kawaihae Harbor, Hawaii
This area on the leeward coast of the Big Island is used for SDVT-1 training. Kawaihae Harbor is the Sea Port of Debarkation (SPOD) for USMC units deploying to Hawaii for training at the US Army training facility on Hawaii.

1.1.8 Kaunakakai, Molokai
The area is to be used for SDVT-1 training operations. Data will be used to update NOAA NOS chart 19XHA19353.

1.1.9 Honolulu/SE Oahu
This area is to be used for SDVT-1 training operations. Data will be used to update NIMA chart COMBT800744 and NOAA NOS chart19AHA19364.

1.1.10 Kaneohe Bay, MCBH Kaneohe
This area is to be used for SDVT-1 training operations. Data will be used to update NIMA chart COMBT800744 and NOAA NOS chart 19BHA19359.

1.1.11 The Hawaiian Islands datasets consist of LIDAR data collected in support of the above requirements, and data collected in support of USACOE and USGS requirements. The delineating factor separating these data and requirements are:

1.2 General Survey Specifications:

All Navy LIDAR operations are planned and executed to meet IHO Order 1 as a matter of policy. No specific survey specifications exist for areas originally outside the Navy areas. However, some of these areas were developed to meet IHO Order 1, as discussed in section 1.4.

1.3 Tasking

1.3.1 The scope of the LIDAR survey was depth measurement only from the shoreline out to the laser extinction depth, with shoreline delineation, limited beach topography and hazard detection within the capabilities of the system. LIDAR did not perform, nor was one intended, a comprehensive hydrographic survey and no comprehensive survey was done in areas worked solely by LIDAR. The survey specification required an IHO order 1 survey with 100% target/obstruction detection in all Navy areas of interest. USCOE and USGS requirements were not to charting specification, but were to support coastal modeling requirements.

1.4 IHO Standards and Coverage

1.4.1 All Navy areas meet IHO Order 1 specifications for positional and depth measurement accuracy. Theoretically, all Navy areas meet IHO Order 1target/object detection requirements at the 95% confidence level for depths from 7m to 20m with single flight coverage. At depths deeper than 20m signal-to-noise ratio limitations greatly reduce target detection capability, particularly for small objects (Figure 1). Multiple flight coverage will theoretically improve the confidence of target detection capability in the depth range of 2m to 7m, and possibly down to 20m.

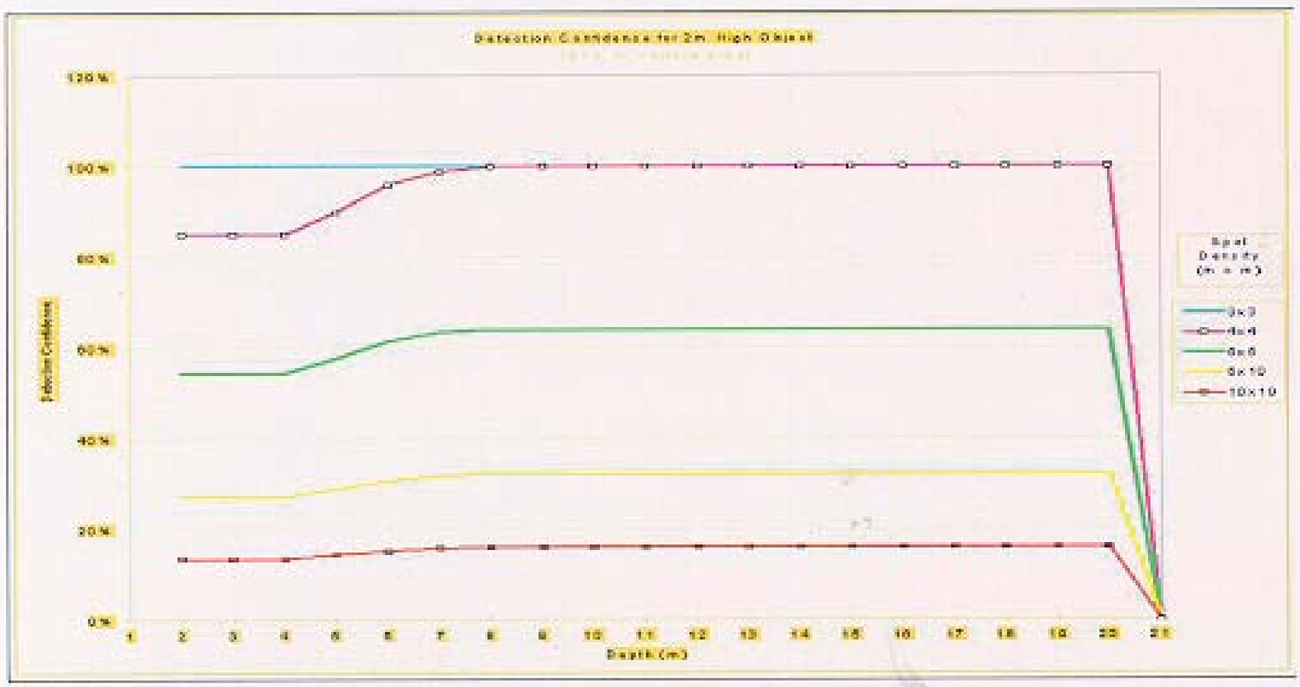
Subsequent testing of the follow-on CHARTS system, utilizing the same operating principles and algorithms and a lower power laser, at 4x4 spot spacing, targets of 2 meters were detected 100% of the time in depths 5 – 30 meters. Based on these actual tests the LIDAR system meets IHO order 1 target detection requirements. Multiple coverage provides a degree of redundancy for this capability.

1.4.2 The Navy areas were surveyed at 4x4-meter spot density and with greater than 200% coverage to ensure a very high confidence of target detection. USGS areas were also flown at 4x4-meter spot density and 100% coverage. USACE areas were flown at 8x8-meter spot density and 100% coverage. USACE and USGS areas were not typically surveyed to meet charting standards, and therefore do not require IHO accuracy and may not meet Order 1 standards for target/object detection. These areas were surveyed to support coastal modeling, storm surge, coral reef and environmental studies. There are, however, exceptions to this procedure, described below.

1.4.3 Where the USACE and USGS areas were small and adjacent to and interleaved with Navy areas, the USGS and USACE areas were typically flown as part of the Navy area for operational efficiency. In such cases, these USGS and USACOE areas will have multiple coverage and also will meet Navy requirements. Regardless of spot density and coverage, all areas meet IHO Order 1 positional and depth accuracy. These specific areas are described in the graphics of Appendix A.

1.4.4 Theoretically, based on target detection probability curves produced by NOAA, Guenther, et al, all Navy areas meet IHO Order 1 target/object detection requirements at the 95% confidence level for depths from 7m to 20m with single-flight coverage. At depths deeper than 20m, signal-to-noise ratio limitations greatly reduce target detection capability, particularly for small objects less than 2 meters (Figure 1). Multiple-flight coverage will theoretically improve the confidence of target detection capability in the depth range of 2m to 7m, and possibly down to 20m.

1.4.5 Subsequent testing of the follow-on CHARTS system, utilizing the same operating principles and algorithms and a lower power laser at 4x4 spot spacing, targets of 2 meters were detected 100% of the time in depths of 5 to 30 meters. Based on these actual tests the LIDAR system meets IHO Order 1 target detection requirements. Multiple coverage provides a degree of redundancy for this capability.



Theoretical detection confidence vs. depth for a 2m target at different laser spot densities.

Figure 1. Target detection confidence

1.5 **Survey Sheet and Survey Area Details.**

1.5.1 Oahu

IHO Order 1 sheets consist of sheets 01 - 03, 06 - 28, and sheet 30. Portions of USACOE area sheets 29, 31, 32, 33, 34 and 35 will meet Order 1 due to multiple coverage. Sheets 04 and 05 do not meet Order 1 due to lack of multiple coverage.

1.5.2 Kauai

All west coast sheets, 01 - 13, from Port Allen north to Barking Sands and the Na Pali coast meet IHO Order 1 requirements. Sheet 14 at Nawiliwili meets Order requirements due to lack of hazard/object detection.

1.5.3 Molokai

Sheets 01 - 10 along the south coast meet IHO Order 1 requirements. Sheets 11 - 18 meet Order 2 requirements due to lack of hazard/object detection.

1.5.4 Maui

All Maui sheets meet IHO Order 2 requirements. Maui sheets do not meet Order 1 requirements. NO TIDE CORRECTIONS APPLIED. Lack of double coverage to ensure target detection.

1.5.5 Lanai

All Lanai sheets meet IHO Order 2 requirements. Lanai sheets do not meet Order 1 requirements. NO TIDE CORRECTIONS APPLIED. Lack of double coverage to ensure target detection.

1.5.6 Hawaii (Big Island)

Kawaihae Harbor meets IHO Order 1 requirements. All other Hawaii areas meet Order 2 requirements due to lack of hazard/object detection. NO TIDE CORRECTIONS APPLIED other than Kawaihae Harbor and Bay.

1.5.7 Coverage. LIDAR coverage is 100% or better from above the shoreline to approximately 35m depth in all areas. Exceptions are:

1.5.8 Oahu - Pearl Harbor, west and north to Kaena Pt. coverage is to 50m depth. Oahu - Kaneohe Bay, coverage limited to 11m - 13m in the channel and inner bay due to water clarity issues. Turbidity and to some extent chlorophyll increases at 8m - 10m depth with a rapid falloff of transmissivity in the 532 nm optical band. See Appendix F for Kaneohe optics data demonstrating optical properties in the bay.

Oahu - Barbers Pt. harbor, coverage very limited due to water clarity.
Oahu - Pearl Harbor, no coverage due to water clarity.
Kauai - Port Allen, harbor coverage very limited due to water clarity.

1.6 **Hydrographic Survey Specifications**:

Hydrographic Survey Specifications for Hawaii, Archive No. 00US16

1.7 **Weather**.

The survey was conducted from late summer into winter. The only weather that affected operations were the winds, occasional rain showers and seas on the windward coasts. The Hawaiian Islands fall within the North east trade winds. The winds were a continuous 15 - 25 kts. Winds flowing over the mountain ranges and funneling down through the valleys made for difficult flying in many areas, with line keeping and altitude holding nearly impossible. Many holidays resulted that required numerous re-fly's. Surf on Oahu's north and east coasts, and the Big Islands windward north and east coasts made getting complete coverage in one or two flights difficult, if not impossible.

1.8 **Extraneous Activities Affecting the Survey**

1.8.1 Honolulu International Airport operations. This is reported to be the 15th busiest airport in the US. Initial discussions with the FAA indicated no flights would be possible within five miles of the airport, the area within the Terminal Control Area (TCA). After NAVO suggestions to the FAA to fly the survey flights during off-peak hours, we worked the survey flights into the midnight to 0500L time slot. Even at this time of day there were an average of 60 arrival/departures that required the SHOALS aircraft to vacate the area for short, though numerous, periods of time. Additionally, transitioning the flight crew from daytime to nighttime operations required a 24-hour rest period prior to and after night ops. As holidays became apparent in processing, usually after swapping back to daytime operations, we had to break flight operations for 24 hours to switch to night ops. This affected productivity and efficiency. Toward the end of the survey as time became a serious constraint, it became apparent there would be areas that did not get the required double flight coverage. This is because we couldn't continue to suffer the loss of 24 hours of survey time to swap the flight crews from days back to nights, and still meet other survey requirements within the allotted time frame. This was deemed not aserious issue in the area affected due to the relatively uniform bottom and no "surprises". The only area affected was within five miles of the VOR tower at Honolulu airport. This is an area of mixed Navy, USACoE and USGS requirements where Navy coverage requirements are not always met.

1.8.2 Political concerns. Prior to survey operations we were informed of numerous possible political concerns and sensitivities of the island residents. These were primarily noise abatement, environmental and governmental intrusion issues. We were informed by the FAA that residents are particularly sensitive to noise with respect to aircraft over-flight, and to expect many complaints concerning our low flying aircraft. During the course of five months of surveying only one noise complaint was received. Local officials informed us of native Hawaiian sensitivities and suspicions with regard to anything government or militarily related, mostly in reference to politically charged land use issues. No problems were encountered.

1.5.1 Surfers and Boogie boarders. Due to the popularity of Hawaii's beaches and surf, some lines had to be rescheduled to avoid "lighting up" the beach goers and wave riders.

2.0 Geodetic Control

2.1	**Horizontal Datum**:	WGS-84
	Projection:	Transverse Mercator
	Spheroid:	World Geodetic System of 1984
	Grid:	Universal Transverse Mercator
	Vertical Datum:	MLLW for LIDAR derived topography
	Sounding Datum:	MLLW

A vertical datum of MLLW for LIDAR-derived topography is contrary to the standard MSL datum for vertical elevations. All LIDAR data is referenced to the sea surface, thus LIDAR topography is referenced to the sea surface which is referenced to MLLW. The only exception to this is with kinematic GPS surveys utilizing On-The-Fly (OTF) processing techniques where the data are referenced to the ellipsoid. The Hawaii survey DID NOT USE OTF techniques.

Sounding Datum: Mean Lower Low Water. The NOAA-maintained automatic tide gauge, located at Honolulu Harbor, Oahu, Mokuoloe, Oahu (northern Kaneohe Bay), Nawilili, Kauai and Kawaihae, Hawaii were all referenced to MLLW.

2.4 **Time.** The time standard is UTC (GMT).

2.5 **Existing and New Control.** None used or established.

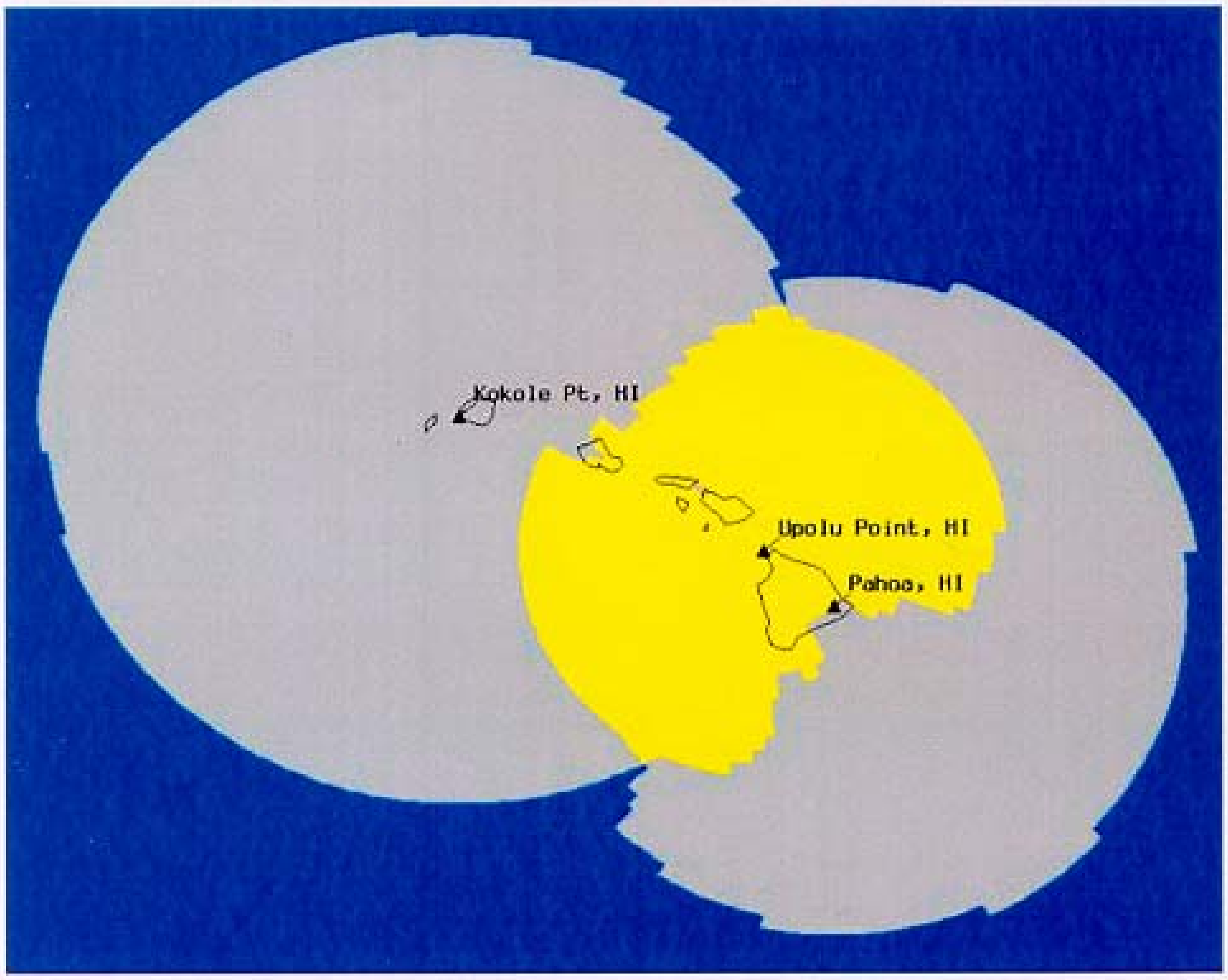
2.6 **Datum Shifts**. No datum shifts were applied.

2.7 **Horizontal Control Reports.** No horizontal control reports were generated.

2.8 **Station Descriptions/Recovery Forms**. No station descriptions/recovery forms were completed or issued.

3.0 **Digital Survey System**

3.1 **SHOALS GPS Positioning Systems**. ASHTECH Z-12 L1/L2 GPS receivers were used during the survey to provide navigational control in the survey platform in the DGPS. USCG DGPS stations located at Kokole Point Kauai, Upolu Point Hawaii (Big Island) and Pahoa Hawaii (Big Island) were utilized continuously to provide DGPS corrections to the aircraft Ashtech Z-12 receiver.



USCG DGPS beacon coverage for Hawaii.

Kokole Point was used for Kauai, and Oahu. Upolu Point was used for Molokai, Maui, Lanai and all but the south shore of Hawaii. Pahoa was used for the south shore of Hawaii.

3.2 **SHOALS Lidar data acquisition system.** The SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) system consists of an airborne laser transmitter/receiver capable of measuring 400 soundings per second. Lidar is an acronym for LIght Detection And Ranging. The system operates from a deHavilland DHC-6 Twin Otter flying at altitudes between 300 and 400 meters with a ground speed of about 104 knots. The SHOALS system also includes a ground-based data processing system for calculating accurate horizontal position and water depth. The system operates by emitting a pulse of light that travels from an airborne platform to the water surface where a small portion of the laser energy is reflected back to the airborne receiver. The remaining energy at the water's surface propagates through the water column and reflects off the sea bottom and back to the airborne detector. The time difference between the surface return and the bottom return corresponds to water depth. The maximum depth the system is able to sense is related to the complex interaction of radiance of bottom material, incident sun angle and intensity, and the type and quantity of organic material or sediments in the water column. As a rule-of-thumb, the SHOALS system is capable of sensing bottom to depths equal to two or three times the Secchi depth.

3.2.1 The airborne system conducts all the data collection and is divided into three subsystems:

1) Acquisition, control and display,
2) Transceiver, and
3) Positioning and auxiliary sensors.

3.2.2 **Acquisition, Control and Display Sub-System (ACDS).** The ACDS is the primary component through which all data are collected and recorded, system integrity and self-checks conducted, and operator monitoring of key real-time system and survey information. All airborne data are recorded on Exabyte 8-mm dual tape drives at a rate of approximately 300 Kbytes per second. These tape drives were selected over other possible data storage media because of their proven performance and reliability in aircraft. The data tape is the only link between the airborne data collection system and the data processing system. It also provides the ability to load survey flight information for each survey mission into the airborne system prior to each flight.

3.2.3 The survey operator's interface with the system is through the ACDS. Real-time information is provided so that the operator can accomplish two tasks, first as the surveyor to ensure that the planned mission is successfully implemented and completed and second, as the Lidar system operator to monitor system status during the mission to ensure that the system operates within expected parameters. The main indicator of survey status and progress is from real-time depths provided to the operator at 100 Hz. These real-time depths are not corrected for tides or water surface waves, but they do provide an estimate of project depths to within approximately +/- 1 m.

3.2.4 The ACDS also provides survey navigation information to the pilot such as the required altitude, speed, and position along a selected survey line, necessary to conduct the planned mission and produce the desired sounding density. The operator selects the flight line and the ACDS converts its position and other flight parameters to navigation information and presents this to the pilot on a small video monitor mounted in the cockpit.

3.2.5 The Transceiver is mounted over a window in the belly of the aircraft. The main component is the laser, which operates at 400 Hz. There are four receiver channels, two for detecting the water surface and two for detecting the sea bottom. The two water surface channels include the IR return from which the surface location is determined. The second channel is to ensure a water surface return by detecting the Raman scattering. The two bottom channels are used to detect returns from shallow and deep depths.

3.2.6 Included is a gyro-stabilized scanner, which directs each laser pulse to a predetermined location on the sea surface. An inertial reference system provides aircraft attitude information allowing the scanner to compensate for aircraft motion and measures accelerations necessary for accurately resolving the sea surface location during post-flight data processing. The width of the scan is nominally equal to half the altitude of the aircraft. At a speed of 120 knots and an altitude of 200 m, this yields a uniform sounding spacing of 4 m x 4 m. the sounding density can be altered by flying higher/lower and faster/slower and also by selecting a different scan width.
Aircraft Positioning And Auxiliary Sensors Sub-System (APASS).

3.2.7 The APASS consist of DGPS and a video camera. DGPS is used for horizontal positioning of the aircraft and the differential correction is available through Fugro's Omnistar system. The other function of the APASS is to record a video image of the area being scanned by the laser. This provides a visual and audio record of each survey mission and a record for the data processor/hydrographer conducting the data processing to check or evaluate any anomalies that may be encountered during data processing, such as algae on the water surface or over-flight of an island.

3.3 SHOALS System Calibration

3.3.1 To ensure accuracy of the system, SHOALS requires both a hard target test and a calibration flight for calibration of the system. The hard target test is accomplished through firing the laser against a known baseline distance. The test is performed for each receiver of the surface and bottom channels. Any observed error is nulled out through adjustment of appropriate parameters.

3.3.2 The SHOALS system undergoes an in-flight calibration for the determination of the small offsets of the scanner mirror frame relative to the optical axes of the system, in the roll, pitch and heading directions as defined by the Inertial Navigation System. Critical to this calibration is locating and flying a calm, flat area in the field. To calculate the angular offsets an average of the water surface is derived by the system, then a special calibration program developed by the National Ocean Service derives these small angular offsets assuming that the sea surface is flat. The offsets are folded back into the collected standard data and the successful plotting of a flat-water surface shows that the angles were correctly derived.

3.3.3 In the first six years of SHOALS operation, a standard survey line was used to derive these small angular offsets. In early 2000 is was thought that a wider excursion of the scanner forward angles would result in better calibration values and a raster scanner pattern became the standard operational procedure. Either procedure raster or standard pattern is acceptable as long as the resulting angular corrections produce a flat-water surface. (Carswell; Optech, Inc. 2002)

3.4 **SHOALS Positioning Quality Control.** The operator continuously monitors position quality in the air. Flight lines are re-flown if any of the following specifications are exceeded:

PDOP exceeds 4. The PDOP is recorded as a field within the data.

The semi-major axis of the positional error ellipse exceeds 3.5m at the 95% confidence level.

The DGPS correction age exceeds 10 seconds.

The minimum number of satellites being tracked for continued sounding is less than 4 healthy SV's.

The minimum elevation for SV is less than 10°angle from the horizontal.

3.5 **SHOALS Lidar data processing system.** Hydrographic Data Processing utilized the SHOALS data processing suite; data tapes from the aircraft are read in and the depth derived from the processed laser pulse. The algorithms utilized in the SHOALS processing suite were developed at NOAA by Gary Guenther, et al. Time tagged position and depth, the *.out file and laser waveform files were then transferred to the NAVOCEANO system. Data quality control, additional editing and validation were carried out using the NAVOCEANO Area Based Editor running under LINUX. Upon return to NAVOCEANO, the data underwent further analysis and refinement using 3D visualization tools (Fledermaus) and application of NOAA verified tides.

3.5.1 **Ground Processing Environment** All processing, cleaning and product generation is carried out on off-the-shelf NT workstations using software developed by Optech, Inc. specifically for SHOALS.

3.5.2 **Processing Of Data, General Principles.** All survey data collected are field processed, verified and validated concurrent with survey operations. Verification methods include comparison of collected data to existing charts and prior surveys. Discrepancies discovered in field processing are resolved immediately. Discrepancies requiring significant additional operational time and effort to resolve are brought to the attention of the Operations Manager, for decision.

3.5.3 **Post Processing Lidar Data**. SHOALS Lidar data is processed by an NT-based automated processing software package that includes automated post-flight depth extraction procedures, various calculation and utility programs, and a manual processor operator interface that provides access to individual waveforms for display and editing. The suite maximizes throughput by recognizing and handling most problems routinely, minimizing the amount of human interaction with the raw data.

3.5.4 After the data is extracted from the flight tape and input into the database, it is processed by an automated routine consisting of a lidar waveform processor and sounding position determination algorithm. The main function of the automated processor is to obtain inputs from the raw data; calculate depths, positions, and other products; correct for tides and waves; and write the outputs back to file database. It runs at a 1:0.1 time ratio with data collection and data processing.

3.5.5 All data is then manually edited for obvious anomalies. Where such anomalies are clearly due to fish, or similar causes, they will be flagged as invalid returns; any other anomalies resembling bottom hazards will require investigation of the waveform in order to determine whether the feature is real and should be retained in the data set. In cases of doubt, such features will be marked for further investigation through re-flight of the area in question.
The processed data is then output as an ASCII (*.xyz) file which can either be input directly into Hypack, or converted to Fugro Binary Format (*.fbf) for input into Starfix.Proc for review, QC and ultimately subsequent mapping and product generation. This process is outlined in Figure 6.

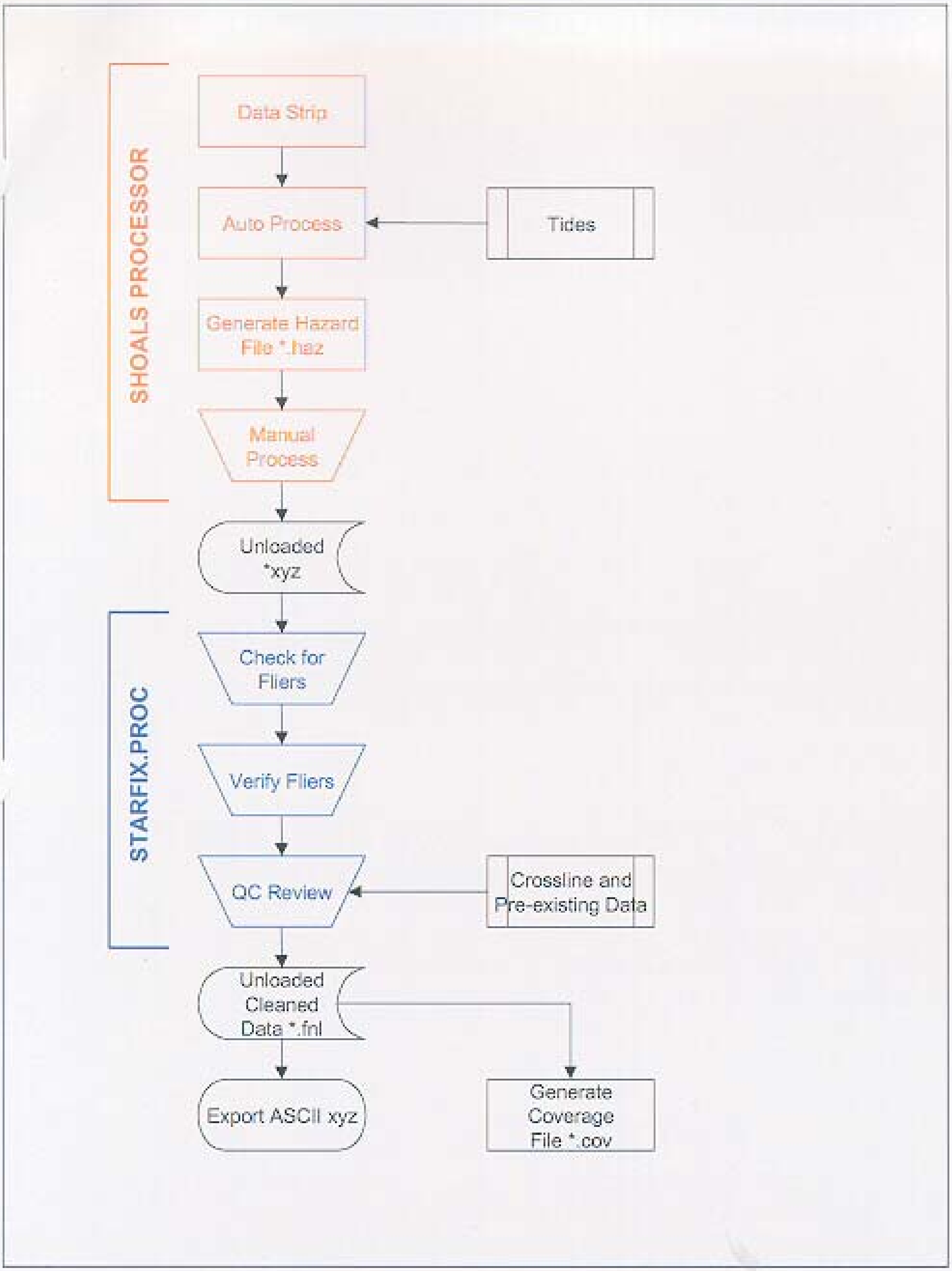


Figure 6: Data Processing Flow

3.5.6 **Data Review and Inspection.** Output xyz data from the processor is transformed to the appropriate projection using Corpscon or GeoCoordinator and then input into Starfix.Proc where the process of spatial review and comparing each data set to expected values is performed. Each dataset is compared with any available pre-existing charts, maps or other information data; overlapping datasets are also compared to each other to make sure each falls within the systems limitations. The data is then plotted out on paper with a contour interval 1 or 2 m in order to identify any further anomalies that may not have been apparent from inspection of individual flightlines and only become evident in a broader spatial context. Any such anomalies will then be resolved through reference back to the waveforms.

3.5.7 **Second Depth Description and Methodology.** The laser waveform from the bottom return is capable of having two valid returns (second depths) for a single sounding. Multiple returns can be from any object suspended in the water column, sharp drops in the bottom topography, or objects rising above the bottom. The initial processing of the data picks the more shallow depth for that particular sounding. The post processing software allows for viewing of all soundings with multiple returns and evaluation by the hydrographer to determine the validity of the return. The hydrographer is allowed to keep, swap or kill the return based on the waveform analysis and review of the surrounding and overlapping data. The keep option will keep the sounding as it was initially calculated by the post processing algorithm. The swap option allows the hydrographer to change the sounding to the second of the valid returns calculated by the software. The kill option allows the hydrographer to kill the sounding so that the sounding is not reported in the final cleaned xyz data. A report of this process is output from the post processing software and details the status of each second depth return as either keep, swap, or kill. See appendix "F" for second depth report for this project. Soundings reviewed here are kept unless there is valid evidence to support change.

3.5.8 **Flier Description and Methodology.** Possible fliers are listed within Starfix.Proc and output to a log file. The timestamps listed in this log file are then reviewed in the post processing software by the hydrographer to determine the validity of the return. The analysis is similar to that of the second depths in that adjacent and overlapping data are reviewed in conjunction with the waveform. A report of these fliers is then compiled with the action taken (either keep or kill) for each sounding. See appendix "G" for the flier report. As with the second depths all soundings are kept unless valid evidence exist to support killing of the sounding.

3.5.9 **Area Investigation and Review.** In areas where soundings are killed due insufficient energy return, or areas where the second depth and / or flier review produce questions to the validity of the sounding, re-flights are performed. The field hydrographer is responsible for determining which areas are to be re-flown based on the client's maximum gap in coverage requirements.

3.5.10 **Data Mapping**. The final cleaned xyz files are then binned using a 4m by 4m bin size to help reduce the size of the files. This file is the final delivered xyz file. The final mapping is performed using MicroStation and Inroads. These programs produce maps in DGN format. The contour files produced by Inroads where derived from a reduced data set of xyz files. The reduced data set was produced by HyPack's point reduction program. After mapping in the DGN format the files were exported to a DXF format for the final deliverable.

4.0 Calibrations

4.1 **Positioning Systems**. No formal calibrations of the Ashtech Z-12 receivers operating in the DGPS mode were conducted in the field. However, internal accuracy (precision) of the system was monitored by the SHOALS system utilizing standard positional QC (HDOP, PDOP, SNR data) techniques. Overall accuracy was not checked against independent (terrestrial) navaids, but crossline, swath overlap and multiple flights over features such as pier ends/corners and NAVAIDS and comparison checks on the sounding data did allow a high degree of trust in positional integrity to be reached. Fugro/Chance personnel received daily solar storm forecasts and activity reports. Data collection during periods of high solar activity was avoided. During processing, graphical analysis of LOP data indicated no problems with the positioning system. With the vast majority of cross-checks and overlapping swaths showing good agreement however, both sounding reduction and navigational accuracy were assessed as adequate for the survey.

4.2 **SHOALS System Calibration.** To ensure accuracy of the system, SHOALS requires both a hard target test and a calibration flight for calibration of the system. The hard target test is accomplished through firing the laser against a known baseline distance. The test is performed for each receiver of the surface and bottom channels. Any observed error is nulled out through adjustment of appropriate parameters.

4.2.1 The SHOALS system undergoes an in-flight calibration for the determination of the small offsets of the scanner mirror frame relative to the optical axes of the system, in the roll, pitch and heading directions as defined by the Inertial Navigation System. Critical to this calibration is locating and flying a calm, flat area in the field. To calculate the angular offsets an average of the water surface is derived by the system, then a special calibration program developed by the National Ocean Service derives these small angular offsets assuming that the sea surface is flat. The offsets are folded back into the collected standard data and the successful plotting of a flat-water surface shows that the angles were correctly derived.

4.2.2 In the first six years of SHOALS operation, a standard survey line was used to derive these small angular offsets. In early 2000 is was thought that a wider excursion of the scanner forward angles would result in better calibration values and a raster scanner pattern became the standard operational procedure. Either procedure raster or standard pattern is acceptable as long as the resulting angular corrections produce a flat-water surface. (Carswell; Optech, Inc. 2002)

4.3 **Survey System Offsets/Alignment**. The laser system and motion sensors are optically aligned and the offsets measured with respect to the phase center of the GPS antenna. This is done at every system or component installation. The measured offsets are contained in what is called the "STATIC" file. This file is written to the survey plan and, during initialization of the data collection system, written to the daily data tape. During processing the offset values are stripped from tape along with the data applied during post processing (SHOALS NT processor). During processing tide corrections are applied. In the event of a kinematic survey the KGPS derived positions and ellipsoid to MSL offset is also applied. For surveys covered in this report no kinematic data collection was conducted.

4.4 Deep Bias Offset Correction

4.4.1 There has been a suspected deep bias present in SHOALS 400 data. This bias has never been quantifiable due to a lack of suitable ground truth data. The SHOALS-400 algorithm applied a constant bias to make the SHOALS derived depths shallower by 12 cm. This was based on the original Sarasota data and also the later Tampa Bay data. Recent testing of the follow-on Lidar system, SHOALS 1000, or CHARTS, the NAVOCEANO term for the system, at the South Florida Test Facility (SFTF) operated by the Naval Surface Weapons Center off Dania Beach Florida has allowed for the quantifying of this deep bias error. True, the deep bias error has been quantified with the SHOALS 1000 system, it is applicable to the SHOALS 400 system because the physics involved is the same as are the algorithms utilized to derive depth from the laser shots.

4.4.2 All of the SHOALS 400 data has been corrected for a depth bias that was discovered during the ground truth tests for the CHARTS system at the South Florida Test Facility. The equation used is as follows:

```
if (out.au.reported_depth > 7.0)
{
  correction = 0.17235 - 0.02485 * out.au.reported_depth;

  out.au.tide_cor_depth -= correction;
  out.au.reported_depth += correction;
  out.au.result_depth += correction;
  out.au.sec_depth += correction;
}
```

4.4.3 The equation represents the difference between the historical depth bias corrector (SHOALS-400) that was applied to the data and the new depth bias corrector taken from the SFTF data. The equation was derived by Grant Cunningham of Optech. This information came in an email (10/10/03) from Paul LaRocque of Optech. Note that the 12cm bias mentioned in the email was not depth dependent and was not removed from the data.

0 cm effect at 7 m

8 cm effect at 10 m
20 cm effect at 15 m
32 cm effect at 20 m
57 cm effect at 30 m
82 cm effect at 40 m.

The SHOALS-400 algorithm applied a constant bias to make the SHOALS derived depths shallower by 12 cm. This was based on the original Sarasota data and also the later Tampa Bay data. The following new recipe will make the SHOALS-400 data even shallower by the amounts stated in table above.

To apply the newest depth bias corrector to older (i.e., SHOALS-400) data, the following equation should be used:

delta_depth = 0.0 m, for reported_depths < 7 meters
delta_depth = [0.17235 - (0.02485 * reported_depth)] m, for
reported_depths >= 7 meters

This delta_depth should be ADDED to the older values of the reported_depth, as below:
new_reported_depth = (old_reported_depth + delta_depth)

Therefore, at 40 meters old_reported_depth this will make the new_reported_depth shallower by about 82 cm.

This bias offset was proven and quantified after the first data delivery to NOAA. Subsequently, the above described procedure was applied to ALL Hawaii data and the data was re-submitted to NOAA. All Hawaii data currently held by NOAA Pacific Hydrographic Branch has been corrected for this bias.

5.0 Side Scan Sonar

5.1 **Requirements.** No side scan sonar requirement was defined for Hawaii.

5.2 **Equipment.** N/A

5.3 **Coverage.** N/A

6.0 **Tides and Water Levels.**

6.1 **General Requirements.** Tidal zoning shall be constructed and tidal data observed and recorded such that derived tidal corrections to the sounding data meet 0.5 meter accuracy standards. The survey area shall be sufficiently zoned and tide gauges strategically located to ensure tidal corrections meet accuracy requirements.

6.2 **Tidal Data Collection, Scope of Work.**

6.2.1 The primary NOAA tide Gauges. Also NOAA CO-OPS was responsible for posting preliminary unverified tidal data on the CO-OPS web site, tidal data processing and verification, posting of verified data to the web site and tidal zoning.

6.3 **Tide Gauges**

NOAA-maintained automatic tide gauges are at the following locations:

Honolulu Harbor, Oahu
Mokuoloe, Oahu (northern Kaneohe Bay)
Nawilili, Kauai
Kawaihae, Hawaii

6.2.3 **Additional Gauges.** NAVOCEANO installed backup gauges on Oahu at the Barbers Pt. Harbor and the Waianae small craft harbor. On Kauai NAVOCEANO installed a tide gauge at a small craft harbor just south of PMRF between Kekaha and Waimea. NOAA gauges supporting the zoning were located on the windward side of the islands, well away from much of the survey area. The NAVOCEANO installed gauges were installed as a backup to the NOAA gauges. Furthermore, the data from the NAVOCEANO installed gauges were used to confirm the NOAA tide-zoning scheme.

6.4 **Preliminary Tidal Zoning.**

6.4.1 Tide zones were developed by NOAA CO-OPS based on historical data from the above mentioned gauges.

6.5 **Tide Zone Accuracy**

6.5.1 Results of comparing zone HAW213 (Oahu west coast from Barbers Pt. harbor to Kepuhi Pt. and including Waianae) referenced to NOAA's Honolulu gauge and the installed Waianae gauge are as follows:

Maximum difference:	0.35 meters
Mean difference:	0.15 meters
Standard Deviation:	0.179 meters

6.6 **Final Tidal Zoning.**

6.6.1 Tidal No adjustment was made to the NOAA CO-OPS zone scheme. Tidal time series from the NAVOCEANO gauges and tidal time series for the appropriate NOAA tide zone agreed very well. No adjustment to the NOAA zones was necessary.

6.7 **Application of Tides.**

6.7.1 The NAVOCEANO processing system does not utilize "tide correctors", per se. The NOAA CO-OPS zoning scheme partitioned the survey areas into zones referenced to a reference tide gauge. For each zone there is a phase and amplitude correction, also referenced to the reference tide gauge. NAVOCEANO's processing system handles tide correction by creating a tide file for each zone by applying zonal corrections to the reference gauge tides. The processing software identifies in which zone a sounding falls and applies that zone's tide to the sounding. Tide correctors are applied during post processing, just prior to data editing and validation.

6.8 **Currents and Tidal Streams**

See Appendix E for a summary of Hawaiian currents from published literature. *Informational for Tactical Products.*

6.8.1 **Large-scale Currents**

Source: www.atftp.soest.hawaii.edu.

The average currents around the Hawaiian Islands form a large Gyre centered at about 32N. The geostrophic basin scale clockwise circulation sweeps the islands roughly east to west and intensifies southward. At and near the surface, currents driven by the wind combined with the geostrophic currents result in more complicated flow patterns.

South of Hawaii, the surface North Equatorial Current (NEC) reaches an average westward speed 0.35 knot at 13 N, and gradually decreases towards the islands. Between 18 N and 22 N, the currents are strongly influenced by the islands. The NEC forks at Hawaii; the northern branch becomes the North Hawaiian Ridge Current (NHRC), and intensifies near the islands with a typical speed of 0.5 knots. West of the islands, two elongated circulations appear. A clockwise circulation is centered at 19 N, merging to the south with the southern branch of the NEC. A counter-clockwise circulation is centered at 20-30 N. Between them is the narrow Hawaiian Lee Counter

Current(HLCC). Surface currents over the western islands and north east of the NHRC are variable. Current variability shown below indicates numerous eddies or swirls in the lee of the islands.

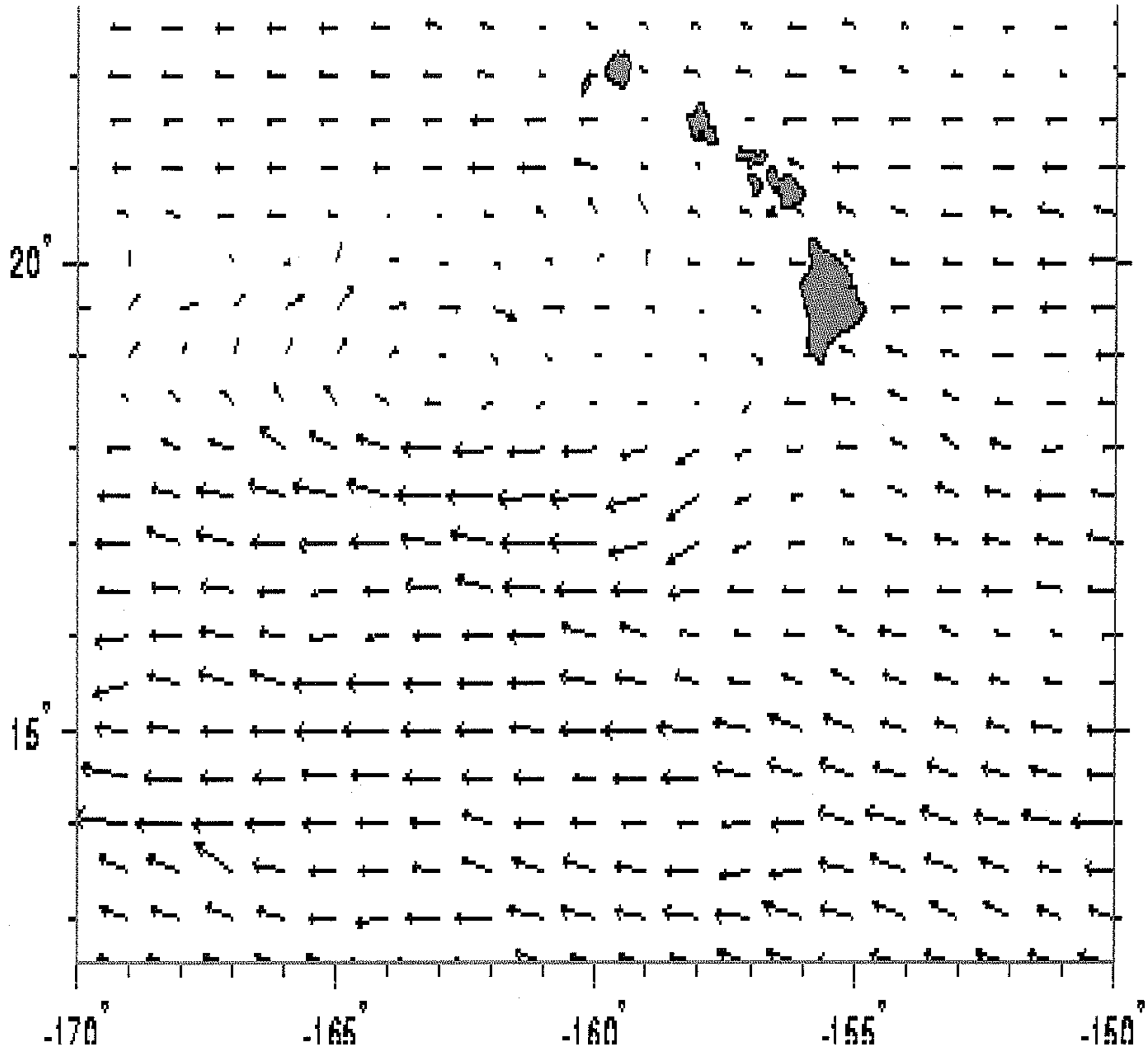


Figure 2. Large-scale ocean circulation around the Hawaiian Islands.

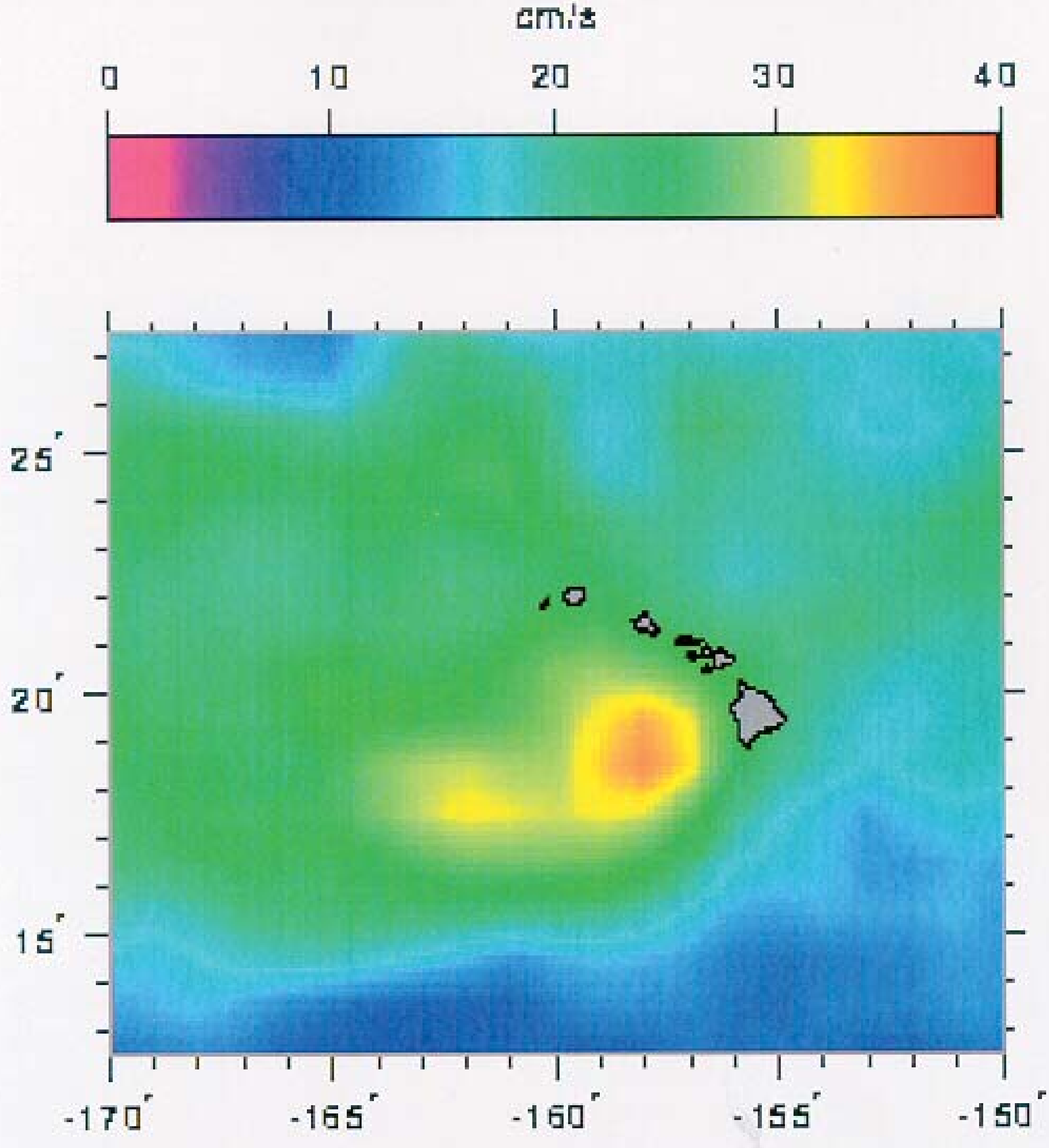


Figure 3. Large-scale ocean circulation variability around Hawaii indicates numerous eddies and swirls which obliterate slower average circulation.

6.8.2 **Regional currents**

The island chain affects the ocean by two important mechanisms:

interactions of the islands with the large scale ocean currents, and wind speed variations in the lee of the islands.

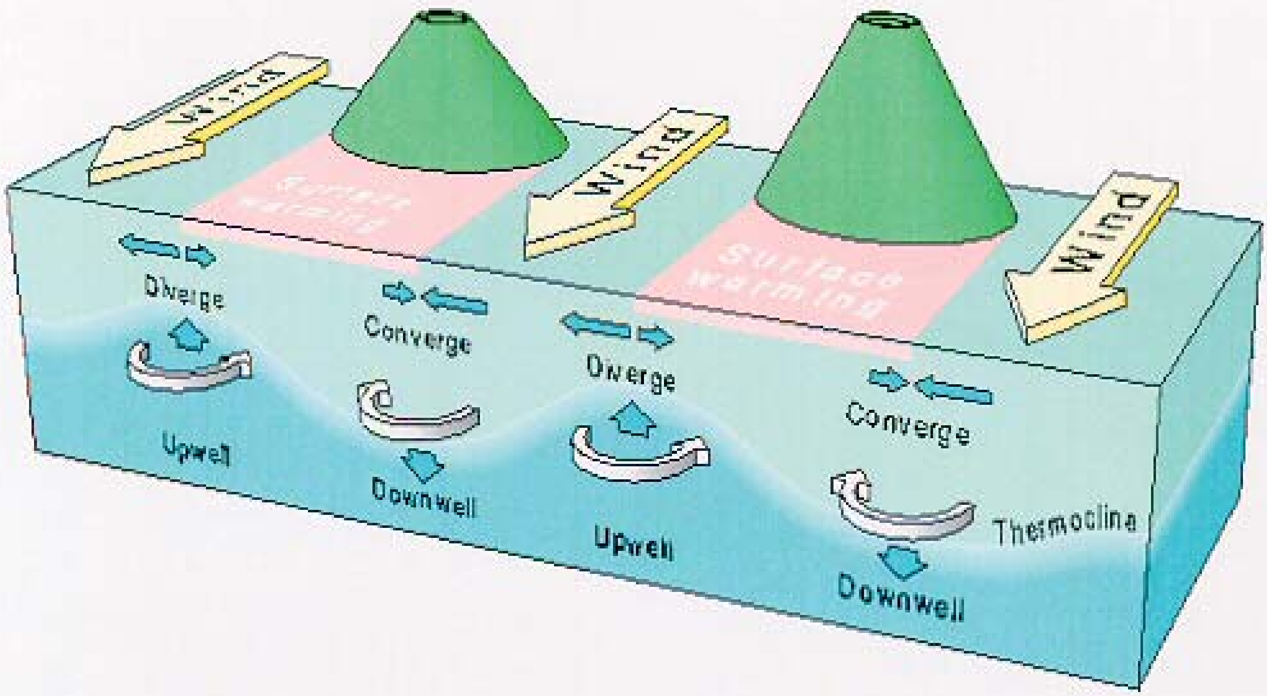


Figure 4. Regional current formation due to the modifying effect of land masses on large-scale circulation.

At the northern and southern boundaries of each island, the trade winds with speeds of 22-44 mph are separated from the calmer lee by narrow wind shear lines. Locally, the depth of the surface mixed layer depends on wind speed: in the channels, deep mixed layers are observed; in the lee, stirring by the wind is not sufficient to mix down solar heating and intense daytime warming of the ocean surface results. Sharp surface temperature fronts, sometimes reaching a difference of 4 C, are often associated with these wind shear lines.

Variations of wind have subtle effects on current patterns. When wind blows for many days over a surface mixed layer, the water moves to the right of the wind in the Northern Hemisphere due to the earth's rotation. Water therefore moves away from the northern shear line. To compensate for this divergent surface motion, water upwells from greater depths, appearing as a cold spot at the surface. Similarly, water moves towards the southern shear line, resulting in a deepening of the thermocline there.

Geostrophic currents result from these variations of thermocline depth, in the form of intense counter-clockwise eddies under northern shear lines, and somewhat less intense clockwise eddies under southern shear lines. This process is quite dramatic -- the depth of the mixed layer in the lee of the island of Hawaii can vary from less than 20 m in the counter-clockwise eddy, to more than 120 m in the clockwise eddy. The large counter-clockwise average circulation is believed to result from the repeated occurrence of eddies spun up by the shear lines of the islands of Maui and Hawaii.

Eddies can also be generated when intense currents such as the NEC impinges on the islands. The large clockwise circulation south west of the island of Hawaii appears to be caused by many such clockwise eddies repeatedly formed near South Point.

6.8.3 **Tidal Currents and other Oscillations**

On scales of oceanic basins, tides exist as very long waves propagating in patterns determined by their period and the geometry of the basin. The figure below shows the response of the North Pacific to the tidal period of 23 h 56 min, the largest diurnal component. Phase lines along which high tide occurs at the same time converge to an amphidrome point west of Hawaii where the tidal range is zero. Phase lines rotate counter-clockwise around this amphidrome, so that the offshore diurnal tide reaches the Hawaii island first, then sweeps across Maui, Oahu and finally Kauai.

Local bathymetry affects the ranges and phases of the tides along the shore, as the tidal waves wrap around the islands. For example, high tide at Haleiwa on the north shore of Oahu occurs over an hour before high tide at Honolulu Harbor.

Tidal currents result from tidal variations of sea level, and near shore are often stronger than the large scale circulation. Current meter records collected off Oahu, Maui and Hawaii (below) show that semi- diurnal and diurnal tidal currents tend to be aligned with the shoreline.

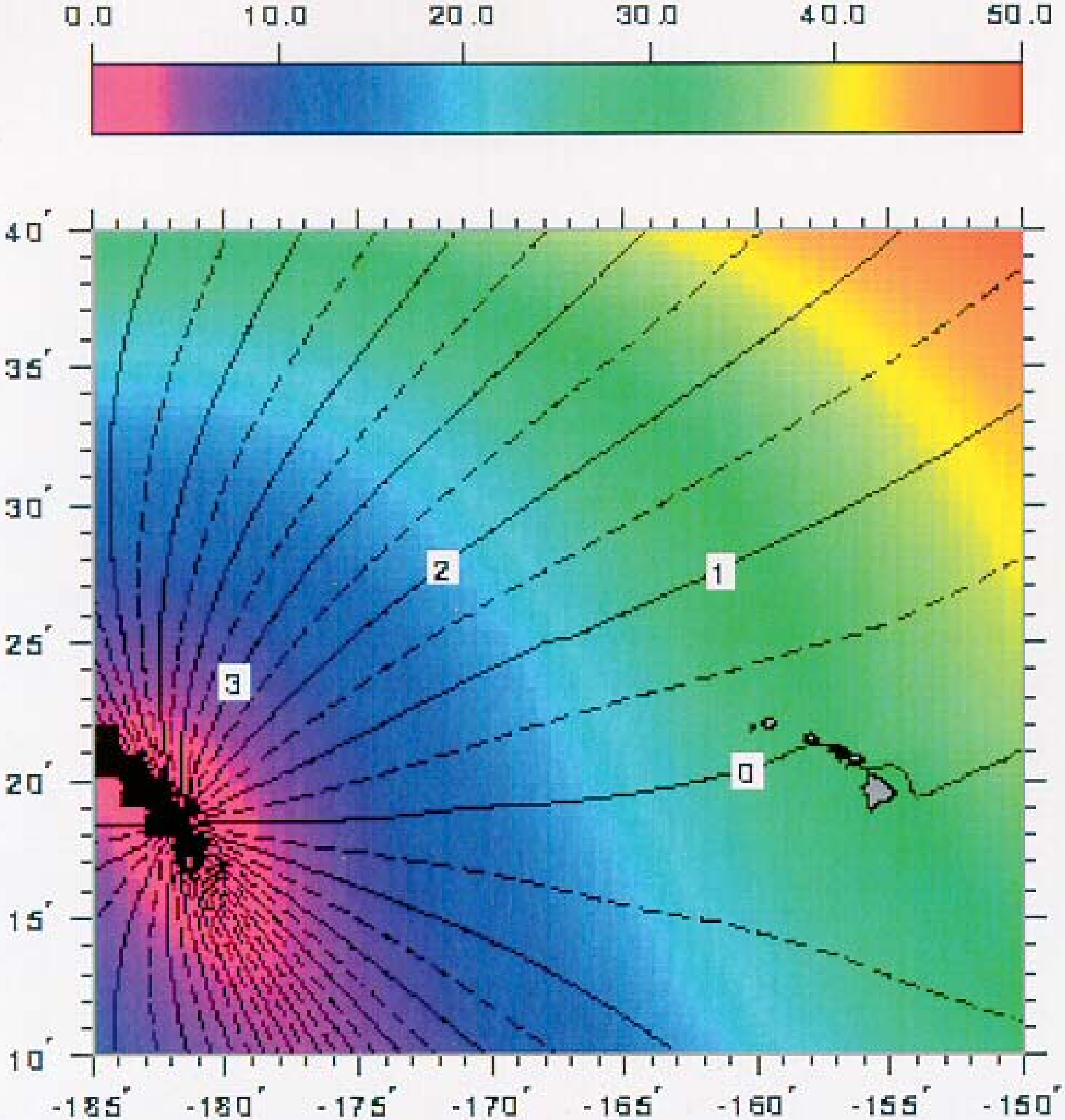


Figure 5. Response of the North Pacific to the longest duration tidal component (23h 56m) and the effect of the Hawaiian land mass.

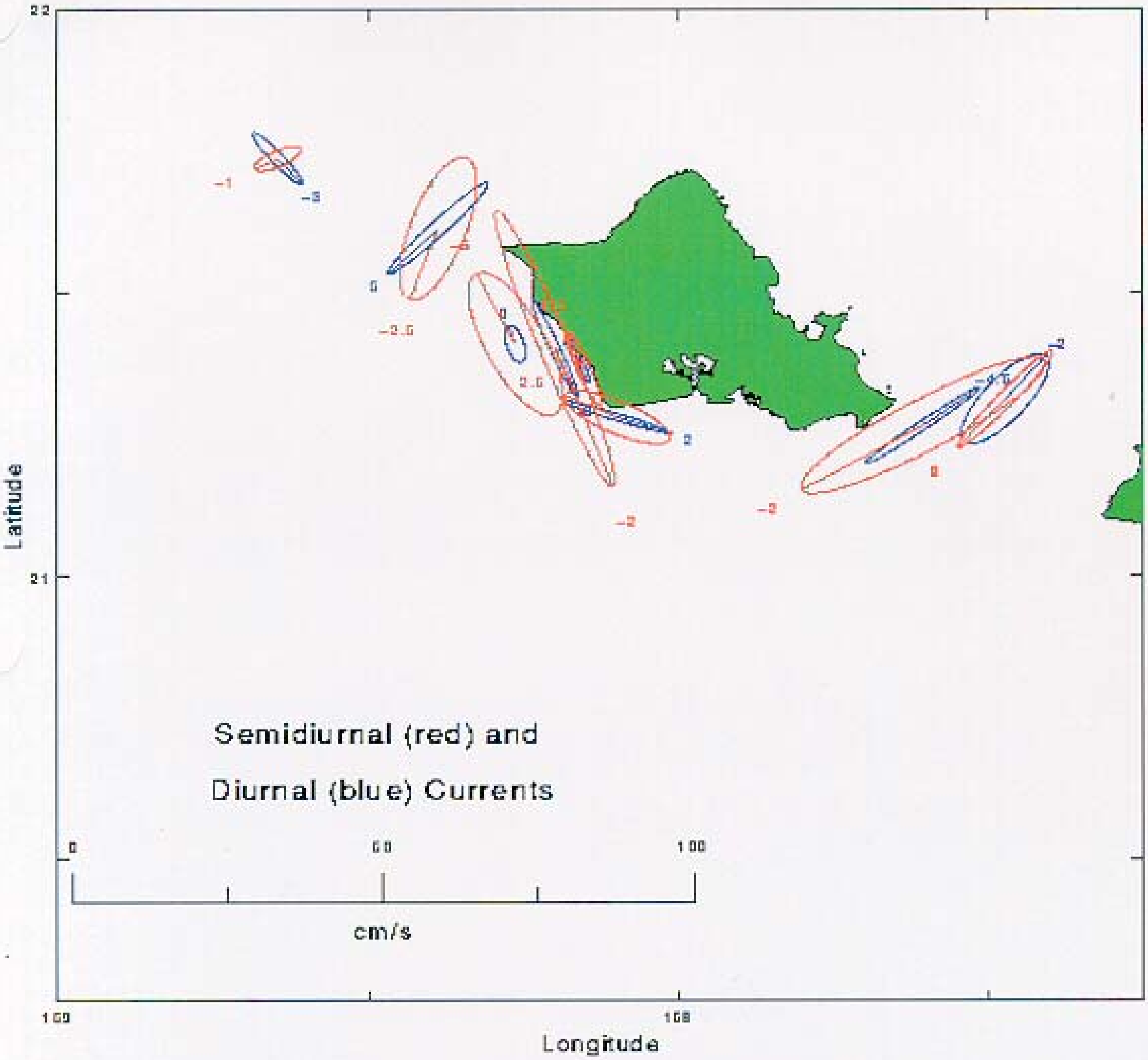


Figure 6a. Representative tidal current flow around the Hawaiian Islands. Diurnal and semi-diurnal tidal flows tend to be aligned with the shoreline. Strong eddies are often found around points and headlands.

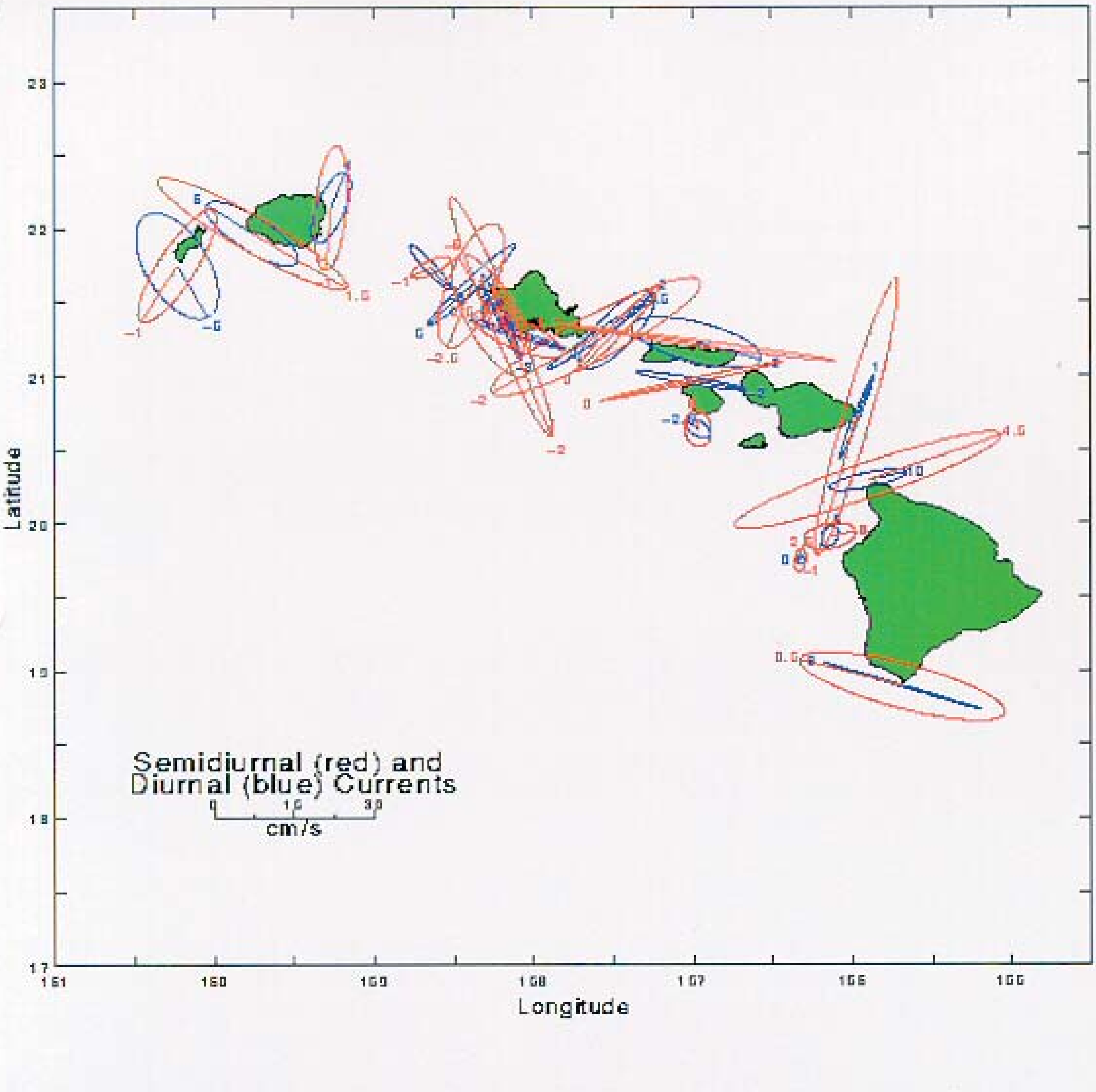


Figure 6b. Representative tidal current flow around the Hawaiian Islands. Diurnal and semi-diurnal tidal flows tend to be aligned with the shoreline. Strong eddies are often found around points and headlands.

Due to high variability of tidal currents around the islands, however, this statistical representation may not correspond to the flow at a particular time -- tidal currents cannot be predicted as precisely as sea level. Strong swirls often result from tidal currents flowing around points and headlands, and present hazards to divers.

Variations of sea level and currents at periods of 1.5 to 3 days are also observed around the Hawaiian islands. Although they manifest themselves as oscillations just like tides, they are not forced by gravitation, but by time-varying winds and possibly swells. They displace the sea surface by only a few centimeters, but the depth of isotherms by tens of meters. Such oscillations, usually occurring during the winter, may be associated with currents up to 1 knot, and horizontal water displacements of 8 km (5 miles).

7.0 Data Collection and Field Work

7.1 **Units**. All soundings are in meters.

7.2 **Corrections to Soundings**. Alignments, offsets and verified tides were applied during appropriate stages of data collection and processing.

7.3 Hydrography

7.3.1 **Source of Shorelines**. The shoreline source was initially generated from the vector shoreline used in the DNC of the area; this should be revised using high resolution shoreline derived from the zero contour obtained from the LIDAR datasets as the charted shoreline accuracy could use some improvement.

7.4 Sounding Development and Coverage

120-meter swath at 4x4 meter spot density. Greater than 200% coverage in Navy areas separated by a time span of several hours. USGS areas werecovered at 4x4-meter spot density at 100% coverage. USGS areas along Oahu's south coast were covered at 200% because of their small size and proximity to Navy areas. USACOE areas were covered at 8x8-meter spot density and 100% coverage. This is also discussed in 1.1.13.1 and 1.1.13.2.

7.5 **Sounding Selection**. NAVOCEANO area-based, shoal-biased sounding selection algorithm.

7.6 Seabed Topography and Texture

Seabed topography is derived from the LIDAR data. No bottom samples were collected.

7.7 **Near Shore Seabed Topography.**

Numerous coastal areas in the Hawaiian Islands are exposed to a Predominatel northerly Swell for most of the year. During the winter months the swell becomes quite significant. As a result the beaches and near shore areas are quite dynamic. Oahu north shore beaches undergo re-sculpting during the winter months. The same occurs along the leeward west coast where the beaches and near shore of Makua and Makaha are significantly altered. Along Kauai's northwest Na Pali coast the beaches completely erode in winter, then reappear in the spring. Along Barking Sands, and Majors Bay (Waiokapua Bay) Kauai, north and south of PMRF, beaches and near shore are quite dynamic during any time of high swell and rough surf.

Figure 7. Barking Sands, Kauai. Near shore seabed topography.

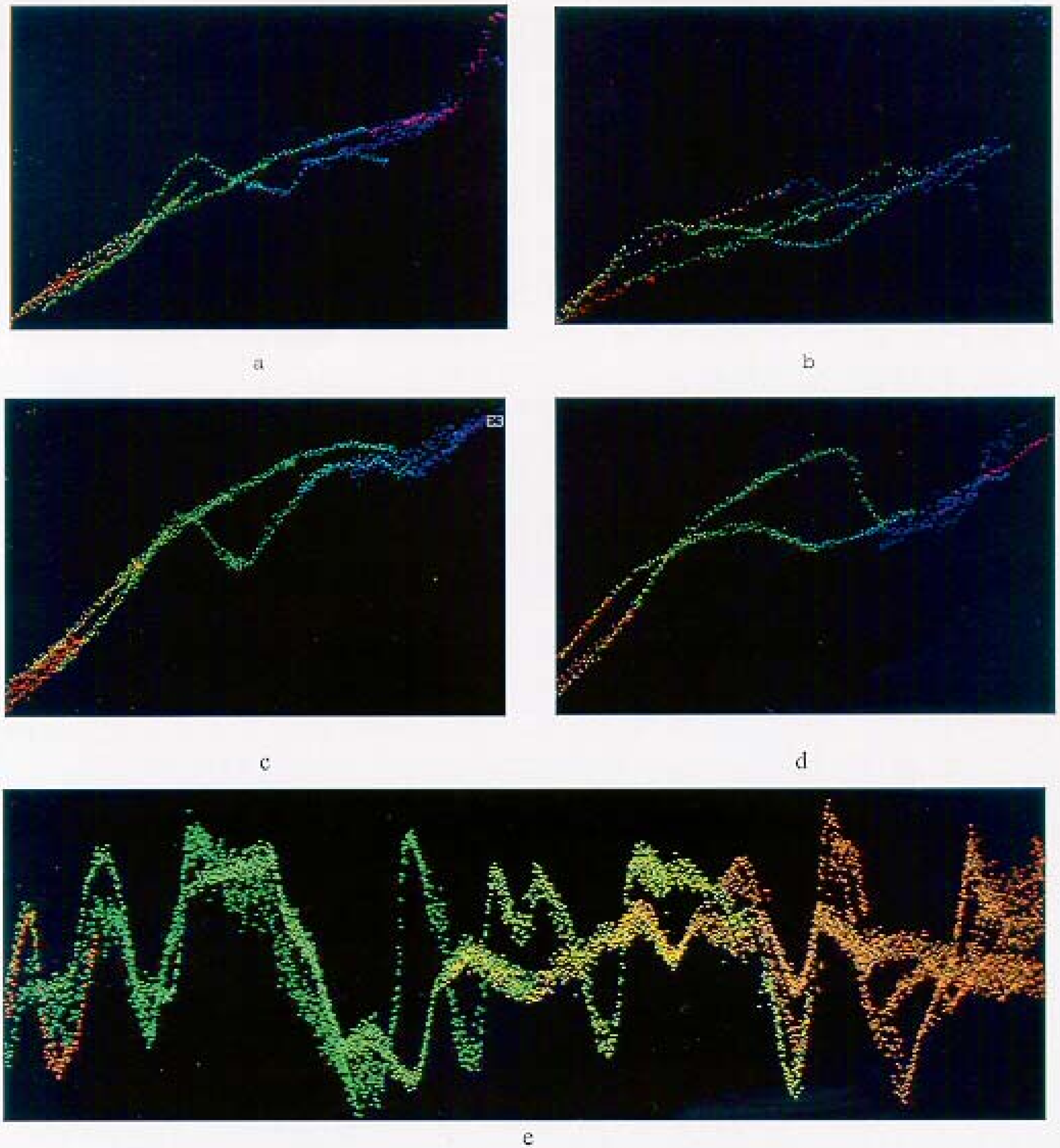


Figure 8. Series of near shore seabed to beach profiles from the area of Barking Sands, Kauai depicted in Figure 7. Insets a-d are west to east cross sections. Inset e is from the north east to southwest along the full length of the near shore.

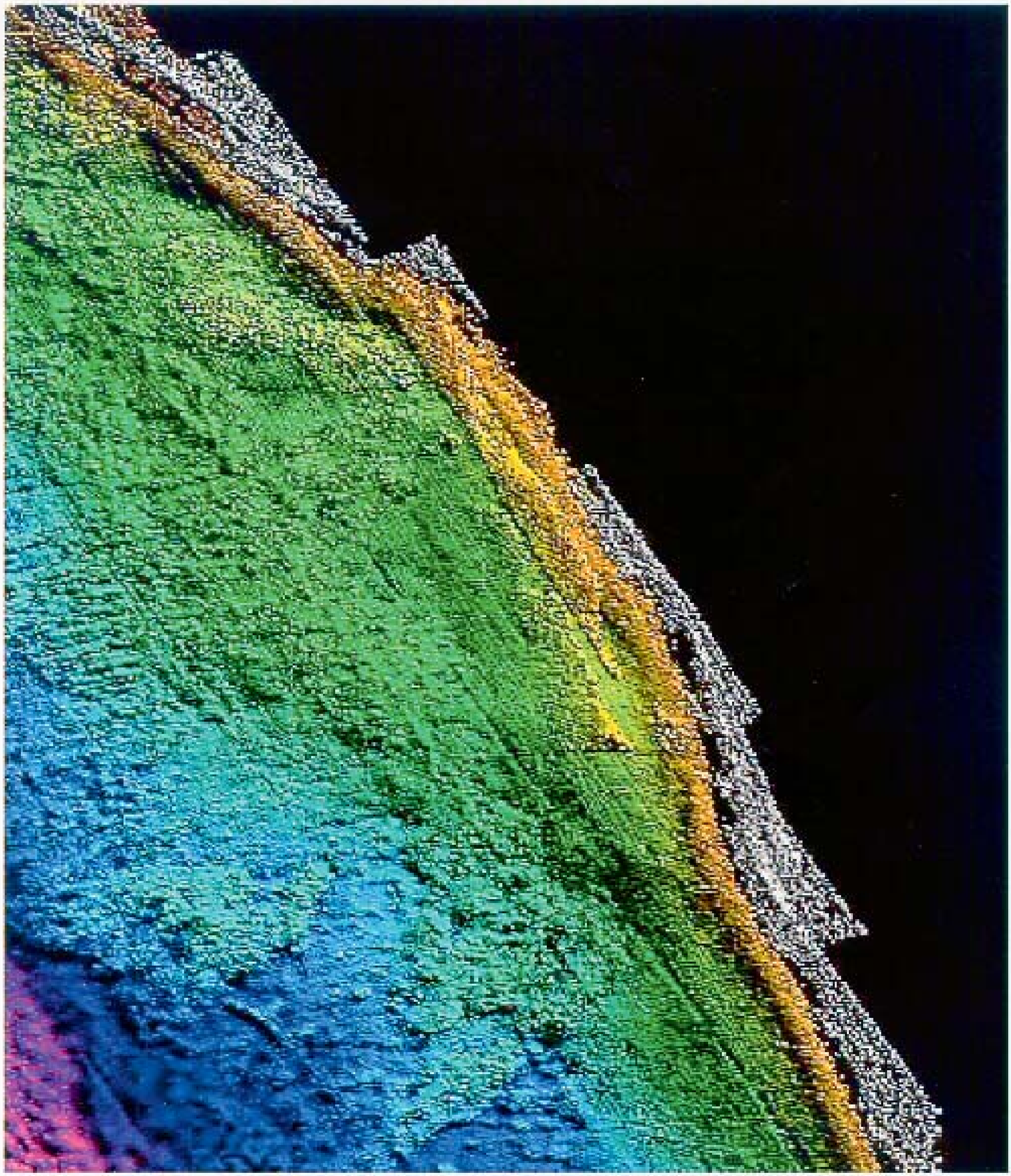
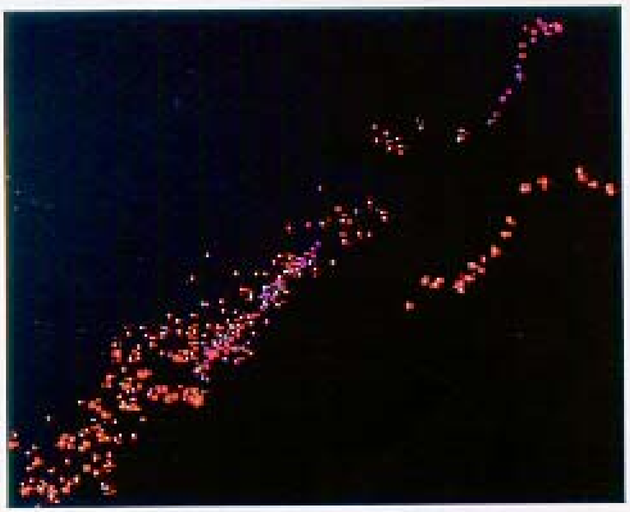
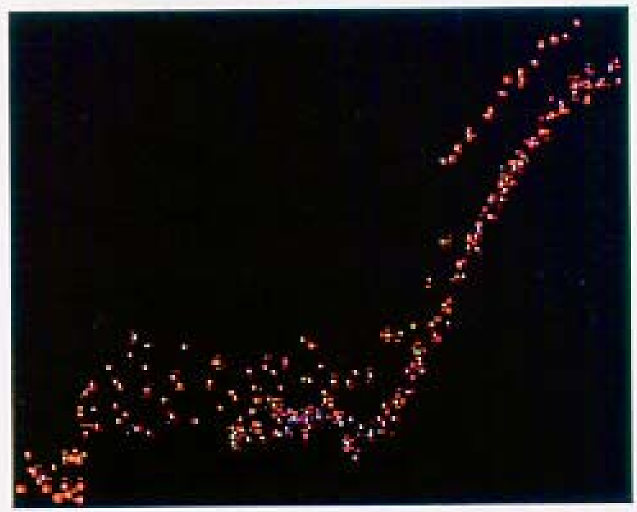


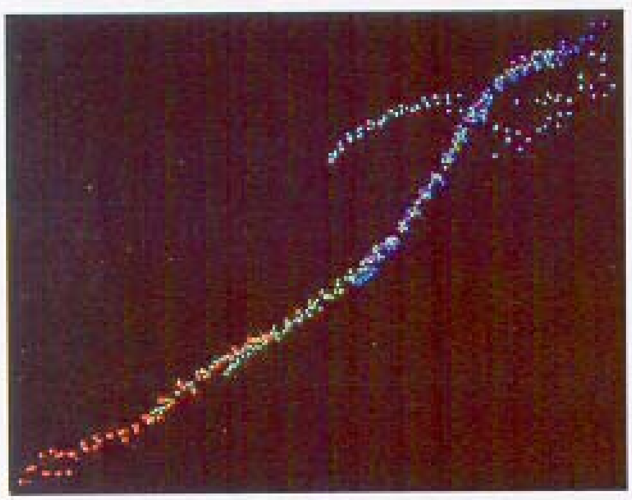
Figure 9. Majors Bay (Waiokapua Bay) Kauai showing near the shore seabed.



a



b



c

d

Figure 10. Series of near shore seabed to beach profiles from the area of Majors Bay (Waiokapua Bay) Kauai depicted in Figure 9. Insets a-d are west to east cross sections. Colors represent datasets from different days. These cross sections cover a time span of 6 weeks.

7.8 Data Quality Control

7.8.1 **Processing Methodology**. Graphical examination/evaluation of LOP time series data and deletion of bad data. Graphical examination/evaluation of roll, heading, vertical acceleration time series. 3D visualization of data as a sun-shaded surface colored by depth, line or file. Visualization of data with color and gray scale palette. Visualization of data from any view angle, elevation or lighting position. Visualization of the sun shaded statistical, minimum, average and maximum surfaces. Area based editing of data. Data can be rotated. Multiple and overlying data can be compared. Complete 3D editing capability through the Area Based Editors. Overlay of GeoTif chart images with sounding sheets.

7.8.2 Cross check/swath overlap agreements

Standard crosscheck lines were not run. All Navy areas required two- flight coverage, with the second flights flown some time after the first flights (4 hours to several days). This survey development technique and adjacent line overlap proved more than sufficient to identify any positional or tide correction problems.

Tide correction problems were identified early in the survey. The problem was not with the tides themselves, but with application of the tide correctors. There were three primary problems. (1) Extraneous and unprintable (viewable) ASCII characters contaminated some tide corrector files such that the tide would not apply when APPLY_TIDES was run, and no error message issued. These were identified early and resolved. (2) A data file time stamp problem was identified in the OPTEK airborne software. When the day changed over at midnight GMT a bit is supposed to be set in the *.fl file. This didn't always happen. However, the time stamp was not reset to zero, just continued. As ping time is derived from the ping counter, the tide correctors were being applied from the wrong day. (3) Four data file format changes occurred of which NAVO was never informed. Three of these affected data time. Addition to these main three problems, a couple of errors were discovered in the tide zone polygon definition files. One polygon was not closed and another had an extraneous point that caused the polygon to cross several others. These errors were all corrected and tides re-applied at NAVOCEANO. Currently, there are no discrepancies in the tide corrections and all soundings are properly corrected.

7.9 Agreement with Existing Charts

See Appendix C for a synopsis of chart and data comparison. The highly detailed LIDAR data show more features. Numerous wrecks indicated along Oahu's south coast were not detected in the LIDAR data. Status and/or existence of these wrecks is unknown.

7.10 **Agreement with Prior Surveys**

Due to the short-notice nature of the tasking and rapid generation of the definitive report, previous survey data were not made available and therefore neither a critical nor favorable comparison can be made.

7.11 **Navigational Aids**

Navaids were not positioned during the course of this survey. No tasking for this was designated and no suitable equipment was available. Discussions, however, with the Honolulu Harbor Master, Hawaii Ports and Harbors Commission, Harbor pilots and the USCG district revealed no discrepancies with charted navaids and the Notice to Mariners.

The only navaids positioned were a Navy-maintained buoy off PMRF Kauai and the observation tower at the Makua Training Area, Oahu.

Buoy designated "TANGO"	Position:	N 22 00.330'	W 159 47.557'
Tower, Makua	Position:	N 21 31' 43.56"	W 158 13' 37.81"

7.12 **Shoreline**

The shoreline source was initially generated from the vector shoreline used in the DNC of the area. This should be revised where possible using high-resolution shoreline derived from the zero contour obtained from theLIDAR datasets.

8.0 **Accuracy and Resolution of Soundings**

8.1 **LIDAR Positional Accuracy**

8.1.1 The error budget discussed below pertains to the positioning system operating in differential mode.

Based on the following:

System measurement circular error:	1.0 m
Slope error (variable, 1.0 m flat bottom)	1.0 m
Navigational System accuracy:	4.0 m
Heading error	0.5 m
Roll/Pitch error (beam pointing error) (less than 0.05 degrees, less than 26 cm @ 300 meters altitude)	0.26 m

8.1.2 The cumulative effects of the above errors (RMS) would be: +/- 4.16 meters: allowing for the navigational accuracy of +/- 5 meters, the total RMS value for sounding positional accuracy is +/- 5.13 meters.

8.1.3 IHO Positional Accuracy (Order 1) requires +5m +5% of depth, which equates to an allowable error of:

5.25 m	in 5 m depth
5.50 m	in 10 m depth
5.75 m	in 15 m depth
6.00 m	in 20 m depth

IHO 1st order positional accuracy is therefore considered to have been met in all areas throughout the survey. In areas of steeply sloping or high bottom variability deeper than 15 m IHO 1st order positional accuracy is considered to have been met.

8.2 Accuracy of Soundings - Assessment and Evaluation

8.2.1 **LIDAR.** Assessment of the accuracy of LIDAR soundings entails an evaluation of the following:

a. LIDAR zero mark (water surface)	+/- 0.10 m
b. Depth measurement (system accuracy)	+/- 0.10 m
c. Laser propagation velocity error	+/- 0.05 m
d. Roll, pitch, heading	+/- 0.00 m
e. Vertical motion (heave)	+/- 0.00 m
f. Tidal Measurement	+/- 0.02 m
g. Co-tidal corrections	+/- 0.10 m
h. seabed slope	+/- 0.0 – 0.25 m

8.2.2 **LIDAR zero mark** (a) The zero or reference mark for Lidar data is not the platform or sensor, it is the water surface while operating in DGPS mode or the GPS antenna while operating KGPS mode. The accuracy of the zero reference is very dependent on the surface model utilized to compensate for wave and swell. The accuracy of the surface reference is considered to be 0.1 meters on a normal ocean surface. The surface reference accuracy improves over calm seas and in protected waters. A nominal value of 0.10 meters has therefore been accepted as typical.

8.2.3 **Depth Measurement error** (b) (Instrument Accuracy/Error). System accuracy (depth resolution) for the LIDAR is 0.1 meters RMS. A nominal value of 0.10 meters has therefore been accepted as typical, given the relatively shallow water nature of this survey.

8.2.4 **Speed of Light Correction**. (c) In any medium light travels more slowly than it does in a vacuum. The velocity of light in a medium is equal to the velocity of light in a vacuum divided by the refractive index of the medium. The refractive index of light in air is 1.00028 and, for our purposes, is not significantly different from that in a vacuum, 1.00 by definition. The refractive index of water, though it varies slightly with temperature, salt concentration and wavelength, may be regarded as 1.33 for all natural waters. Assuming a velocity of light in a vacuum of 300,000,000 m/s, the velocity in water is about 225,000,000 m/s. The refractive index variability in natural waters is negligible, as is the speed. Therefore variation in light speed is not a limiting factor for LIDAR data and errors attributed to velocity of light variability can be considered non-existent.

8.2.5 **Roll, Pitch, Heading** (d) Roll, Pitch and Heading are sensed by an onboard POS/AV. Roll, pitch and heading are fully compensated for in real time through direct interfacing to the laser/scanner servo control system. Servo compensation within the limits of +/- 20 degrees of motion ensures the scanning mirror is referenced to nadir at all times. All out-of-tolerance motion results in system warnings and discarded Lidar pulses. Roll, pitch and heading errors are considered negligible.

8.2.6 **Vertical Motion Corrections**. (e) Not applicable for LIDAR data because the zero reference is not the platform or sensor, it is the water surface (when operating in DGPS mode) or the GPS antenna (when operating in KGPS mode). However, aircraft platform motion is compensated for by an aircraft mounted inertial motion system (POS/AV). This resolves undulations in the flight path. Aircraft movement outside of normal parameters result in "jerk" flags and rejected data.

8.2.7 **Tide corrections**. (f), (g) Tide correction errors consist of the actual observation errors at the tide gauge and any errors resulting from a tidal zoning schema or cotidal analysis. Observation errors from the NOAA tide gauges are known to be very low. The estimated error for observed tides is 0.025 meters (1 SIGMA). A similarly small margin of error for co-tidal corrections (0.35 meters) was calculated from comparison of a gauge installed on the leeward sides of Oahu and Kauai and the zone corrected reference tide station data. The standard deviation between the observed tide at these locations and the tide derived from the zoning was 0.179 meters. A similarly small margin of error for co-tidal corrections is based on the range and extent of the survey area in relation to the reference tidal stations and minimal shallow water effects due to the deep surrounding ocean water.

8.2.7.1 Incidentally, the three-day period when there was 0.35 meter difference between the observed tide and the NOOA COOPs cotidal zoned tide on the west coast of Oahu, no data was being collected in the area at this time. This error was strictly an observation and part of the tidal zone validation.

8.2.8 **Sea bed slope** (h) Slope error is normally related to footprint size at the sea floor. Directly related to beam spreading, the Lidar footprint is approximately 0.5 times the water depth. In 25 meters of water the footprint size is about 8 meters across. Normally, this would induce significant error on a sloping bottom due to the shallower part of the footprint reflecting back before the deeper edge of the footprint. This error is significantly reduced with the use of a narrow field-of-view (FOV) receiver telescope. The Lidar receiver telescope FOV is approximately 1.0 meters in diameter. Regardless of the actual beam spreading, only the 1 meter diameter area in the center of the beam is actually received. The leading edge of the return pulse, that which would be received from the shallowest part of the footprint, is not where the depth is computed. Depth determination utilizes a centroid of mass method within the 1 meter receiver FOV. Induced error estimates due to seafloor slope are based on the narrow receiver FOV footprint size.

8.3 SHOALS Lidar Sounding Error Budget

The resultant theoretical error budget is tabulated below representing typical shallow, mid-water and deepest values in the survey area

Source of Error		At 10m	At 25m	At 50m
a LIDAR zero reference (surface mark)		0.10	0.10	0.10
b system measurement accuracy		0.10	0.10	0.10
c laser propagation velocity error		0.05	0.05	0.05
e roll, pitch (this is positional error)		0.0	0.0	0.0
f tidal measurements		0.025	0.025	0.025
g co-tidal corrections (maximum 0.35m, STDEV 0.179m)		0.179	0.179	0.179
h seafloor slope 0		0.0	0.0	0.0
seafloor slope 1:4		0.0625	0.0625	0.0625
seafloor slope 1:2		0.125	0.125	0.125
seafloor slope 1:1		0.25	0.25	0.25
Combined total $(\Sigma(a^2 + \ldots\ldots l^2)^{1/2})$	flat bottom 1:4 bottom slope 1:2 bottom slope 1:1 bottom slope	0.235 0.25 0.354 0.500	0.235 0.25 0.354 0.500	0.235 0.25 0.354 0.500
IHO Cat 1 Requirement $[+/-(a^2 + (b*d)^2)^{1/2}]$		0.502m	0.509m	0.542m
Standard Met?		YES	YES	YES

8.3.1 As an adjunct to the standard calibration procedures approximately 200 tide corrected lead line observations were collected over a flat sand bottom and flat seas. Comparison of the lead line data to LIDAR data indicated agreement within a maximum of 0.06 meters with a mean agreement of 0.04 meters. Very close agreement with the lead line observations allows a very high confidence in the accuracy of LIDAR soundings.

8.3.2 **IHO Standards**. The accuracy for Order 1 allowable error (95% or 2 SIGMA) for depths from 0 to 50 meters is +/- 0.5 meters to +/- 0.542 meters. The calculated error for the motion-corrected LIDAR data and observed tides (see comments above) for this survey has a maximum value of approximately 0.354 meters and is therefore within the IHO accuracy limits for Order 1 surveys. As has been discussed, it is considered that the accuracy's estimated are both realistic and pragmatic; in no way do they negate the quality of the survey data so rendered nor do they serve to provide critical comment on the methods and equipment used in the survey. Indeed, the error could probably be reduced a bit with tide gauges installed on all sides of the islands.

8.4 **SHOALS LidarTarget Detection** Theoretically, based on target detection probability curves produced by NOAA, all Navy areas meet IHO Order 1 target/object detection requirements at the 95% confidence level for depths from 7m to 20m with single-flight coverage. At depths deeper than 20m signal-to-noise ratio limitations greatly reduce target detection capability, particularly for small objects less than 2 meters (Figure 1). Multiple-flight coverage will theoretically improve the confidence of target detection capability in the depth range of 2m to 7m, and possibly down to 20m. Subsequent testing of the follow-on CHARTS system utilizing the same operating principles and algorithms, targets of 2 meters and larger were detected 100% of the time in depths of 5 to 30 meters. Based on actual tests the LIDAR system meets IHO Order 1 target detection requirements. Multiple coverage greatly improves this capability.

8.4.1 Subsequent testing of the follow-on CHARTS system, utilizing the same operating principles and algorithms and a lower power laser, at 4x4 spot spacing, targets of 2 meters were detected 100% of the time in depths of 5 to 30 meters. Based on these actual tests the LIDAR system meets IHO Order 1-target detection requirements. Multiple coverage provides a degree of redundancy for this capability. The results of these tests have not yet been formally documented.

9.0 N/A

10.0 **Navigational Aids**

10.1 Navigational aids were not positioned during this survey due to a lack of available equipment during the survey period.

11.0 **Sailing Directions**

11.1 **General**. Not verified due to the nature of the survey.

11.2 **Coastal Pollution**

None noted although water quality in the harbors is somewhat degraded in comparison to that of the open ocean, primarily as a result of increased turbidity due to vessel activity and reduced circulation. Local environmental awareness, however, results in minimal pollution.

11.3 **Anchorage and Moorings**. N/A\

11.4 **Photography**. Photographs of selected areas of shoreline were taken in support of future STOIC production in Navy exercise areas. Areas that were photographed are the Makua Training Area, Pokai Bay, Waimanalo Bay (Bellows AFS), Kahuku, MCBH Hawaii at Kaneohe (east of Pyramid Rock), PMRF and Majors Bay, Kauai.

12.0 **Charted and Uncharted Wrecks and Obstructions**. Targets are listed in Appendix D. Other than what is listed, no other wrecks, objects or targets, charted or uncharted, were detected or observed with the LIDAR system.

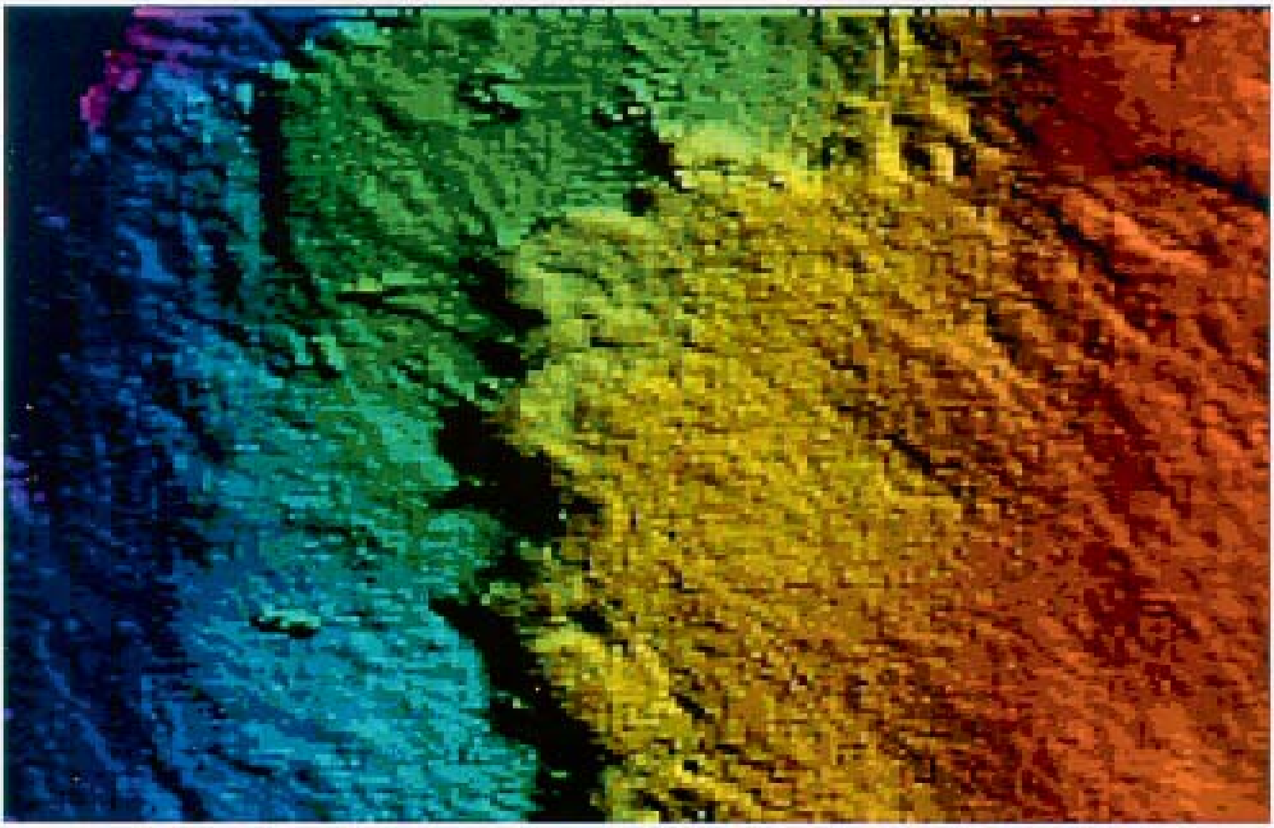


Figure 11. Wrecks and wreckage off Oahu's leeward west coast between Maili Pt. and Waianaae. Charted as fish haven and wrecks. One of these is believed to be the "Mali", a popular dive spot.

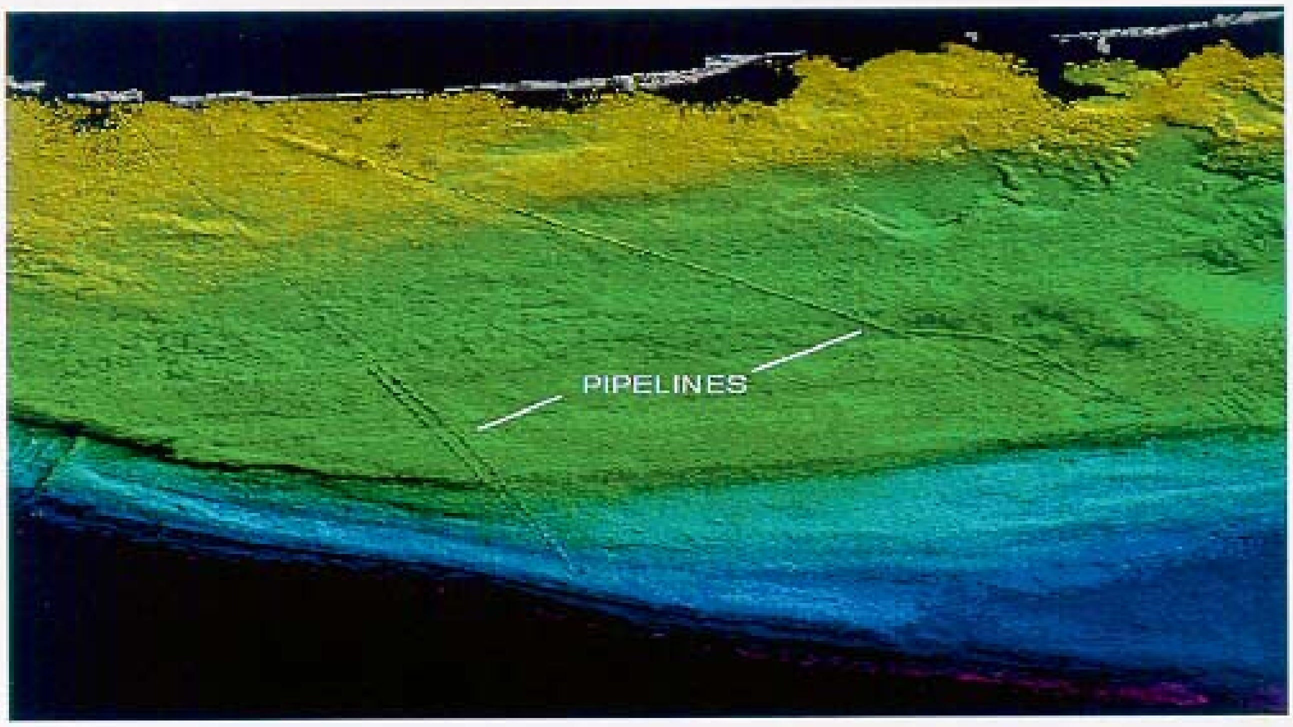


Figure 12. Offshore oil terminal pipelines off Barbers Pt. Oahu.

Figure 13. Barbers Pt. Oahu. Offshore oil terminal

13.0 Ancillary Observations

13.1 Water Clarity Observations

See Appendix F

13.2 Meteorological Observations

N/A

13.3 Biological Observations

N/A

NOAA FORM 75-96
(10-83)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

MARINE CHART BRANCH

RECORD OF APPLICATION TO CHARTS

FILE WITH DESCRIPTIVE REPORT OF SURVEY NO. W00056, W00057

INSTRUCTIONS

A basic hydrographic or topographic survey supersedes all information of like nature on the uncorrected chart.

1. Letter all information.
2. In "Remarks" column cross out words that do not apply.
3. Give reasons for deviations, if any, from recommendations made under "Comparison with Charts" in the Review.

CHART	DATE	CARTOGRAPHER	REMARKS
19327	5/9/05	Russ Davies	Full ~~Part~~ ~~Before~~ After Marine Center Approval Signed Via Full application
			Drawing No. of soundings, curves and features from
			smooth sheet W00056
19330	5/2/05	Russ Davies	Full ~~Part~~ ~~Before~~ After Marine Center Approval Signed Via Full application
			Drawing No. of soundings, curves and features from
			the smooth sheets W00056 and W00057
			Full Part Before After Marine Center Approval Signed Via
			Drawing No.
			Full Part Before After Marine Center Approval Signed Via
			Drawing No.
			Full Part Before After Marine Center Approval Signed Via
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SUPERSEDES C&GS FORM 8352 WHICH MAY BE USED.