Location: *Pagan, CNMI* Depth: 263 meters Species: *Aphareus rutilans*, Lehe

Location: *Arakane, CNMI* Depth: 241 meters Species: *Pristipomoides filamentosus*, Opakapaka

Location: *Tinian, CNMI* Depth: 185 meters Species: *Pristipomoides auricilla*, Yellowtail Kale

Location: *Arakane, CNMI* Depth: 241 meters Species: *Pristipomoides auricilla*, Yellowtail Kale

POSTER
OS14F-14

BotCam

Bottom Camera Bait Station

Development of Autonomous Underwater Bait Stations with Stereo Imaging for Size, Distance, and Abundance Estimates of Living Marine Resources

Merritt, D. W. Wong, K. B. Kelley, C. D. Parke, M. Laughlin, J.

Location: *Penguin Bank, Hawaii* Depth: 250 meters Species: *Etelis carbunculus*, Ehu

Location: *Sampan Pinnacle, Hawaii* Depth: 240 meters Species: *Etelis coruscans*, Onaga

Location: *Arakane, CNMI* Depth: 241 meters Species: *Pristipomoides zonatus*, Gindai

Location: *Supply Reef, CNMI* Depth: 233 meters Species: *Epinephelus octofasciatus*, Eight Barred Grouper

SYSTEM SUMMARY

Background Problem

Resource managers, researchers, and policy makers have a need to understand the effects of management activities, such as the opening or closing of fishing areas, and the allocation of catch quotas, on populations of targeted fish species. Population parameters, such as community structure (e.g., habitat utilization, rank order of abundance of different species, age class distribution, health) are critical to developing such measures and to monitoring their effectiveness in order to develop adaptive management programs. Acquiring bottomfish population data within and adjacent to marine protected areas (MPAs) may be complicated by the need to restrict or avoid extractive sampling within these areas, and the difficulty in enumerating such stocks in this near-boundary region using shipboard acoustical methods. For deepwater fisheries, such as bottomfish fisheries, the task may be further complicated by the preclusion of scuba surveys, catch and release, and other non-lethal techniques typically used in shallow water.

Tool Development

Periodic assessments and monitoring of fish populations is required in order to support ecosystem-based management, to determine the effectiveness of MPAs, and to assess the impact of fishing activities. To address this need, current work has focused on developing a prototype, deep water (350m) camera station that can be used as a cost-effective and non-extractive method to assess and monitor bottomfish and other commercially important deep water species. This **Bottom Camera ("BotCam")** system includes programmable control functions which allow for the activation of imaging systems, bait release, image scaling indicators, and acoustic recovery. The camera bait station can be deployed repetitively during a survey of a site or can sit unattended on the seafloor and will activate at a preset time. Further, the stereo-video configuration allows for the sizing and ranging of both fish and benthic features. The availability of a field-tested deep-water camera bait station, coupled with a standard method to analyze the image data, represents a cost-effective and non-extractive method to obtain size and abundance information on these fish populations and to study ecological linkages to more shallow water ecosystems, such as coral reefs. The BotCam is a tool that can assist researchers, resource managers and policy makers in effectively managing stocks that frequent deepwater habitats.

Data

I. Relative Abundance and Density of Fish Species
   a. Spatial Comparison
   b. Temporal Comparison
II. Measurement
   a. Fish Size
   b. Sample Area Definition
   c. Distance
   d. Benthic Feature Size
   e. Fish Swimming Speed
   f. Current Speed/Turbulence
III. Habitat
   a. Identification
      i. Hard Bottom/Soft Bottom
      ii. Benthic Cover (e.g. corals, algae)
      iii. Benthic Structure/Composition
      iv. Slope
   b. Ground Validation for Multibeam Surveys
   c. Ground Validation for Defined Bottomfish Region
   d. Ground Validation for Passive Acoustic Surveys
IV. Fish Behavior
   a. Ambient Light Markings
   b. Reaction to Bait/Lures
   c. Inter and Cross-Species Interaction
   d. Aggressive/Passive
V. Fish Tag Identification/Tracking

Statistical Methods of Analysis

Statistical methods for camera bait stations in productive regions were established and tested by Ellis and DeMartini (Ellis and DeMartini 1995). Four parameters were used:

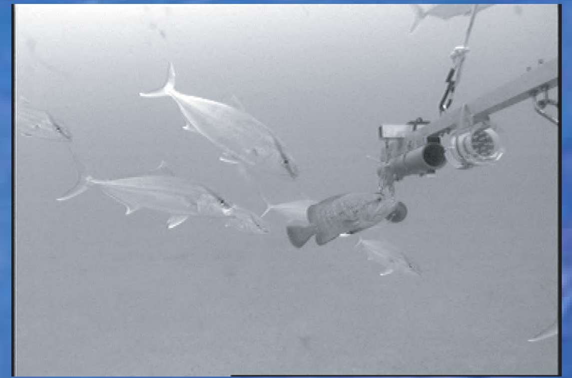
I. Time to first arrival (TFAP)
II. Maximum number in any frame (MAXNO)
III. Total duration in sequence (TOTTM)
IV. Species present and duration of bait attachment (BTM)

In these tests, the "Maximum Number" (MAXNO) parameter correlated best to the traditional "Catch Per Unit Effort" (CPUE) parameter used in fishing surveys. This method avoids the potential problem of counting the same fish multiple times as it exits and re-enters the camera's field of view. This method yields conservative relative density estimates.

The current iteration of BotCam improves upon these methodologies because it provides the means to not only estimate relative abundance and species composition, but also size of the observed species. Further, in preliminary studies, the measurement capabilities have been shown to provide order of magnitude estimates of current speeds and the potential to directly measure turbulence allowing the extent of area of influence of the bait to be quantified (Merritt 2005).

Results

Between April and August 2005, a prototype BotCam was tested at several locations around the island of Oahu, Hawaii including 4 restricted fishing areas (RFA). Depths ranged from 70 to 350 meters and bottom types ranged from soft mud flats to wire coral covered pinnacles. The unit was also tested on slopes greater than 45 degrees and in high current areas. Several target species were identified including *Seriola dumerili, Pseudocaranx dentex, Pontinus macrocephalus, Pristipomoides filamentosus, Pristipomoides zonatus , Pristipomoides sieboldii, Etelis carbunculus, Etelis coruscans and Epinephelus quernus.*



Location: *Oahu, Hawaii.* Depth: 73 meters. Species: *Seriola dumerili*, Kahala; *Epinephelus quernus*, Hawaiian Grouper.

Location: *Penguin Bank, Hawaii.* Depth: 250 meters. Species: Etelis carbunculus, Ehu; *Squalis mitsukurii*, Dogfish Shark; *Antigonia eos*, Antigonia.

Between September and October 2005, a second prototype unit was deployed during a Pacific Island Fisheries Science Center (PIFSC) Reef Assessment and Mapping Program (RAMP) cruise to the Commonwealth of the Northern Mariana's Islands, Guam, and Wake Atoll from the NOAA Research Vessel O.E. Sette. The unit was deployed 45 times to depths ranging from 100 to 350 m. Bottom slopes reached well over 50 degrees on several drops. 17 fish species including all of the commercially important stock were identified and several others remain unidentified. Further, deep water corals and algae's were visualized.

Location: *Arakane, CNMI.* Depth: 241 meters. Species: *Pristipomoides auricilla*, Yellowtail Kale; *Caranx lugubris*, Black Jack.

Location: *Wake Island.* Depth: 347 meters. Species: Etelis carbunculus, Ehu.

Future Directions

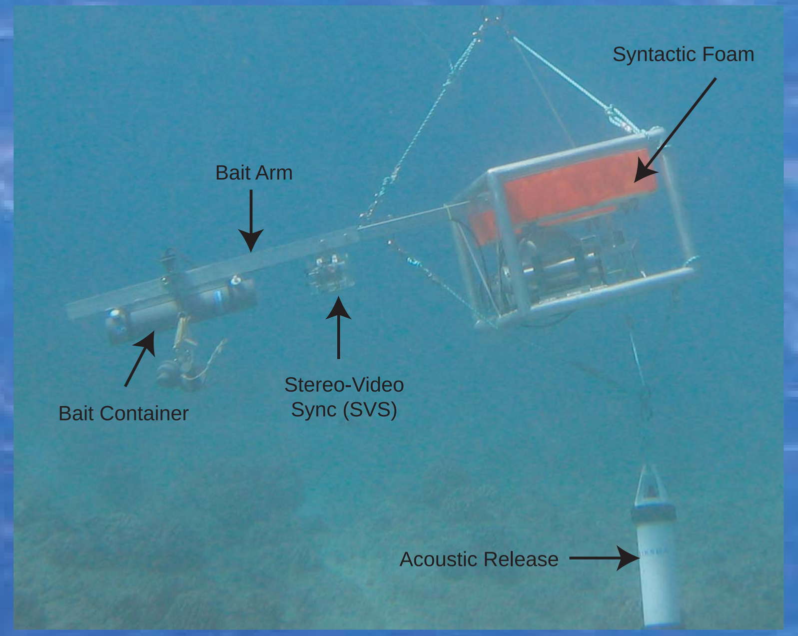
- Simplify deployment and recovery by eliminating surface line and incorporating an anchor release system that is triggered by a depth limit or an acoustic signal from the ship.
- Improve field of view.
- Reduce size/weight of overall package.
- Update electronics and software modules to improve battery life, image quality and data uploading process.
- Develop automated video analysis methods.
- Investigate alternatives for acquiring higher resolution images.
- Engage the larger fisheries science and management community in developing widely applicable sampling methodologies (i.e. bait mixture, set times, sample size, fish sizing parameters).

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

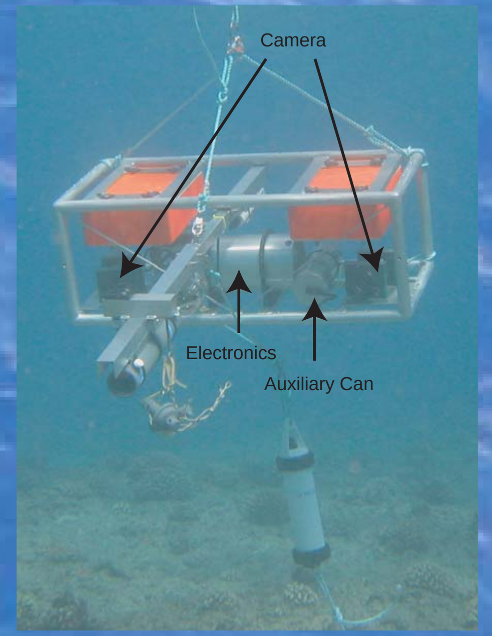
Funding for this project was provided by the NOAA Coral Reef Conservation Program, the NOAA Advanced Sampling Technology Working Group and the Western Pacific Fisheries Management Council (WestPac).

Special Thanks to Deborah Yamaguchi.

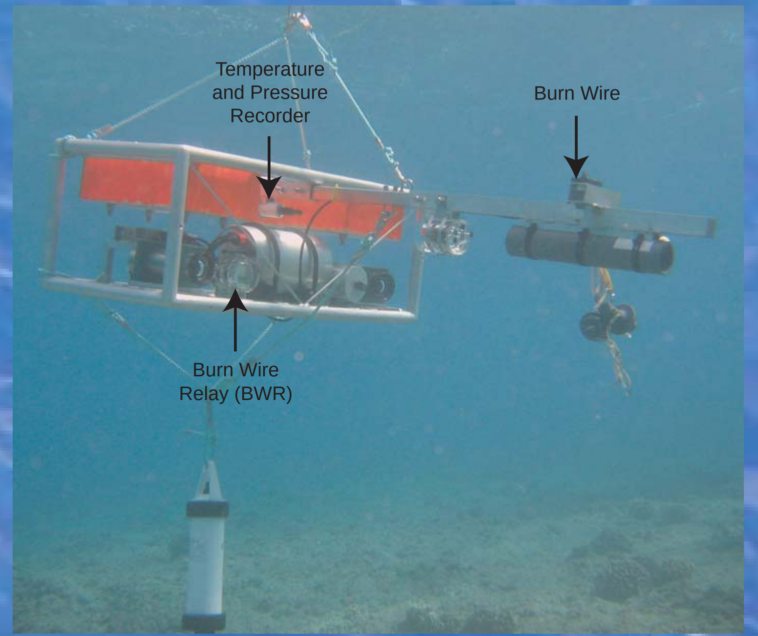
SYSTEM DESIGN



Side View of BotCam. The frame is adjusted to point the cameras downward at a 10 to 20 degree angle to provide a view of the benthic features while maintaining a large field of view of the water column. The frame is also designed to point down current. When bait is released, the scent will travel down current attracting fish into the field of view.



Front View of BotCam. Here the orientation of the cameras is clear. The cameras are fixed in place and "Toed In" by 10 degrees. This both increases the field of view and allows fish to be measured closer to the frame.

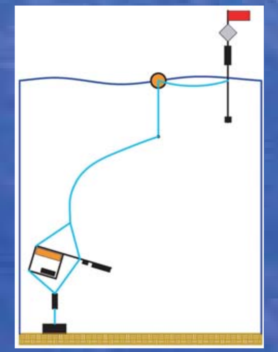


Oblique View of BotCam. A bait arm is used to place the bait release container and the stereo-video sync device into the field of view.

Key Features

- Fully Automated – Camera's On/Off, Record Start/Stop, Bait Release
- Ambient Light Recording to 350 meters
- Stereo-Video Images for High Precision/Accuracy Measurements
- Operational on Multiple Bottom Types Including Steep Slopes and High Rugosity
- Compact Design – Deploy and Recover from a Variety of Vessels Without the Need for Mechanical Systems
- All Systems Depth Rated to 500 meters

Bait Release System. The top image shows the bait release container (1.7L Niskin Bottle) closed. The bottom image shows the bait release container immediately after opening. A ground mixture of squid and opelu (bait mixture) is shown exiting the container.

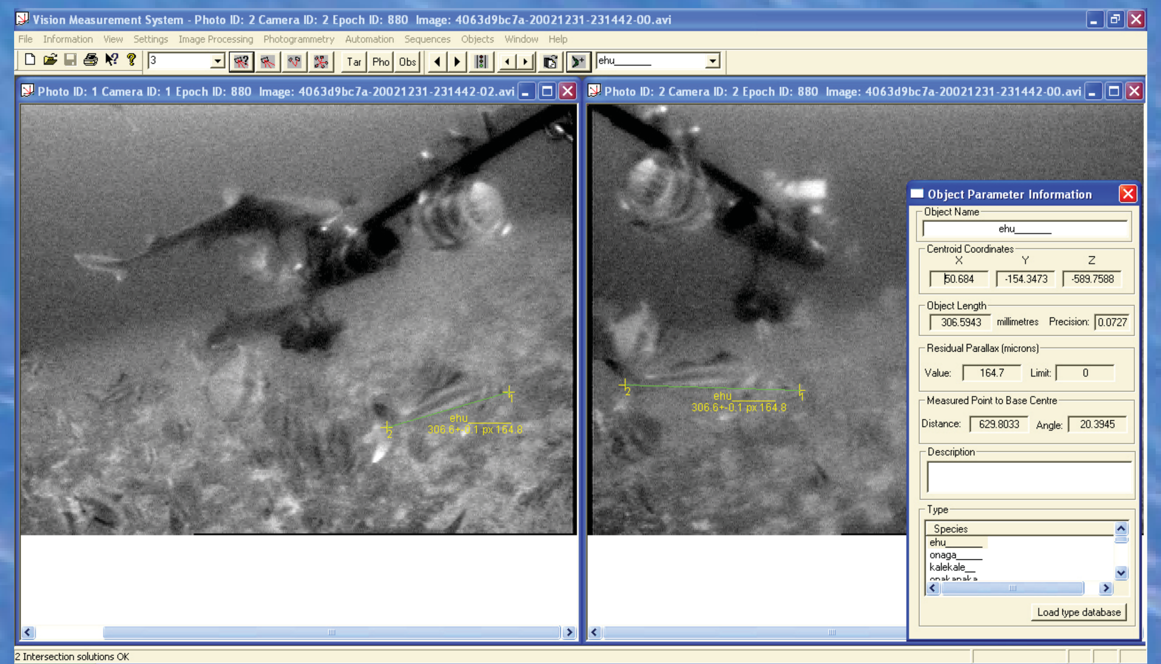


Schematic of BotCam deployed. A "High Flyer" is attached to a mooring ball to create a grappling line target for recovery. A line weight is used to remove wave action from the line acting on the BotCam. The unit can be recovered using an acoustic release or via line haul. *Note: Not to Scale.

The BotCam can be deployed and recovered from a wide variety of vessels. The top image shows the BotCam being recovered from the Wailoa (Cates International Charter), a 46' Australian Catamaran. The bottom image shows the BotCam being deployed from the 224' NOAA R/V O.E. Sette (see photo below).

The photo above shows the BotCam surface signature with the NOAA R/V O.E. Sette in the background at Wake Island.

STEREO-VIDEO



The image above shows the VMS PC interface. Stereo-video images from a BotCam deployment at Penguin Banks, Hawaii, is shown. A 306 mm Ehu (*Etelis carbunculus*) has been measured. Other species present include Dogfish Sharks (*Squalus mitsukurii*) and Antigonia (*Antigonia eos*). Water depth is 250 meters.

Table 1. Errors associated with stereo-video estimates of length and width measurements of southern bluefin tuna. (Adapted from Harvey et. al. 2003)

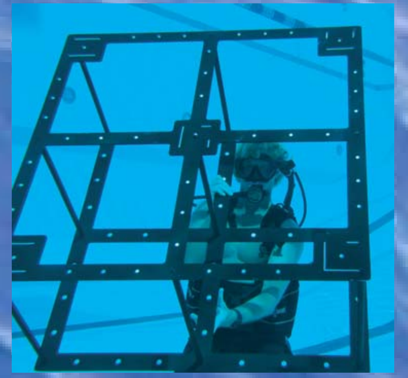
Forklength (Sample Size: 54)	Error (mm)	Absolute Error (mm)	Relative Error (%)	Relative Absolute Error (%)
Mean	1.72	6.06	**0.16**	0.56
1 Std. Dev.	8.13	5.62	0.76	0.54
1 Std. Error	1.11	0.77	0.10	0.07
Max. Body Depth (Sample Size: 47)	Error (mm)	Absolute Error (mm)	Relative Error (%)	Relative Absolute Error (%)
Mean	1.37	3.93	**0.51**	1.37
1 Std. Dev.	5.06	3.43	1.78	1.24
1 Std. Error	0.74	0.50	0.26	0.18

Error	Stereo Video Observed Value - Measured Value
Absolute Error	Absolute Value of Error
Relative Error	(Error/Measured Value)*100
Relative Absolute Error	(Absolute Value of Relative Error)*100

Measured Forklength Range:	830 - 1412 mm
Measured Maximum Body Depth Range:	228 - 365 mm

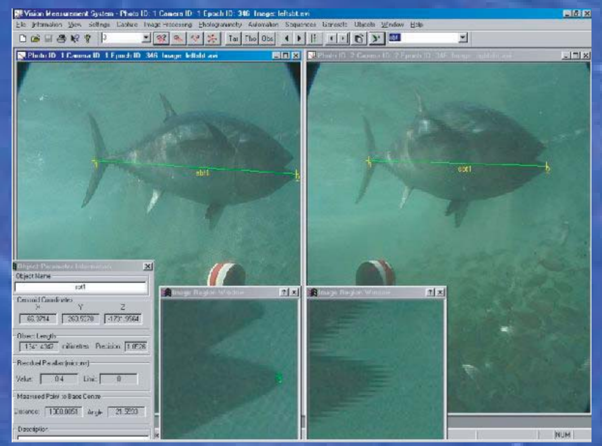
The BotCam's stereo-video system is based on the principles of stereo-photogrammetry. Stereo-photogrammetry allows objects in images (photographs or frame grabs of video) to be measured with high precision and accuracy. All measurements require a minimum of two images of an object (moving objects must be synchronized in time) from two distinct locations with known relative camera orientations. This information combined with the internal geometry of the cameras allows three-dimensional space to be defined.

The BotCam's stereo-video images are processed using a software package called Vision Metrology System (VMS) from Geomsoft (www.Geomsoft.com). An example of the VMS interface is shown. Objects (e.g. fish) that can be seen in both the left and right images are measured by clicking on the same points in both images and then choosing the object's name from a pull down menu. The length of the object is projected on both images. The objects distance and angle from the cameras, the frame number (time) and the X, Y, Z coordinates in space are all reported in a data file that can be uploaded to alternative data management programs (e.g. Microsoft Excel, Matlab).



Stereo-video calibration cube. This custom built frame is used to "self-calibrate" the BotCam cameras. This calibration process determines the relative orientation of the cameras to one another and corrects for lens distortion.

VMS has been tested in several underwater applications by Dr. Euan Harvey from the University of Western Australia and others. Results from one report by Harvey et. al. 2003 using caged Blue Fin Tuna is shown. The results compare stereo-video measurements to physical measurements of the fish taken with calipers after being removed from the cages.



VMS interface showing a Southern Bluefin Tuna from Harvey et. al. 2003.

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Contact Information:

For more information, please visit: www.pifsc.noaa.gov/cred/applied_research.php

Or contact:

Merritt, D W (Daniel.Merritt@noaa.gov) , Joint Institute for Marine and Atmospheric Research, University of Hawaii, 1125-B Ala Moana Blvd., Honolulu, Hi 96814 United States

Wong, K B (Kevin.Wong@noaa.gov) , NOAA Fisheries, Pacific Islands Fisheries Science Center, 1125-B Ala Moana Blvd., Honolulu, HI 96814 United States

Kelley, C D (ckelley@hawaii.edu) , Hawaii Undersea Research Laboratory, University of Hawaii, 1000 Pope Rd. MSB 303, Honolulu, HI 96822 United States

Parke, M (Michael.Parke@noaa.gov) , NOAA Fisheries, Pacific Islands Fisheries Science Center, 1125-B Ala Moana Blvd., Honolulu, HI 96814 United States