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CRUISE REPORT[1]

VESSEL: *Oscar Elton Sette*, Cruise SE-12-02

CRUISE PERIOD: April 2 – April 19, 2012

AREA OF OPERATION: Tutuila, American Samoa

TYPE OF OPERATION: Comparison of Fishery-Independent Sampling Methods for Coral Reef Fish

ITINERARY:

2 April	Began cruise. Departed Pago Pago Harbor and sampled shallow-water (0-30 m) zone on Ta'ema Bank and east of Pago Pago Harbor using baited underwater stereo-video camera stations (BRUVS) and autonomous underwater vehicle (AUV). AUV main CPU canister flooded.
3 April	Sampled 11 Stationary Point Count (SPC) sites in northwest Tutuila (0-30 m depths) using BRUVS.
4 April	Sampled 11 SPC sites in southwest Tutuila (0-30 m depths) using BRUVS.
5 April	Sampled 11 SPC sites in northeast Tutuila (0-30 m depths) using BRUVS. Dr. Kunz arrived and began repair work on the AUV.
6 April	Sampled 11 SPC sites in northeast Tutuila (0-30 m depths) using BRUVS.
7 April	Sampled 12 SPC sites in north Tutuila (0-30 m depths) using BRUVS and AUV.
8 April	Sampled 14 SPC sites in east Tutuila (0-30 m depths) using BRUVS and AUV.
9 April	Sampled 9 SPC sites in southeast Tutuila (0-30 m depths) using BRUVS and AUV.

[1] PIFSC Cruise Report CR-12-003
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10 April Completed 2 dives near southeast Tutuila (0-30 m depths) using AUV. BRUVS conducted mid-cruise calibration at Faga'alu.

11 April Sampled 9 sites in west Tutuila (30-100 m depths) using BRUVS and completed 2 AUV dives.

12 April Sampled 10 sites in northwest Tutuila (30-100 m depths) using BRUVS and completed 2 AUV dives.

13 April Sampled 9 sites in north Tutuila (30-100 m depths) using BRUVS and completed 2 AUV dives.

14 April Sampled 10 sites in northeast Tutuila (30-100 m depths) using BRUVS and completed 2 AUV dives.

15 April Sampled 9 sites in southeast Tutuila (0-30 m depths) using BRUVS. Conducted general vehicle maintenance on the AUV. Returned to Pago Pago Harbor to take on fuel.

16 April Sampled 10 sites in east Tutuila (30-100 m depths) using BRUVS and completed 2 AUV dives.

17 April Sampled 4 sites in northeast Tutuila (30-100 m depths) using BRUVS and completed 2 AUV dives. Final day of sampling.

18 April General demobilization and equipment breakdown.

19 April Continued demobilization. Returned to Pago Pago Harbor. End of cruise. Departed for airport.

MISSIONS AND RESULTS:

This mission, led by Dr. Benjamin L. Richards of the Pacific Islands Fisheries Science Center (PIFSC) and Dr. John Rooney of the Joint Institute for Marine and Atmospheric Research (JIMAR), was designed to cross-compare fishery-independent methodologies for sampling coral reef fish assemblages surrounding the island of Tutuila, American Samoa. The mission involved the fielding of three separate gear types: SCUBA Stationary Point Count Surveys (SPC), Baited and Unbaited Remote Stereo-Video Camera Stations (BRUVS), and a SeaBED Autonomous Underwater Vehicle (AUV) from two NOAA Ships: the *Hi'ialakai* and *Oscar Elton Sette*. The challenge of coordinating between two NOAA ships worked out better than expected and each gear type performed well. Each method is detailed below. Post-mission data analyses were carried out in collaboration with Drs. Jerald Ault and Steve Smith of the University of Miami, Rosenstiel School of Marine and Atmospheric Science, as well as Dr. Euan Harvey from the University of Western Australia to quantify the power of the data generated by each method and to make comparisons among methods. Strengths and

weaknesses will be outlined and the usability of each method for stock assessment will be discussed.

Each member of the scientific party and the crew and officers of the NOAA Ship *Oscar Elton Sette* and R/V *Huki Pono* performed their required duties exceptionally and should be commended. Significant logistical and scientific challenges were encountered throughout the mission, and each member of the team rose to the occasion.

A. Methods

1. *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-min 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'.

2. *BRUVS*

Baited remote underwater video stations (BRUVS) are nondestructive 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 min 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 ~ 50 kg) from the vessel at predefined GPS locations with a rope and floats attached. Established soak time is 15 to 60 min (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.

3. *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 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 used 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 2000 m, and maximum single-dive time of 6−8 h, 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.

B. Results

1. CRED Stationary Point Count Surveys (SPC)

    a. 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 (0-6 m), mid (6-18 m), and deep (18-30 m) (Fig. 1).

    b. The 2012 surveys were the first to test a sampling design which included habitat information from the NOAA Biogeography maps.

    c. Three habitat categories were taken into account for site allocation: aggregate reef, pavement, and spur and groove. Overall, the habitat map was generally accurate, especially for large scale features (e.g., a large offshore bank with mostly pavement habitat).

2. Baited and Unbaited Remote Stereo-Video Stations (BRUVS)

    a. BRUVS preformed very well during SE-12-02, completing 138 sampling stations across 6 depth strata using baited and unbaited systems (Table 1, Fig. 2).

    b. 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).

c. 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.

d. Roughly 300−350 h of raw/unprocessed station video (doubled if one considers two cameras/station drop) were collected during the course of the cruise.

3. SeaBED Autonomous Underwater Vehicle (AUV)

a. The SeaBED AUV also preformed well, completing 17 individual dives that covered a total of 29,400 meters (Table 3, Fig. 3).

b. 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.

c. A secondary sensor, a downward facing 5 megapixel, 12 bit dynamic range Prosilica GigE camera in a 6000 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.

d. The electronics housing on the AUV leaked during the first operational dive of the cruise, letting in approximately 0.5 l of seawater, which caused the dive to abort and damaged or destroyed some components. Collaborators at the Woods Hole Oceanographic Institution flew out a post-doctoral researcher with a replacement, which he modified to accommodate the sensor suite on the AUV. The most likely cause of the leak was as a result of inadequate sealing between the endcaps on the electronics canister due to the endcaps having been recently re-anodized. The endcaps had been pressure tested to a depth of 1500 m using a different canister body after re-anodizing, and the canister held vacuum during AUV pre-dive checks. Despite these precautions a leak occurred, leading to the following lessons learned:

i. Replace, rather than re-machine and re-anodize pitted pressure vessel components.

ii. Pressure test all components of a pressure vessel together. Although they should be interchangeable, testing the re-machined endcaps with a different canister body may have contributed to the leak.

iii. Early detection of a leak might have enabled the dive to be aborted before components were damaged. Inclusion of a leak detector is being considered in the design of the replacement electronics and their canister.

iv. The failure of a critical component of the AUV stresses the previously recognized need for a complete backup vehicle to be available on all cruises. The loss of 6 days of AUV dives could have been avoided if a complete set of spares was available. Fortunately, this incident led to emergency funding to construct two replacement electronics canisters, but funding for spares for other parts of the vehicle has not yet been secured.

SCIENTIFIC PERSONNEL:

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Tables

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 SE-12-02.

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

Figures

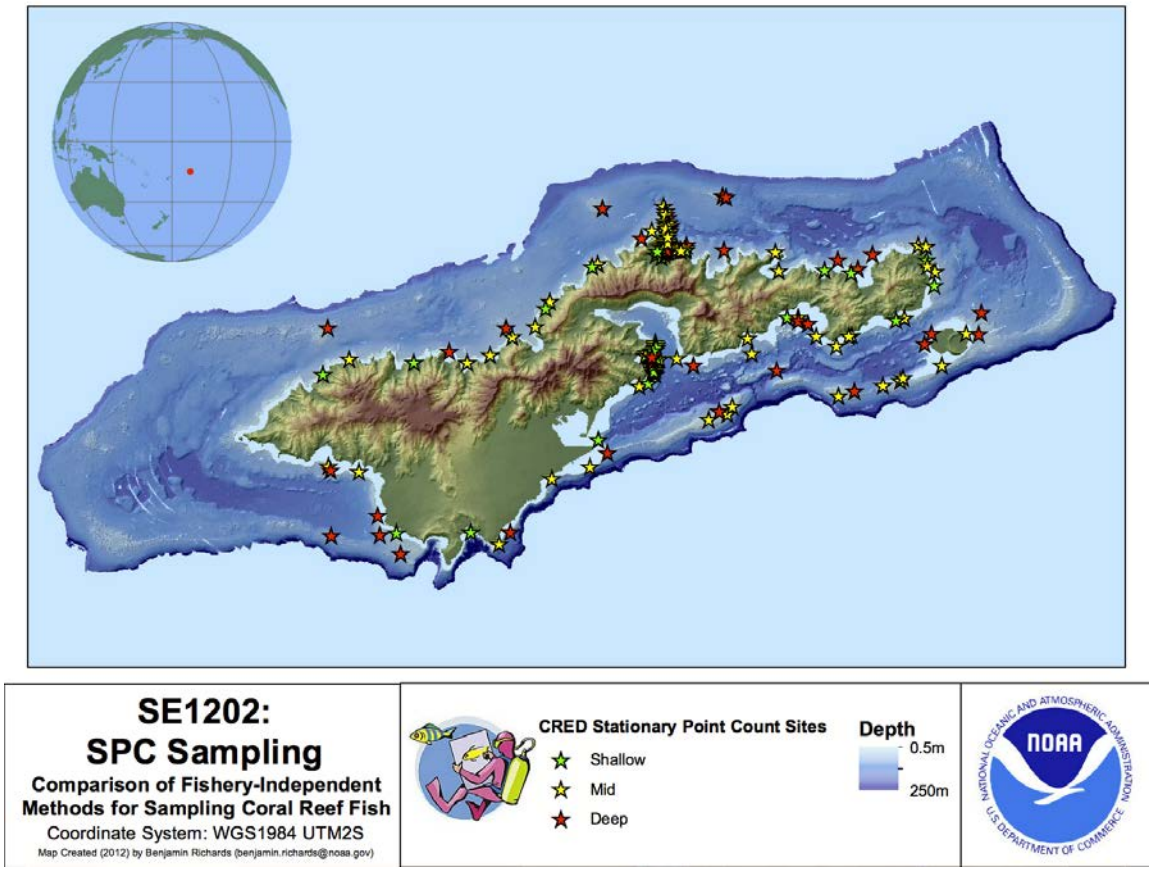

Figure 1.--Spatial distribution of the 158 Stationary Point Count deployment locations sampled during SE-12-02. Each site was sampled by a pair of scuba divers from the PIFSC Coral Reef Ecosystem Division.

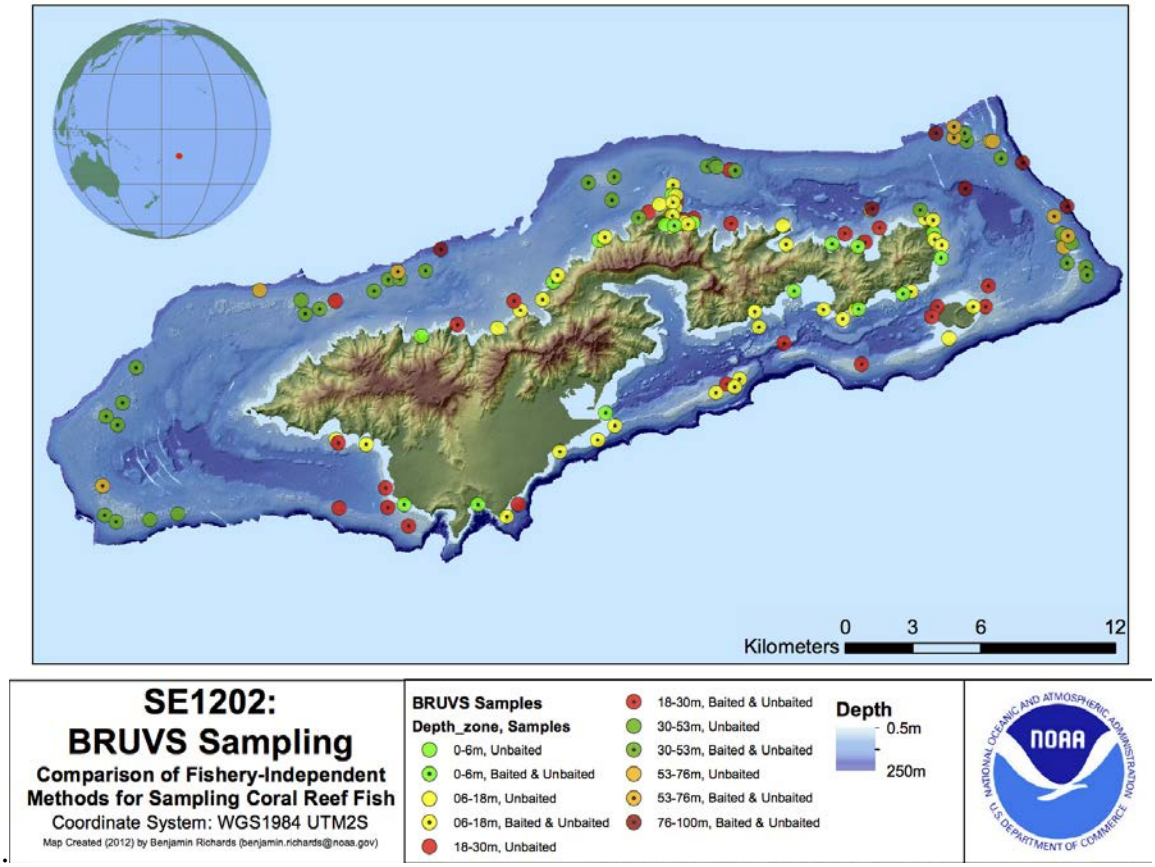

Figure 2.--Spatial distribution of the 138 BRUVS deployment locations sampled during SE-12-02. The majority of sampling locations were sampled using a pair of unbaited BRUVS followed by a pair of baited BRUVS.

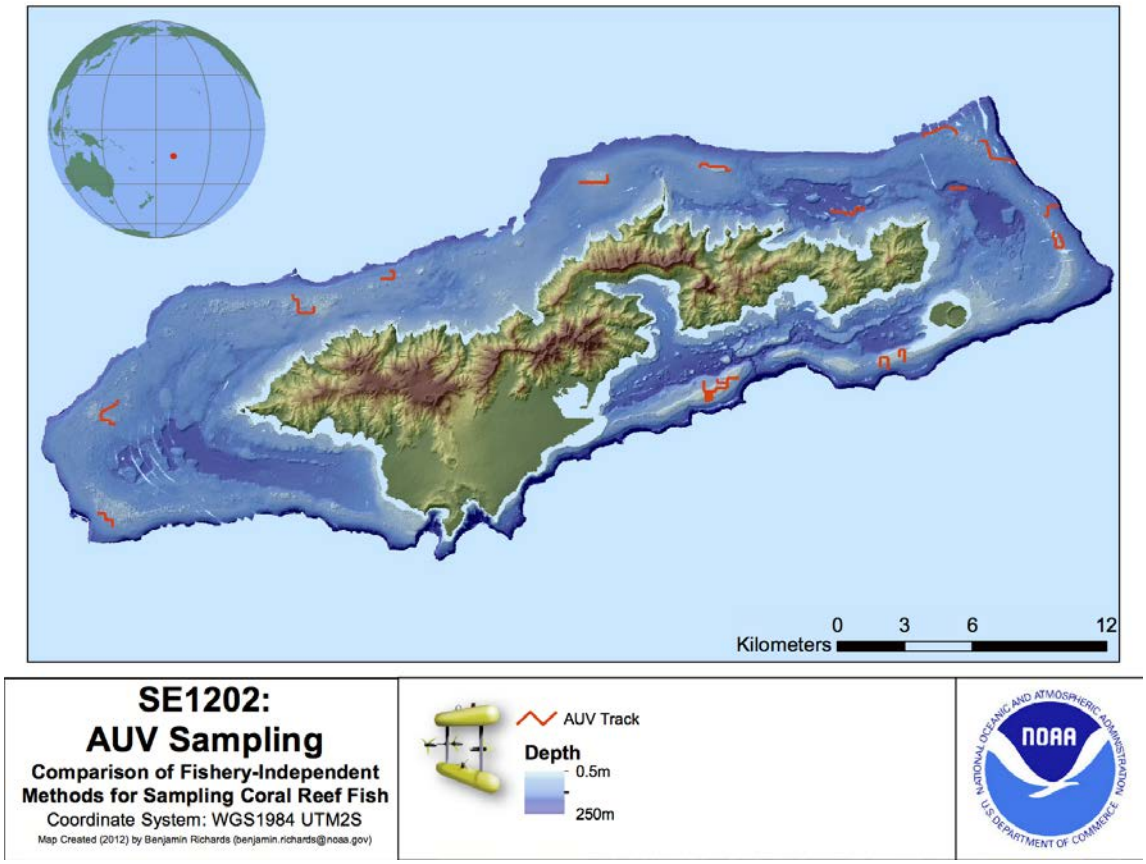

Figure 3.--Survey tracks of the SeaBED AUV during SE-12-02. The 17 separate survey dives had a cumulative length of 29,394 meters. Mean survey length was 1729 meters.