**FY12 Annual Progress Report:**

# Estimation of Habitat-Stratified Catch Efficiency of Fishery-Independent Reef Fish Survey Methodologies to Improve Estimates of Stock Size

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## *Progress Report*

To-date, three research missions have been carried out to support the Estimation of Habitat-Stratified Catch Efficiency of Fishery-Independent Reef Fish Survey Methodologies to Improve Estimates of Stock Size. The first of these missions (SE1202) was carried out in the waters off of Tutuila, American Samoa from April 2 – 19, 2012. The second (SE1207) and third (SE1208) were carried out in the coastal waters of the island of Oahu, Maui, Molokai, and Lanai in the Hawaiian Island from September 1 – October 3, 2012. These three missions represent the bulk of the data collection efforts required to support this study. At this point in the project, all required data has been collected and data processing is in progress. Detailed analysis of catch efficiency will begin once data processing has been completed.

## *SE1202: American Samoa*

During SE1202, three survey methodologies were compared in the waters off of Tutuila, American Samoa: SCUBA divers conducting stationary point count surveys (SPC), baited and unbaited remote stereo-video camera stations (RUVS), and an autonomous underwater vehicle carrying a stereo-video camera system (AUV).

### *Stationary Point Counts*

The stationary point count (SPC) method involves a pair of SCUBA divers conducting simultaneous counts in adjacent visually-estimated 15 m-diameter plots extending from the substrate to the limits of vertical visibility. Prior to beginning each SPC pair, a 30 m line is laid across the seafloor. Markings at 7.5 m, 15 m and 22.5 m enabled survey divers to locate the mid-point (7.5 m or 22.5 m) and two edges (0 m and 15 m; or 15 m and 30 m) of the survey plots. Each count consists of two components. The first is a 5-minute species enumeration period in which the diver records all species observed within their cylinder. Following that is a tallying portion, in which the diver systematically works through their species list successively recording the number and size (total length, TL, to nearest cm) of all fishes on the species list. The tallying portions are conducted as a series of rapid visual sweeps of the plot, with one species-grouping counted per sweep. To the extent possible, divers remain at the center of their cylinder throughout the count. However, small and cryptic species, which will tend to be underrepresented in counts made by an observer remaining in the center of a 7.5 m radius cylinder, are left to the end of the tally period, at which time the observer swims through their plot area carefully searching for those species. In cases where a species is observed during the enumeration period but is not present in the cylinder during the tallying period, divers record their best estimates of size and number observed in the first encounter during the enumeration period and mark the data record as 'non-instantaneous'.

### *BRUVS*

Baited remote underwater video stations (BRUVS) are non-destructive baited stereo-video samplers which can provide scientifically rigorous estimates of fish abundance and size structure. BRUVS were originally developed by the lab of Dr. Euan Harvey at the University of Western Australia. The use of stereo-cameras enables accurate size (and hence length-frequency and biomass) estimates to be obtained. Each of a group of up to 8 units is deployed for approximately 15 minutes and is recovered and redeployed in a "leap frog" fashion throughout the day. This allows for considerable replication in space and time throughout the cruise.

BRUVS are termed 'remote' because the systems are deployed on the seafloor independent from an operator or observer. Each BRUVS system uses two off-the-shelf high definition (HD) video cameras mounted 0.7 m apart on a base bar that is inwardly converged at 8 degrees to gain an optimized field of view (with a forward-viewing range of ~10 m). These are placed within PVC pipe housings with acrylic front and rear ports, and mounted within a galvanized roll-bar frame. Stabilizing arms and bait arms (20 mm plastic conduit) are attached and detached during and after deployment.

Each BRUVS can be left unbaited or can accommodate up to 1 kg of bait which is placed in a plastic-coated wire basket suspended on a bait arm 1.2 m in front of the unit. Alternative baits may be used, depending on supply/local availability. Each BRUVS is deployed by hand (each unit weighs ~ 50kg) from the vessel at predefined GPS locations with a rope and floats attached. Established soak time is 15 to 60 minutes (depending on survey design), after which vessels can retrieve them by grappling surface floats and hauling lines with a hand-powered or electric winch or pot-hauler. Video footage can be reviewed as soon as the camera is retrieved to the vessel and can be archived for later analysis.

### *AUV*

The SeaBED-class AUV, unlike other more traditional AUV's, employs a twin-hull design that provides enhanced stability for low-speed photographic surveys. Designed and built by the lab of Dr. Hanaumant Singh at the Woods Hole Oceanographic Institute (WHOI), SeaBED is designed to autonomously follow the terrain approximately 3 to 4 m above the sea floor, collecting high resolution color and black-and-white imagery while maintaining a forward speed of .25 - .5 m/sec. For this mission, SeaBed was also be outfitted with a forward-looking stereo video camera system as well as a forward-looking imaging SONAR unit. The stereo-video system is similar to that use on the BRUVS and allows for accurate measures of fish abundance and size structure. The imaging SONAR unit is being tested as a means to assess fish assemblage outside the visual range of the cameras and in zero light situations including nocturnal or operations in depths to which light does not reach.

SeaBED is approximately two meters long and weighs nearly 200 kg. It has two main pressure housings, a top hull and a bottom hull. The CPU electronics are located in the top hull, and the batteries, cameras, and sensors are located in the bottom hull, and all are connected by wet cabling that is routed through vertical struts. With a maximum depth range of 2,000 m, and maximum single-dive time of 6 - 8 hours, SeaBED can be used to survey habitats ranging from shallow coral reefs to deep groundfish environments.

The AUV is programmed while still aboard the ship. Programming parameters include navigational waypoints, speed, altitude to maintain above the seafloor, and frequency of photographs. Once submerged, the AUV does not resurface until the end of its mission. An RD Instruments 1200 kHz Doppler Velocity Log, iXSea Octans Inertial Navigation Unit, and Paroscientific Depth Sensor provide the data necessary for the vehicle's autonomous navigation. The AUV does report its position to the ship periodically in telemetry messages via acoustic MODEM. Additionally USBL tracking shows range and bearing between the ship and AUV during the mission. If any of these telemetry messages indicate an unexpected change in the AUV's planned mission, the mission can be aborted via acoustic MODEM message, resulting in the AUV returning to the surface for recovery.

The SeaBED AUV carries a forward-facing ROS Navigator black-and-white, low-light stereo-video camera system, two 5 megapixel, 12 bit dynamic range Prosilica GigE strobe-lighted cameras, one perpendicularly downward-looking and one forward looking (~35°). Imagery from the downward-looking camera can be analyzed to characterize the benthic communities while the forward-looking cameras are used to collect species-specific abundance and length information. Combined, these 2 imagery data sets can be used to create spatial species-specific abundance, biomass, and length-frequency distributions, along with the benthic communities around which

they associate. An onboard Seabird model 49 FastCat CTD records temperature and salinity data along the AUV track, providing further environmental insight.

### *Results*

A. CRED Stationary Point Count Surveys (SPC)
   1. SPC surveys went according to plan with 158 sites visited around Tutuila (one SPC replicate was implemented at each site). Three depth strata were sampled shallow (0-6m), mid (6-18m), and deep (18-30m) (Figure 1).
   2. The 2012 surveys were the first to test a sampling design that included habitat information from the NOAA Biogeography maps.
   3. Three habitat categories were taken into account for site allocation: aggregate reef, pavement, and spur & groove. Overall, the habitat map was generally accurate, especially for large scale features (e.g. a large offshore bank with mostly pavement habitat).

B. Baited and Unbaited Remote Stereo-Video Stations (BRUVS)
   1. BRUVS preformed very well during SE1202, completing 138 sampling stations across 6 depth strata using baited and unbaited systems (Table 1, Figure 2).
   2. Stereo-camera calibrations were a vital component for this mission, with three series completed (pre-cruise/mid-cruise/post-cruise). These values between paired systems will be integral in obtaining length data for all species examined in BRUVS video, using image captured from "off-the-shelf" Sony Handycam systems (several models).
   3. Two small boat platforms (SE-4/SE-6) were used to deploy baited/unbaited systems around Tutuila across depth strata, with each vessel completing an average of 4-6 sites/day and up to 33 (unbaited/baited) combined camera station deployments and retrievals/day.
   4. Roughly 300 - 350 hours of raw/unprocessed station video (doubled if one considers two cameras/station drop) were collected during the course of the cruise.

C. SeaBED Autonomous Underwater Vehicle (AUV)
   1. The SeaBED AUV also preformed well, completing 17 individual dives the covered a total of 29,400 meters (Table 3, Figure 3).
   2. The primary sensor on the AUV was a stereo pair of Remote Ocean System's Navigator low light monochrome cameras mounted on the AUV's forward strut and aimed forward to enable the identification, enumeration and sizing of fish encountered along the AUV's path. Each camera recorded more than 78 hours of in-water video during the cruise.
   3. A secondary sensor, a downward facing 5 megapixel, 12 bit dynamic range Prosilica GigE camera in a 6,000 m rated titanium Deepsea Power and Light housing collected 52,579 still images of the seafloor just using ambient light. In most cases image spacing was close enough to enable the images to be mosaicked together to create a continuous photographic strip of the seafloor. These data provide information about benthic organisms, some of the more cryptic demersal species, and habitat information linked to the fish observations from the stereo cameras.

**Table 1.** Breakdown of BRUVS sampling stations by depth strata and baiting

| Depth Range | Number of BRUVS Sites |
|---|---|
| **0-6 m** | 18 |
| **6-18 m** | 41 |

| | |
|---|---|
| **18-30 m** | 27 |
| **30-53 m** | 34 |
| **53-76 m** | 11 |
| **76-100 m** | 7 |
| | |
| **Unbaited** | 138 |
| **Baited** | 109 |

**Table 2.** Breakdown of SPC sampling stations by depth strata and baiting

| Depth Range | Number of SPC Sites |
|---|---|
| **0-6 m** | 36 |
| **6-18 m** | 74 |
| **18-30 m** | 48 |

**Table 3.** Statistics on AUV dives during SE1202

| Dive No. | Date | Distance (m) | Duration (hh:mm) | # Photos | Min. Depth (m) | Max. Depth (m) | Mean Depth (m) |
|---|---|---|---|---|---|---|---|
| **1** | 4/2 | 900 | 1:00 | 0 | 8 | 33 | 32 |
| **2** | 4/8 | 2,100 | 2:30 | 900 | 10 | 41 | 48 |
| **3** | 4/8 | 2,250 | 4:40 | 6,123 | 8 | 62 | 44 |
| **4** | 4/9 | 1,180 | 1:45 | 2,938 | 9 | 40 | 32 |
| **5** | 4/10 | 1,400 | 2:25 | 3,390 | 12 | 69 | 29 |
| **6** | 4/10 | 1,250 | 1:30 | 2,812 | 30 | 48 | 37 |
| **7** | 4/11 | 2,000 | 3:00 | 3,896 | 25 | 48 | 29 |
| **8** | 4/12 | 2,050 | 2:30 | 3,945 | | | |
| **9** | 4/12 | 1,150 | 1:40 | 3,830 | | | |
| **10** | 4/13 | 1,850 | 2:15 | 3,517 | 23 | 45 | 37 |
| **11** | 4/13 | 1,600 | 2:00 | 3,147 | 24 | 48 | 43 |
| **12** | 4/14 | 1,975 | 2:25 | 3,596 | 38 | 80 | 51 |
| **13** | 4/14 | 2,100 | 3:00 | 4,320 | 39 | 150 | 41 |
| **14** | 4/16 | 2,150 | 2:50 | 4,396 | 22 | 54 | 50 |
| **15** | 4/16 | 1,150 | 2:00 | 0 | 37 | 89 | 35 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **16** | 4/17 | 2,250 | 2:45 | 4,103 | 48 | 81 | 69 |
| **17** | 4/17 | 800 | 1:00 | 1,666 | 80 | 92 | 40 |

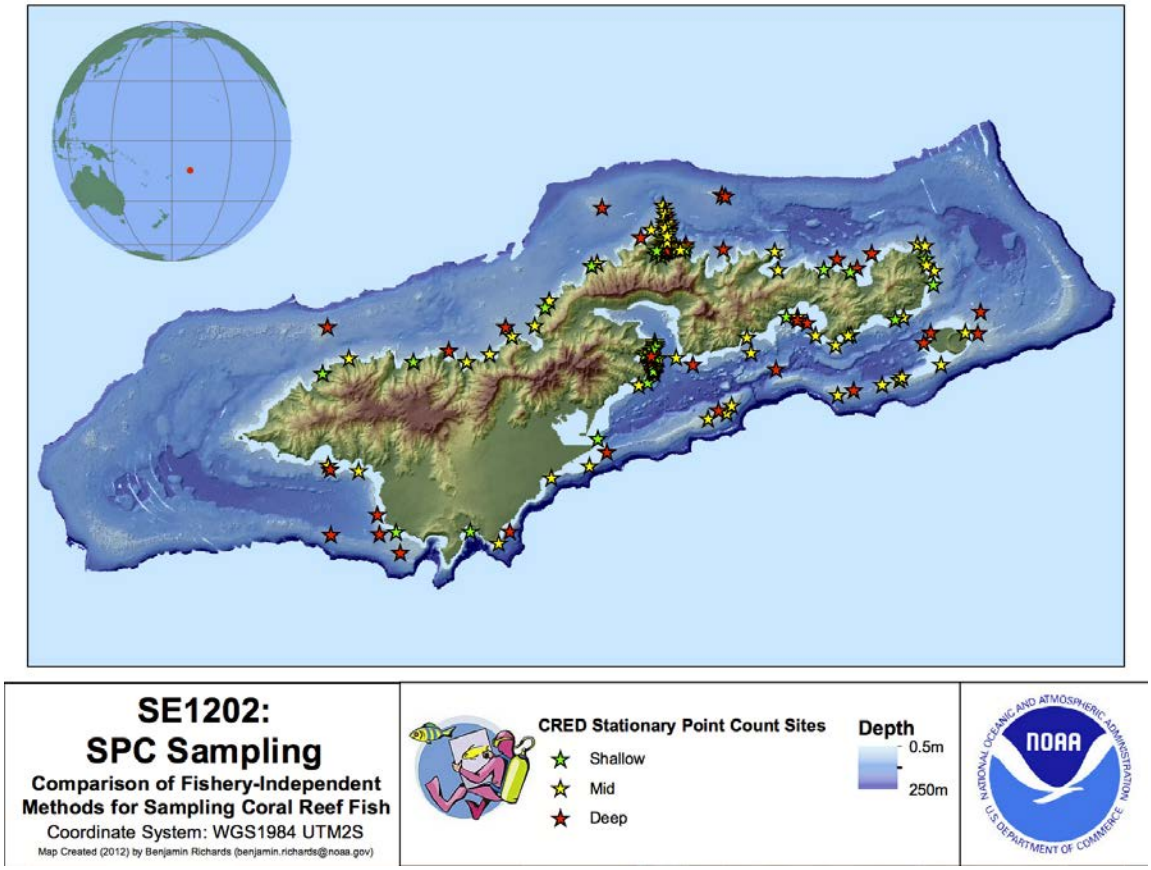


Figure 1 -- Spatial distribution of the 158 Stationary Point Count deployment locations sampled during SE1202. Each site was sampled by a pair of SCUBA divers from the PIFSC Coral Reef Ecosystem Division.

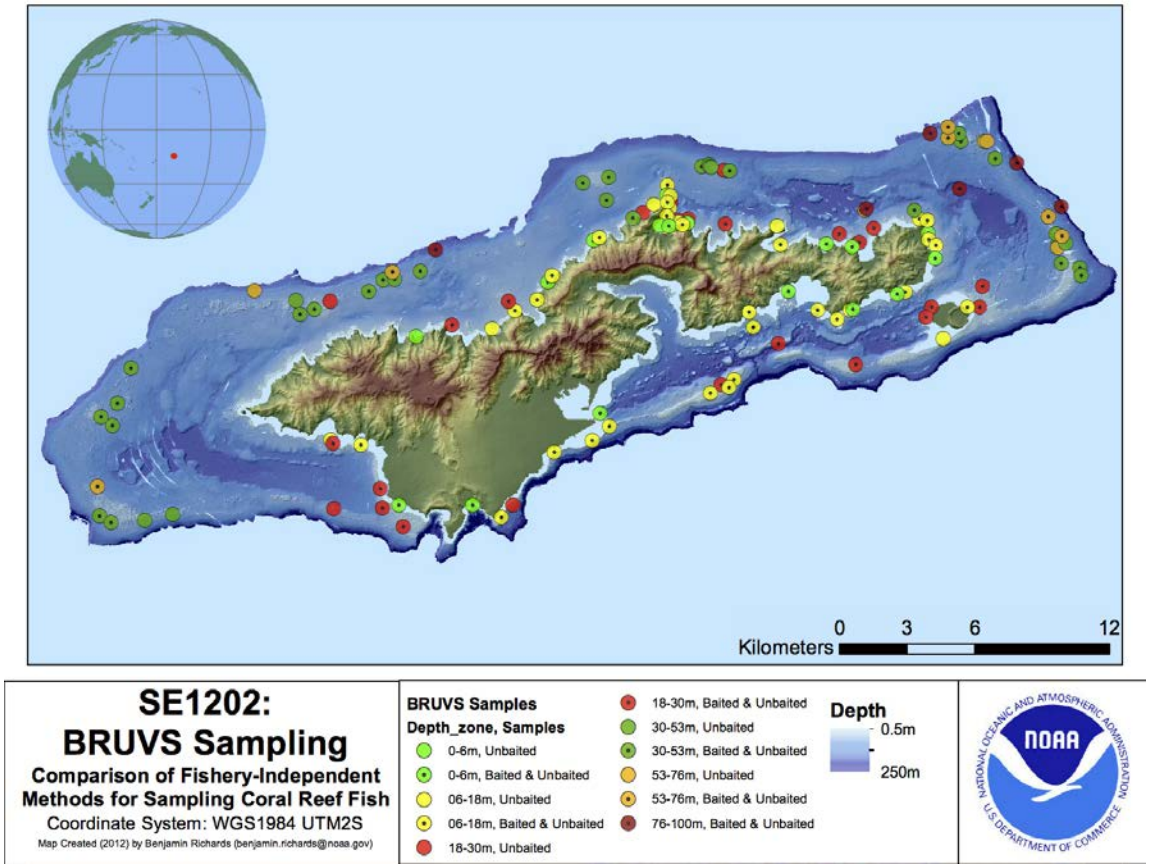


Figure 2 -- Spatial distribution of the 138 BRUVS deployment locations sampled during SE1202. The majority of sampling locations were sampled using a pair of unbaited BRUVS followed by a pair of baited BRUVS

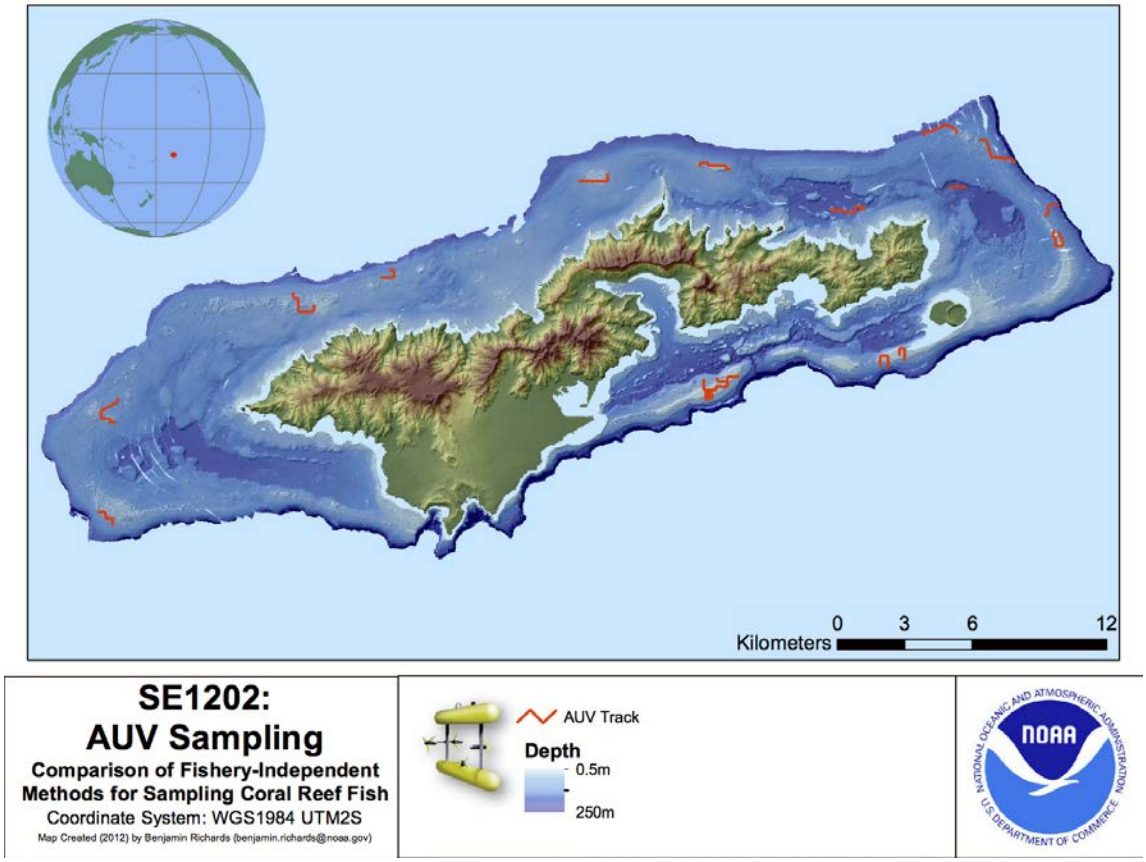


Figure 3 -- Survey tracks of the SeaBED AUV during SE 1202. The 17 separate survey dives had a cumulative length of 29,394 meters. Mean survey length was 1,729 meters.

## *SE1207: Main Hawaiian Islands*

During SE1207, two survey methodologies were compared in the waters off of the islands of Oahu, Molokai, Maui, and Lanai in the Main Hawaiian Islands: SCUBA divers conducting stationary point count surveys (SPC), baited and unbaited remote stereo-video camera stations (RUVS). The methodologies for these two survey methods can be found above.

### *Results*

SPC divers conducted surveys at a total of 163 sites; 35 at Oahu, 50 at Molokai, 49 at Maui, and 29 at Lanai. RUVS were deployed at 100 of these locations; 25 at Oahu, 29 at Molokai, 27 at Maui, and 19 at Lanai. These sites followed a stratified-random site allocation similar to that use in SE1202.

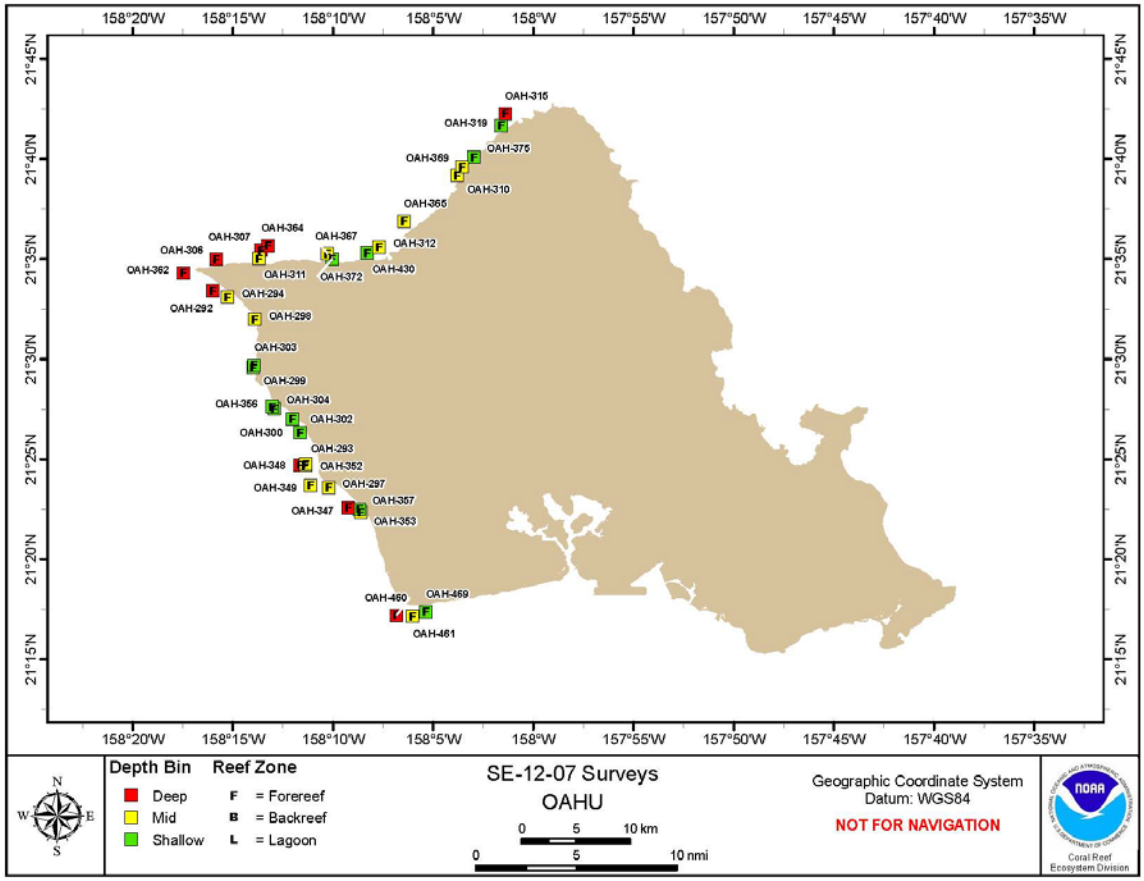


Figure 4 -- Locations of REA fish sites surveyed at O`ahu Island during cruise SE-12-07. All of these REA sites were selected using a stratified random design.

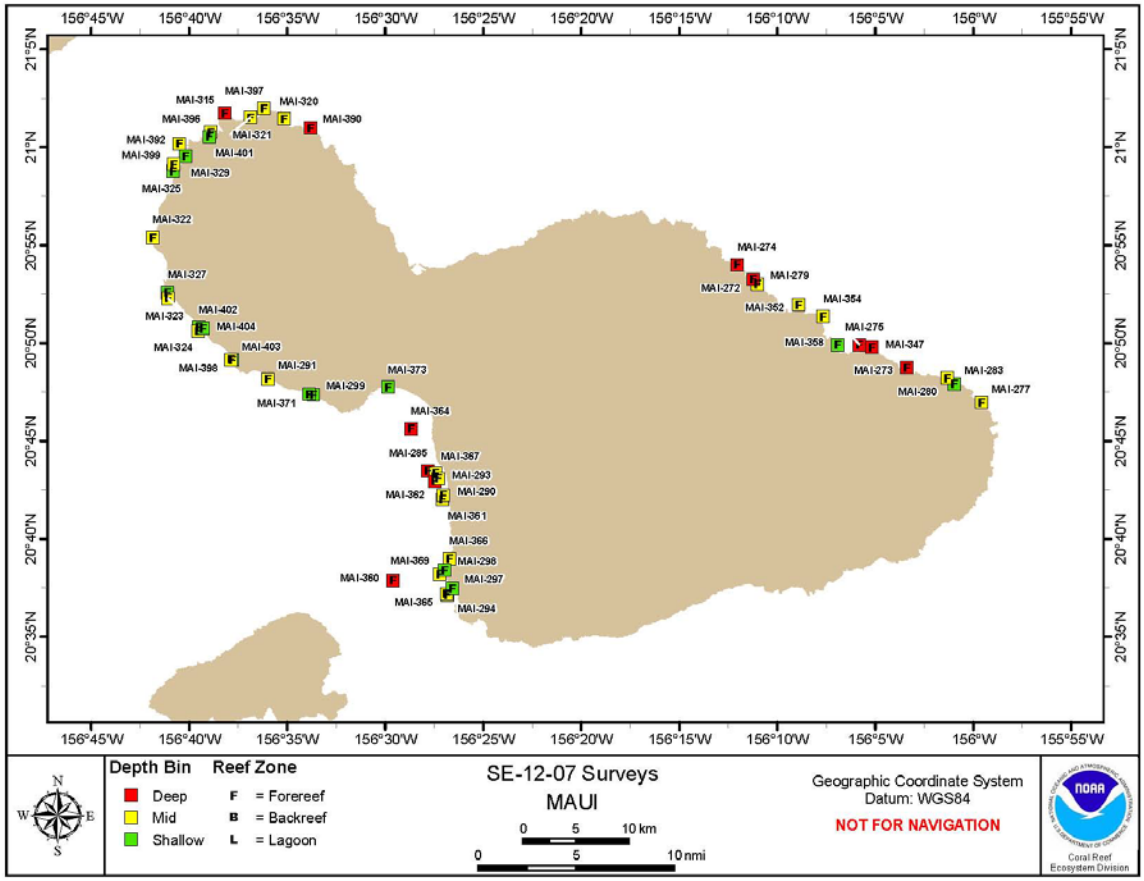


Figure 5 -- Locations of REA fish sites surveyed at Maui Island during cruise SE-12-07. All of these REA sites were selected using a stratified random design.

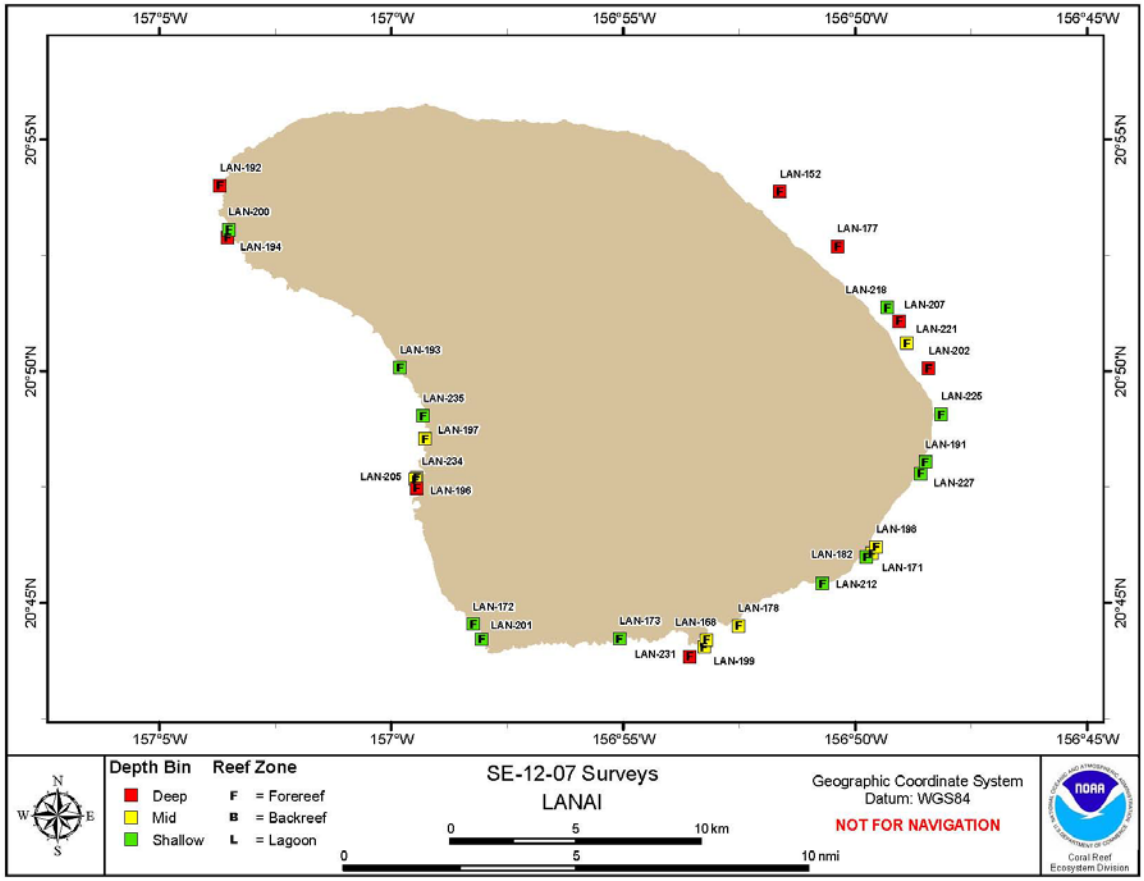


Figure 6 -- Locations of REA fish sites surveyed at Lāna`i Island during cruise SE-12-07. All of these REA sites were selected using a stratified random design.

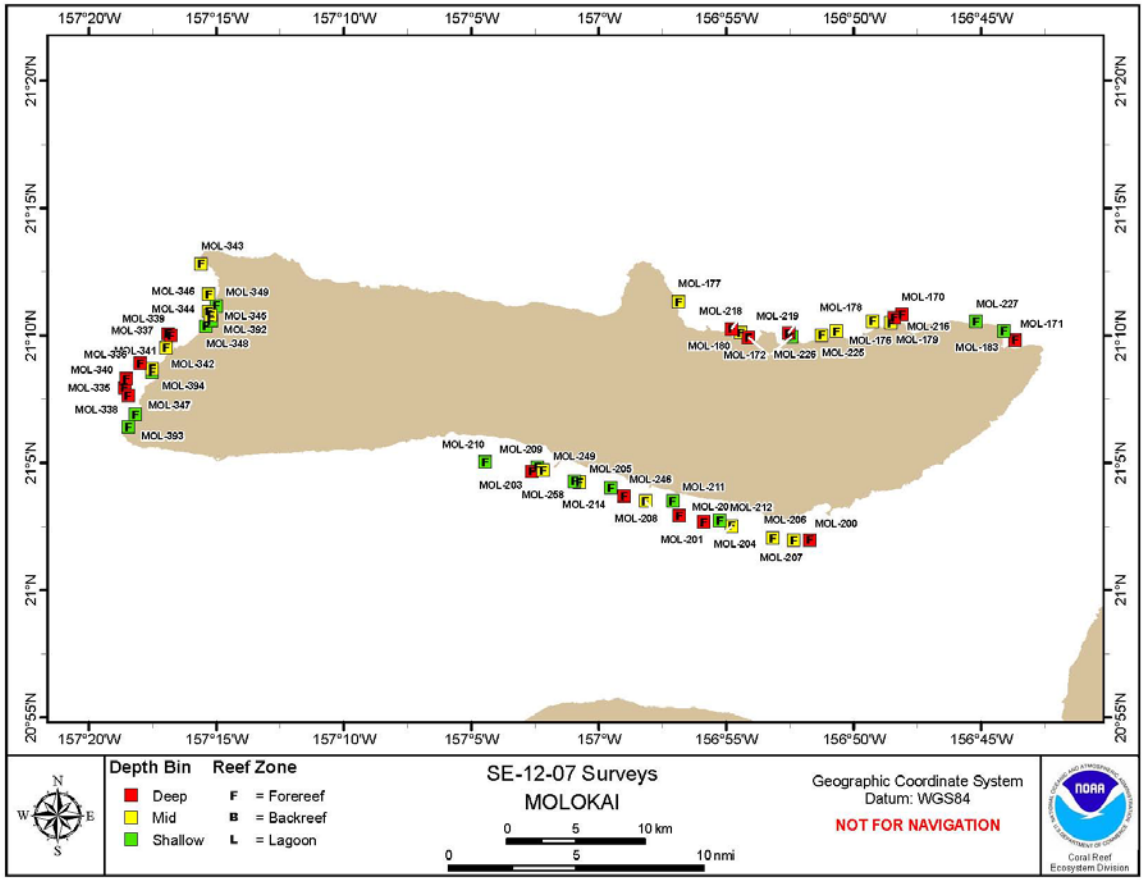


Figure 7 -- Locations of REA fish sites surveyed at Moloka`i Island during cruise SE-12-07. All of these REA sites were selected using a stratified random design.

| Island | Depth (m) | Baited | Unbaited |
|---|---|---|---|
| **Oahu** | 0-6 | 0 | 3 |
| | 6-18 | 2 | 10 |
| | 18-30 | 3 | 4 |
| | 30-53 | 0 | 3 |
| **Maui** | 0-6 | 0 | 3 |
| | 6-18 | 1 | 7 |
| | 18-30 | 2 | 7 |
| | 30-53 | 0 | 5 |
| | 53-76 | 0 | 2 |
| **Lanai** | 0-6 | 1 | 3 |
| | 6-18 | 2 | 5 |
| | 18-30 | 2 | 4 |
| | 30-53 | 0 | 2 |

| | | | |
|---|---|---|---|
| **Molokai** | 0-6 | 0 | 2 |
| | 6-18 | 1 | 9 |
| | 18-30 | 2 | 7 |
| | 30-53 | 1 | 4 |
| | 53-76 | 0 | 3 |

## *SE1208: Main Hawaiian Islands*

During SE1208, three survey methodologies were compared in two survey areas, designed “B” and “D” in the waters off of leeward Maui as well as in the coastal waters of northeast Lanai in the Main Hawaiian Islands: shallow and deep-water baited and unbaited remote stereo-video camera stations (RUVS), EK60 active acoustics, and cooperative fishing vessels sampling using hook and line.

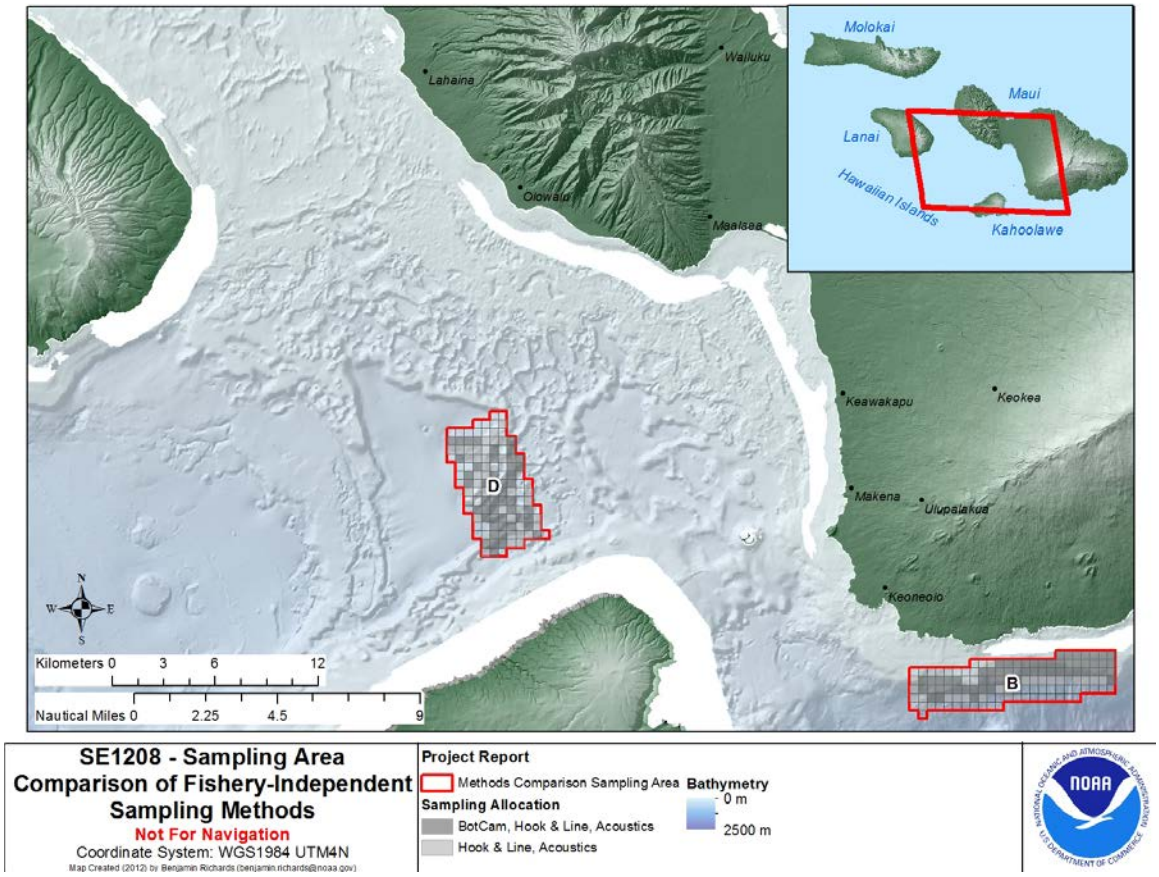


Figure 8 -- SE1208 Sampling Area. Due to weather conditions, the majority of sampling took place in survey area “D” with some BotCam and Hook & Line sampling in “B”. BRUVS operations were conducted along leeward Maui and eastern Lanai.

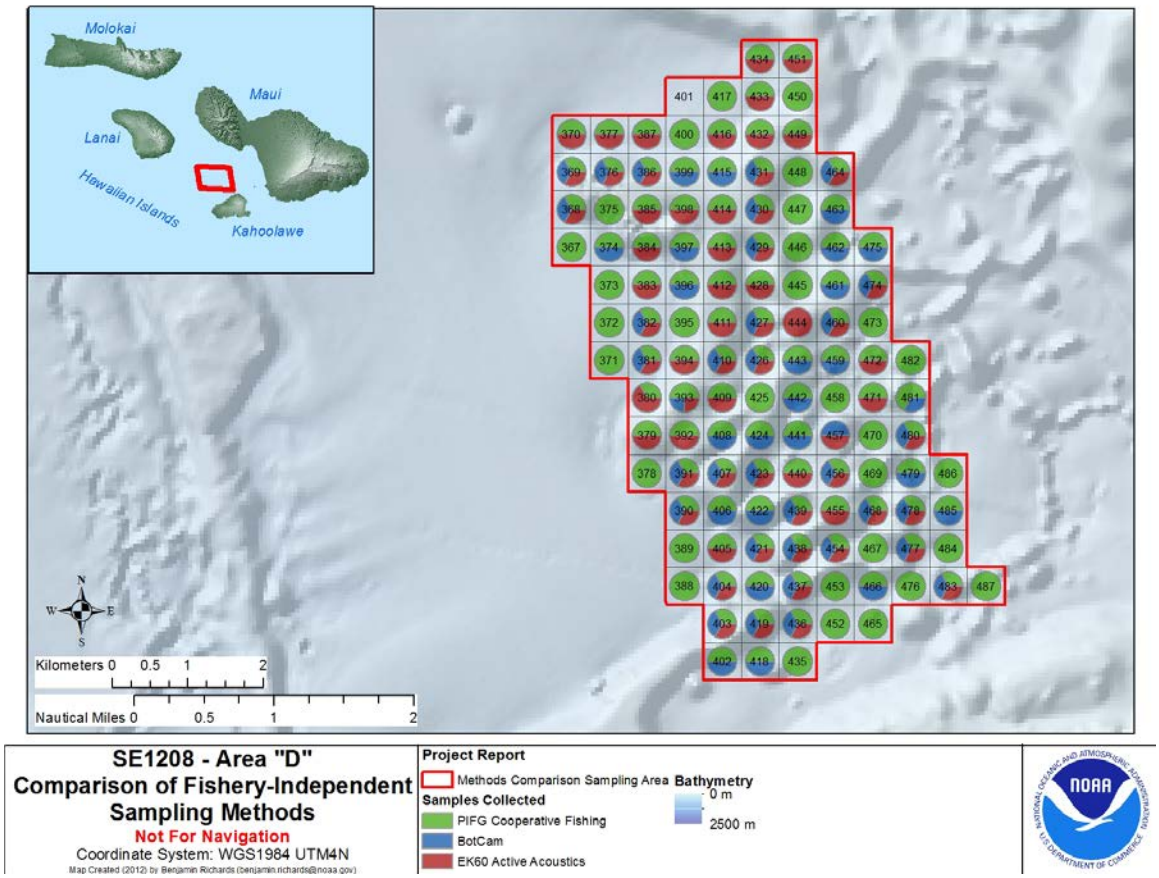


Figure 9 -- A map of sampling area "D" showing the distribution of sampling gears by grid cell (e.g. PIFG Cooperative Fishing, BotCam Operations, and EK60 Active Acoustics). Colored circles indicate only that the grid cell was sampled. The size of the circle does not correlate with abundance or biomass data.

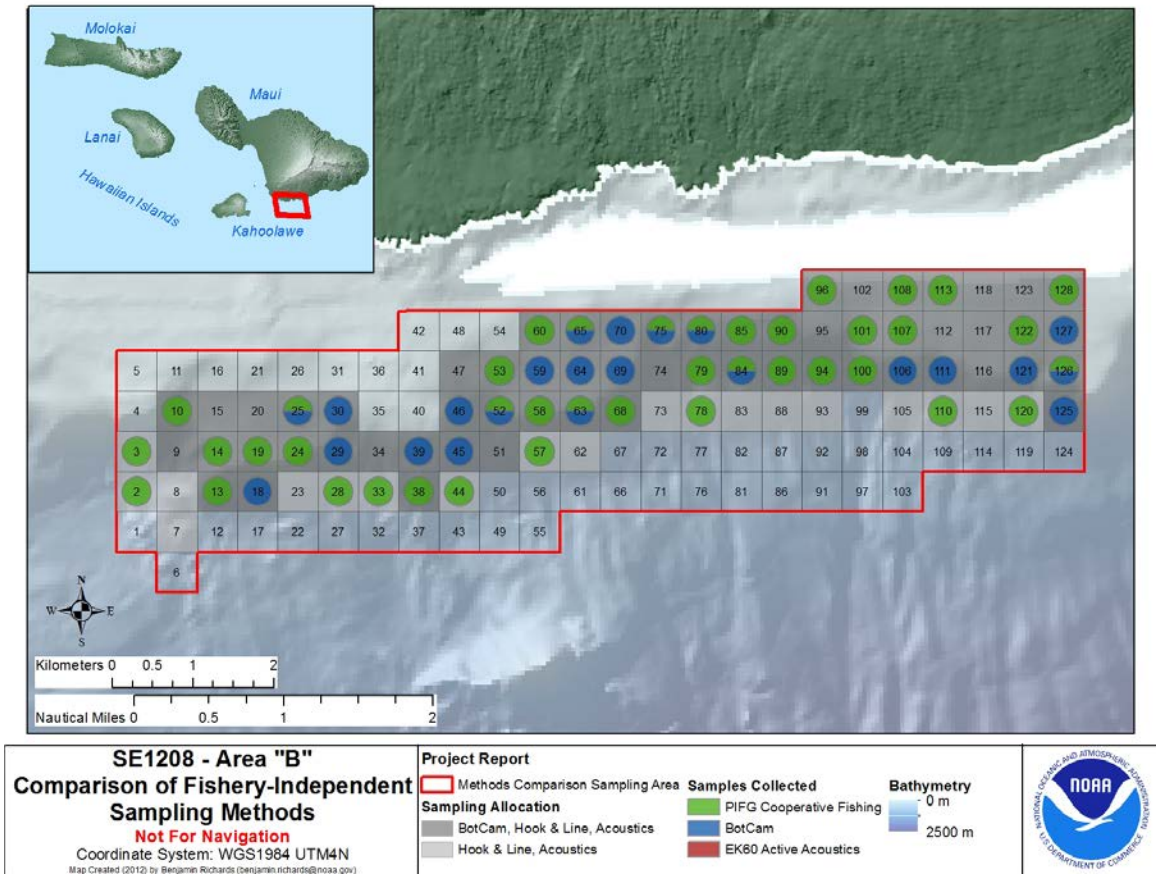


Figure 10 -- A map of sampling area "B" showing the distribution of sampling gears by grid cell (e.g. PIFG Cooperative Fishing and BotCam Operations). Colored circles indicate only that the grid cell was sampled. The size of the circle does not correlate with abundance or biomass data. EK60 Acoustic data were not collected in area "B".

### *EK60 Active Acoustics*

EK60 acoustic transected were conducted within and adjacent to survey area "D". Transducer settings were updated with the calibration values and sound speed was updated with the value from a CTD performed at the study site. Two types of surveys were conducted, single-pass and multi-pass. Single pass surveys were designed to achieve maximum coverage across the survey area and to quickly quantify the acoustic field of each grid cell. Typically, three grid cells were surveyed in a single pass, but additional grid cells were often sampled, especially when transiting between multi-pass surveys. Multi-pass surveys were designed to quantify short-term variability within a grid cell to determine how many acoustics passes are necessary to adequately quantify a typical grid cell. Multi-pass surveys were accomplished by maxing six EK60 acoustic passes through a single grid cell in quick succession. Three north-south passes were made followed by three east-west passes.

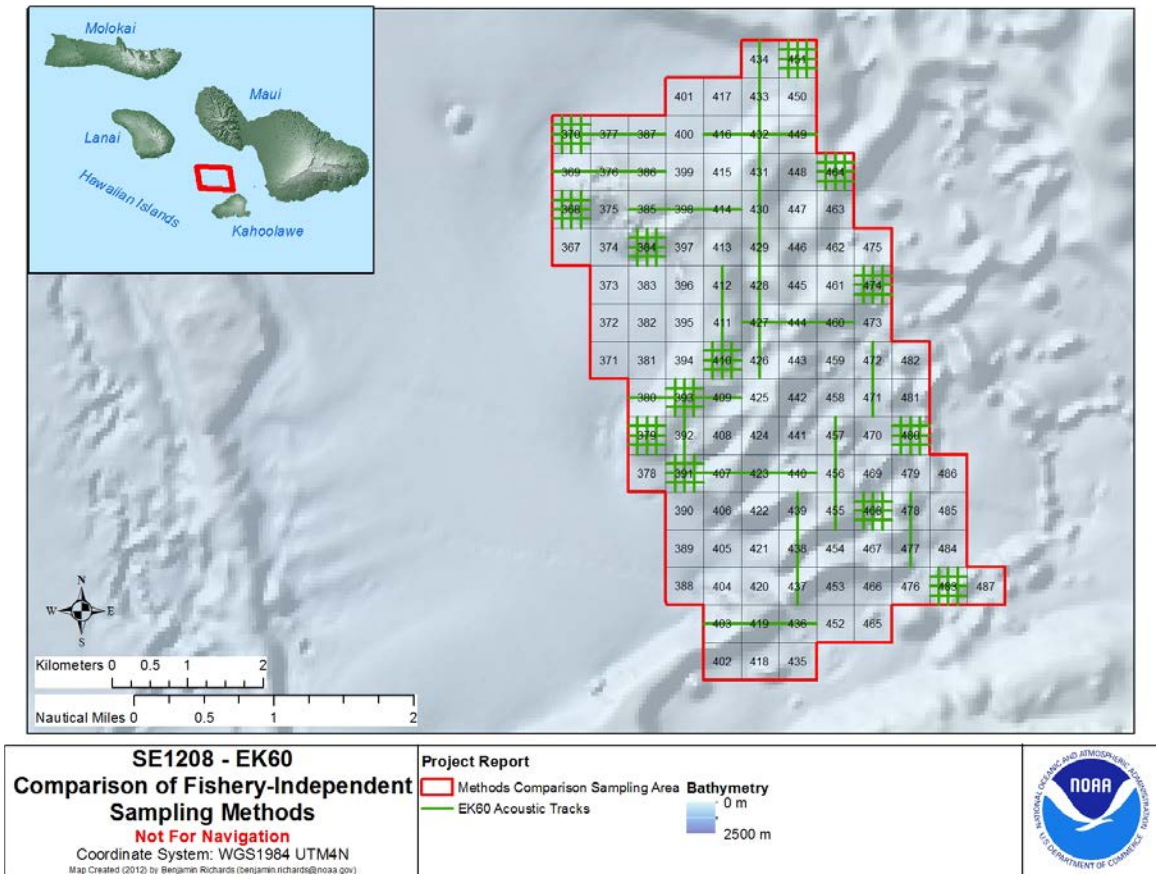


Figure 11 -- A map showing EK60 Active Acoustic transects conducted during SE1208. Grid cells were sampled using both single and multiple passes. Multiple passes were conducted immediately after one another, three running north to south and three east to west. These multiple passes were considered replicates are will be used to assess variability with the grid cell and therefore how many replicates are necessary to adequately characterize a typical grid cells.

Table 1 – Distribution of EK60 Active acoustics sampling during SE1208

| Sample Type | Number of Samples |
|---|---|
| Single Pass Acoustics | 65 |
| Multi Pass Acoustics | 13 |

### *Cooperative Fishing Operations*

Cooperative fishing operations were conducted by three charter vessels under the direction of the Pacific Islands Fisheries Group (PIFG). These three vessels, *Naomi K*, *Imua*, and *Hokuloa*, were randomly assigned to grid cells within each of the survey areas. Within each grid cell, each vessel conducted two 15-minute drift with hook and line, simulating normal commercial bottomfishing methods. Fishing methods were standardized among vessel with each vessel fishing two bottom lines with 4 hooks on each line. Hooks were #10 size and were attached the to down-line with 1-meter leaders. One line was baited with squid while the other was baited with anchovy. Over the course of SW1208, PIFG fishing vessels sampled a total of 146 grid cells, 40 in survey area “B” and 106 in survey area “D”.

### *Deepwater RUVS*

Deepwater RUVS sampling was conducted from the contract *RV Huki Pono* by staff from the lab of Dr. Jeffrey Drazen at the University of Hawai‘i-Mānoa. Four RUVS were used, each equipped

with stereo ROS Navigator cameras, SBE 39 CTD's, DataToys DVR's, CART acoustic releases, bait arm/light sync and a single unit with Nortek Aquadopp current meter. Each unit is suspended off the bottom approximately 3m and was tethered to surface buoys. Technical difficulties reduced the sampling to 3 functional units. Each deployment was baited using a 50/50 mix of ground anchovies and squid. Each deployment recorded video for 45 minutes and then was retrieved and re-deployed.

There were a total of 29 deployments in survey area "B". One deployment failed to record and one deployment recorded partial video (25min). Three deployments recorded full videos on only a single camera. Wind and sea conditions forced us to terminate after two days of sampling. Sampling was relocated to survey area "D" where a total of 61 deployments were made in 6 days. One deployment failed and was repeated with success. All 48 grids designated for RUVS, Hook/Line, and Acoustics were completed. An additional 12 grids designated for Hook/Line and Acoustics were sampled. This included grid #393, which had shown aggregations of interest in EK60 surveys.

Table 2 – Distribution of Deepewater RUVS deployments during SE1208

| Survey Area | Depth Range | Number of Samples |
|---|---|---|
| B | 80-120 m | 19 |
| B | 121-200 m | 5 |
| B | 201-300 m | 5 |
| D | 80-120 m | 1 |
| D | 121-200 m | 23 |
| D | 201-300 m | 36 |

### *Shallow-water RUVS*

Shallow-water RUVS followed the methodology outlined above in SE1207 and were deployed at sites located in the coastal waters of leeward Maui and northeast Lanai (Figure 5, Figure 6).

Table 3 – Distribution of shallow-water RUVS deployments during SE1208.

| Depth Range | # Sites Surveyed | Unbaited Deployments | Baited Deployments |
|---|---|---|---|
| 0-6 | 13 | 18 | 8 |
| 6-18 | 16 | 22 | 15 |
| 18-30 | 4 | 6 | 3 |
| 30-53 | 11 | 22 | 9 |
| 53-76 | 5 | 10 | 4 |
| 76-100 | 1 | 2 | 1 |
| Totals | 50 | 80 | 40 |