SCTB15 Working Paper

ALB - 2

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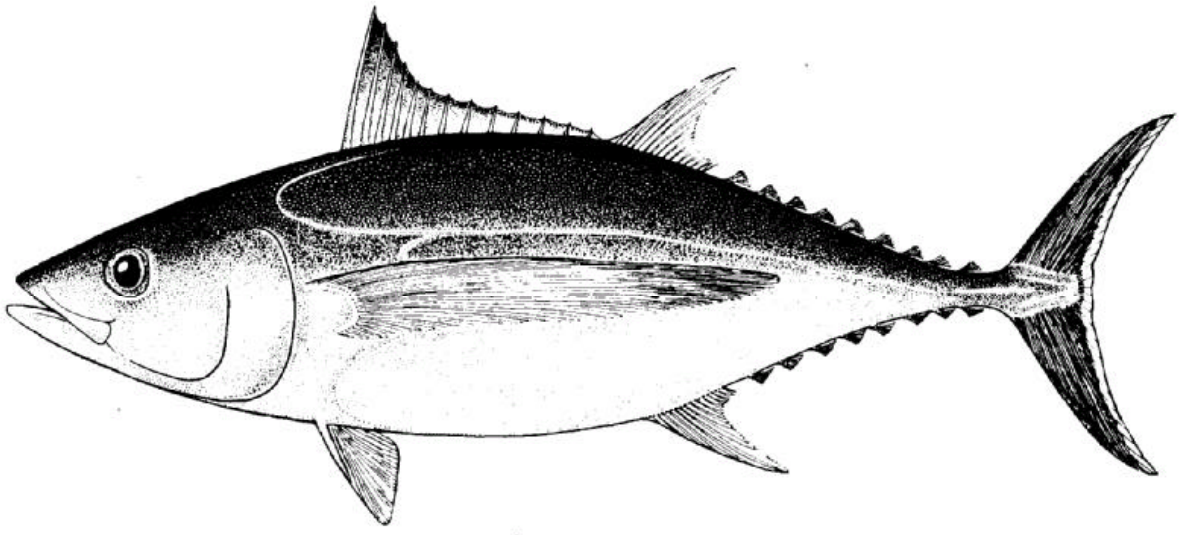

Michael P. Seki and Jeffrey J. Polovina

National Marine Fisheries Service (NMFS), Honolulu Laboratory, Hawaii

A new study to characterize the oceanography of the American Samoa longline fishing grounds for albacore, *Thunnus alalunga*.[1]

Michael P. Seki and Jeffrey J. Polovina
National Marine Fisheries Service, NOAA
Southwest Fisheries Science Center Honolulu Laboratory
2570 Dole Street
Honolulu, HI 96822-2396

Background and Motivation

Support for a new study to conduct an oceanographic characterization of the American Samoa longline fishing grounds for albacore, *Thunnus alalunga*, has recently been awarded by the Pelagic Fisheries Research Program of the Joint Institute of Marine and Atmospheric Research at the University of Hawaii School of Ocean and Earth Science and Technology. The American Samoa domestic longline fishery has recently undergone extraordinary growth, particularly in the fleet composition of large (>50 ft in length) vessels that have fueled a fivefold increase in fishing effort and landings from 1999 to 2001 (Fig. 1a). Prior to the sudden expansion, most longline fishing around American Samoa were accomplished through a fleet of smaller, 30 ft, open-decked catamarans known as *alia*. To illustrate the expansion, over 50 boats actively participated in the fishery during 2001 deploying 4,690 sets (over 5 million hooks) resulting in catch rates of about 40 fish·1000 hooks^{-1}. By comparison, only 23 vessels made up the fishery in 1999, making 2,102 sets (ca. 912,742 hooks) yielding 32.38 fish·1000 hooks^{-1} (Fig. 1b,c).

Albacore tuna (*Thunnus alalunga*) is the target species in the fishery and dominates the catch (DMWR 2002, WPRFMC 2001). Depth distribution of albacore in the Pacific ranges from the surface down to at least 380 m and is typically governed by the vertical thermal structures and oxygen contents of the water masses (Collette and Nauen 1983). Longline fisheries such as those operating in Samoan waters specifically target and harvest the deeper dwelling, larger sized mature albacore that, like bigeye tuna, *Thunnus obesus*, have catch rates that increase with depth fished (Boggs 1992, Nakano et al. 1997). Saito (1973) reported that the large sized albacore are broadly found between 80 and 380 m but the center and concentration of their vertical distribution was about 200-260 m. Interestingly much of the incidental catch taken in the domestic American Samoa deep longline fishery is composed of species considered to occupy shallower depths and that are also targeted by local surface troll fishers. These include species such as blue marlin (*Makaira mazara*), wahoo (*Acanthocybium solandri*), mahimahi (*Coryphaena hippurus*), and skipjack tuna (*Katsuwonus pelamis*). Concerns now abound that the rapidly expanding fleet may threaten the local supply of these large pelagics and negative trends in both the longline and troll catch rates of the shallow species do little to suppress these fears

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(Fig. 1c, d). To address these concerns, a 50-nautical mile closed fishing area to the large vessels has recently been designated around the islands of American Samoa and a moratorium on the entry of any new longline vessels into the fishery has been proposed until a limited entry program can be implemented.

Oceanographically, there has been little study regarding the pelagic habitat in the American Samoa region, much less the spatial and temporal variability of the oceanographic climate. Historical studies conducted on South Pacific longline fisheries and the corresponding environment have focused on foreign fishing activities primarily in waters farther to the west; e.g., west of Fiji (Yamanaka 1956, Saito 1973). Large scale oceanographic circulation patterns suggests that the waters of the American Samoa EEZ are heavily influenced by the meandering flow of the South Equatorial Current (SEC) (Lukas 2001). Cursory examination of sea level height and computed geostrophic currents from satellite altimetry seem to support this (Fig. 2). The horizontal shear of strong ocean currents associated with the SEC would reduce the likelihood of getting longline gear to settle in the desired deeper waters for albacore (e.g., Mizuno et al. 1994); final longline set depths have been reported to end up considerably shallower (e.g., 54% to 68%) than target depths (Boggs 1992). One could then hypothesize that fishing operations conducted under the prevailing influence of the SEC would result in shallower sets and corresponding catches composed more of the shallow dwelling fauna such as those described above for the observed incidental take in the fishery. Mesoscale (10-100 km) oceanographic perturbations in the form of meanders, jets, and eddies dynamically forced by the major current flow can also have profound effects on the physics and biology at large scale systems such as the SEC (e.g., Seki et al., in press) further influencing the distribution of pelagic animals and their vulnerability to fishing gear.

Two prominent geological features may further complicate the flow regime and water column properties in the vicinity of Samoa. Within the American Samoa EEZ and positioned 45 km east of Ta'u Island at 14˚12.9'S 169˚03.5'W is the undersea volcano, Vailulu'u (Fig. 3). The physical presence of the active volcano which rises from the ocean floor at 5000 m to within 590 m of the ocean surface will alter the flow field and like seamounts, may have a strong influence on the adjacent open-ocean food web (see Seki and Polovina 2001). Hydrothermal plume activity in the 2 km wide summit center reportedly influences the adjacent waters at least seven kilometers away from the summit; influence on the upper water column is unknown (Hart et al. 2000). To the immediate southwest of the Samoa Islands is the Tonga Trench (Fig. 3). At 10,800 m deep, the convergent tektonic boundary is one of the two deepest trenches in the world (Francheteau 1983); little is known how the abrupt bathymetry influence the surrounding water circulation.

Objectives

The proposed research will (1) conduct an extensive oceanographic characterization of the pelagic habitat and fishing grounds occupied by the American Samoa longline fishery through the use of satellite oceanographic remote sensing and *in situ* shipboard surveys and (2)

couple the oceanographic assessment with fishery information to develop a functional understanding of the spatial and temporal occupation and movement tendencies of large South Pacific albacore and the role of the environment on longline gear performance and catch. In the latter phase of the project, fishery information will include incorporation of albacore depth distribution and gear performance obtained from commercial longlines instrumented with time-depth-temperature recorders (TDRs) and the set level catch information from the American Samoa fishery logbook program. Products from the study will lead to a better understanding of the pelagic habitat and an improved interpretation of catch rates and patterns, thus providing information necessary to move forward on ecosystem-based fishery management policies and stock assessment efforts.

Specific objectives of the study are (1) to develop a spatial (horizontal and vertical) and temporal (seasonal) oceanographic characterization of the fishing grounds occupied by the American Samoa longline fishery through satellite remote sensing and *in situ* shipboard surveys; (2) to obtain information on the vertical and horizontal distribution patterns of South Pacific albacore and other incidentally caught species through the analysis of catch and catch rates from commercial logbooks, instrumentation of commercial longlines with TDRs, and if available, fish instrumented with popup satellite archival tags (PSATs); (3) to validate satellite remote sensing oceanographic information in this South Pacific region through concurrent *in situ* shipboard data collection; and (4) to provide training on the use of oceanographic tools and the role of oceanography on pelagic fishery resources to American Samoan scientists and resource managers.

Methods

To meet these objectives, a combination satellite remote sensing and shipboard field program would be undertaken to characterize the oceanography of the region frequented by participants of the American Samoa longline fishery and particularly, the waters of the American Samoa EEZ. Because of the likely influence of currents on longline gear and the nature of deep targeting strategy in the fishery, developing an understanding of the subsurface hydrodynamics is critical. So although several satellite oceanographic products including sea surface temperature (SST) and ocean color (chlorophyll) will be examined, sea surface height (SSH) from altimetry will be the principle remote sensing parameter employed. In particular, near real-time altimetry products from the Global Ocean Data Assimilation Experiment (GODAE) which outputs a higher resolution (than single satellite) SSH product blended from the sensors aboard the TOPEX/POSEIDON and ERS satellites, will be employed. Data from the altimeter aboard the recently launched JASON-1 satellite will be phased into the blended product databank as it becomes available. The satellite remotely sensed coverage will allow the examination of the seasonal and interannual dynamics of key features (SEC and eddies) as well as basic physical and biological properties.

Acknowledging that historical attempts to link deep longline fishery catch patterns with surface oceanography (e.g., SST) have resulted with minimal success, developing an ability to

infer subsurface vertical structure of the water column from altimetry will be among the highest priorities in this study. To accomplish this, a 30 day shipboard surveys aboard the NOAA ship *Oscar Elton Sette* will be conducted during each of two years. Sampling will include high resolution CTD casts along transect lines coinciding with preselected satellite overpasses (see Fig. 2). Transect length and sampling resolution will be designed to accommodate time and space scales necessary to address oceanographic mesoscale perturbations as well as logistical constraints of the field program. Since dissolved oxygen concentration (DO_2) is one of the key water properties identified that influences vertical distribution of tunas (Sund et al. 1981, Brill 1994), DO_2 will be measured in *situ* with a CTD-mounted DO_2 sensor and calibrated against independent DO_2 determinations from discrete depth water collections taken with a CTD-rosette sampler. Standard biological sampling will also include chloropigment profiles from CTD-mounted determinations and discrete depth water sampling for extracted pigment and inorganic macronutrient determinations. Information currents and current shear will be measured with continuous data acquisition from a vessel-mounted 150 kHz acoustic Doppler current profiler (ADCP). The shipboard surveys will thus enable the collection of some much needed data to ground truth satellite remote sensing oceanographic information in this South Pacific region and provide a good opportunity to provide training on the use of oceanographic tools and the role of oceanography on pelagic fishery resources to American Samoa scientists and resource managers, who will be encouraged to participate in the surveys as members of the scientific party.

Information regarding albacore distribution and longline performance will be extracted from several sources. These include: (1) set level fish catch and assemblage patterns obtained from commercial longline logbooks made available through the Western Pacific Fisheries Information Network (WPacFIN), (2) high resolution instrumentation of commercial longlines in the American Samoa fishery with TDRs (e.g., up to 8 TDRs section^{-1}) to obtain high detailed profiles of fished depths (and capture depths when applicable), and (3) possible information on vertical distribution and movement of South Pacific albacore made available from other ongoing and proposed studies aiming to instrument an assortment of large pelagics with popup satellite archival tags (PSATs). Past observations, however, regarding the viability of larger albacore taken on deep longlines and recent experience with efforts aimed at instrumenting larger animals with PSATs suggest that instrumenting the longline caught albacore with PSATs will pose a considerable challenge. These biological and fishery data will be merged with the oceanographic assessment to develop a functional understanding of the spatial and temporal occupation and movement tendencies of large South Pacific albacore and to gear characterization and performance in the American Samoa longline fishery.

Literature Cited

Boggs, C. H. 1992. Depth, capture times, and hooked longevity of longline-caught pelagic fish: timing bites of fish with chips. Fish. Bull., U.S. 90:642-658.

Brill, R. W. 1994. A review of temperature and oxygen tolerance studies of tunas pertinent to fisheries oceanography, movement models and stock assessments. Fish. Oceanogr. 3:204-216.

Collette, B. B., and C. E. Nauen. 1983. FAO Species Catalogue, Vol. 2, Scombrids of the world. FAO Fish. Synop. 2(125):137 p.

DMWR. 2002. American Samoa Department of Marine and Wildlife Resources (DMWR) report on the NMFS logbook program for the American Samoa longline fishery, October-December 2001, 6 p.

Francheteau, J. 1983. The oceanic crust. In: The dynamic earth, Scientific American.

Hart, S. R., H. Staudigel, A. A. P. Koppers, J. Blusztajn, E. T. Baker, R. Workman, M. Jackson, E. Hauri, M. Kurz, K. Sims, D. Fornari, A. Saal, and S. Lyons. 2000. Vailulu'u undersea volcano: the new Samoa. Geochem. Geophys. Geosys. 1:2000GC000108.

Lukas, R. 2001. Pacific Ocean equatorial currents. IN J. H. Steele et al. (editors), Encyclopedia of Ocean Sciences 4:2069-2076, Academic Press, San Diego, California.

Mizuno, K., M. Okazaki, H. Nakano, and H. Okamura. 1997. Estimation of underwater shape of tuna longline by using micro-BTs. Bull. Nat. Res. Inst. Far Seas Fish., 34:1-24.

Nakano, H., M. Okazaki, and H. Okamoto. 1997. Analysis of catch depth by species for tuna longline fishery based on catch by branch lines. Bull. Nat. Res. Inst. Far Seas Fish. 34:43-62.

Saito, S. 1973. Studies on fishing of albacore, *Thunnus alalunga* (Bonnaterre) by experimental deep-sea tuna longline. Mem. Fac. Fish., Hokkaido Univ. 21:107-184.

Seki, M. P., and J. J. Polovina. 2001. Ocean gyre ecosystems. IN J. H. Steele et al. (editors), Encyclopedia of Ocean Sciences 4:1959-1965, Academic Press, San Diego, California.

Seki, M. P., J. J. Polovina, D. R. Kobayashi, R. R. Bidigare, and G. T. Mitchum. In press. An oceanographic characterization of swordfish longline fishing grounds in the Subtropical North Pacific. Fish. Oceanogr

Sund, P. N., M. Blackburn, and F. Williams. 1981. Tunas and their environment in the Pacific Ocean: a review. Oceanogr. Mar. Biol. Ann. Rev. 19:443-512.

WPRFMC. 2001. Pelagic fisheries of the Western Pacific region. 1999 annual report. Western Pacific Regional Fisheries Management Council.

Yamanaka, H. 1956. Vertical structure of the ocean and albacore fishing conditions in the vicinity of 10˚S in the western South Pacific. Bull. Jap. Soc. Sci. Fish. 21:1187-1193.

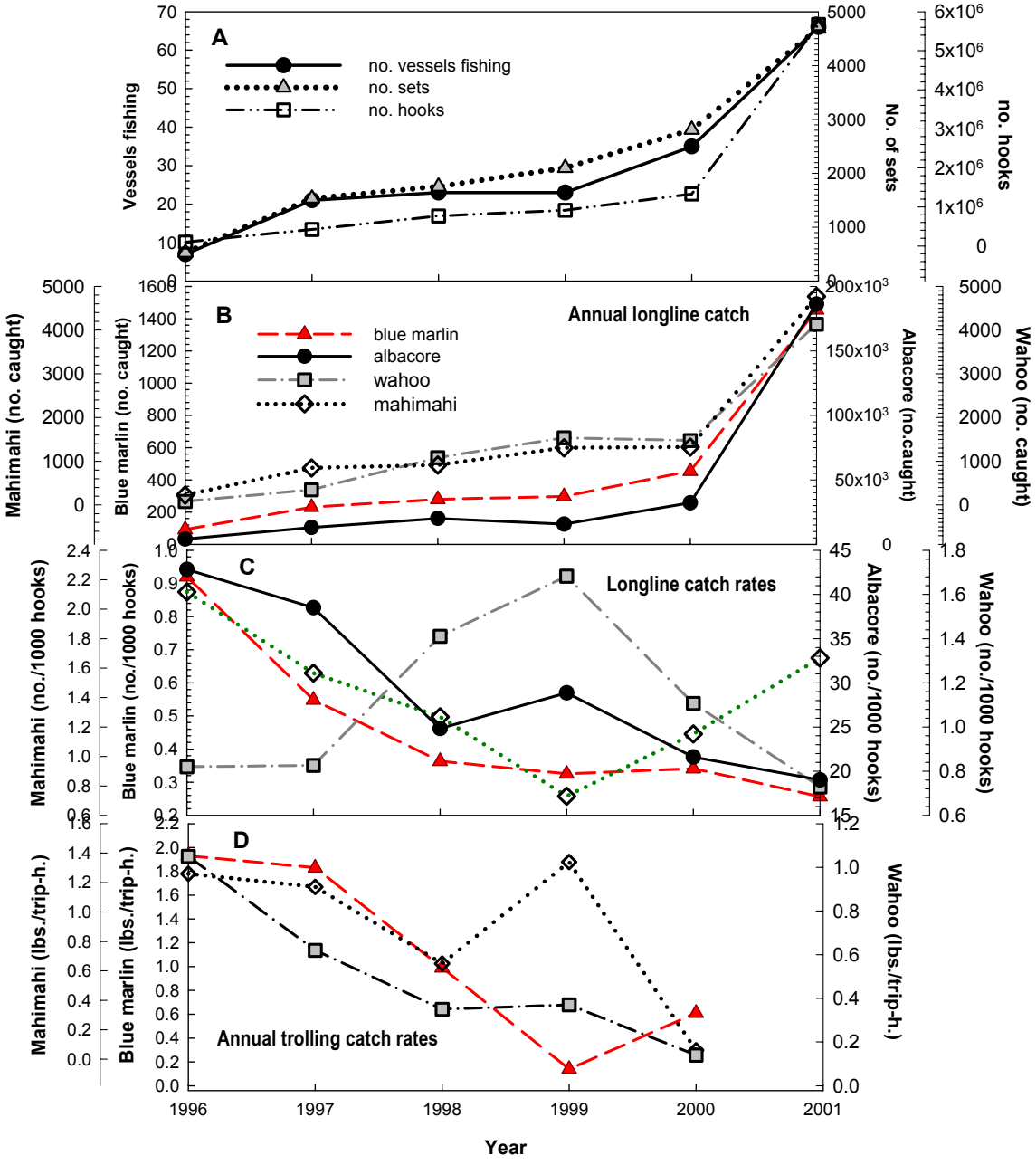

Figure 1. Annual fishing statistics for the American Samoa longline fishery, 1996-2001: (A) total number of vessels fishing, longline sets made, and the number hooks set; (B) number caught; (C) longline catch rates; and (D) trolling catch rates of selected pelagic species.

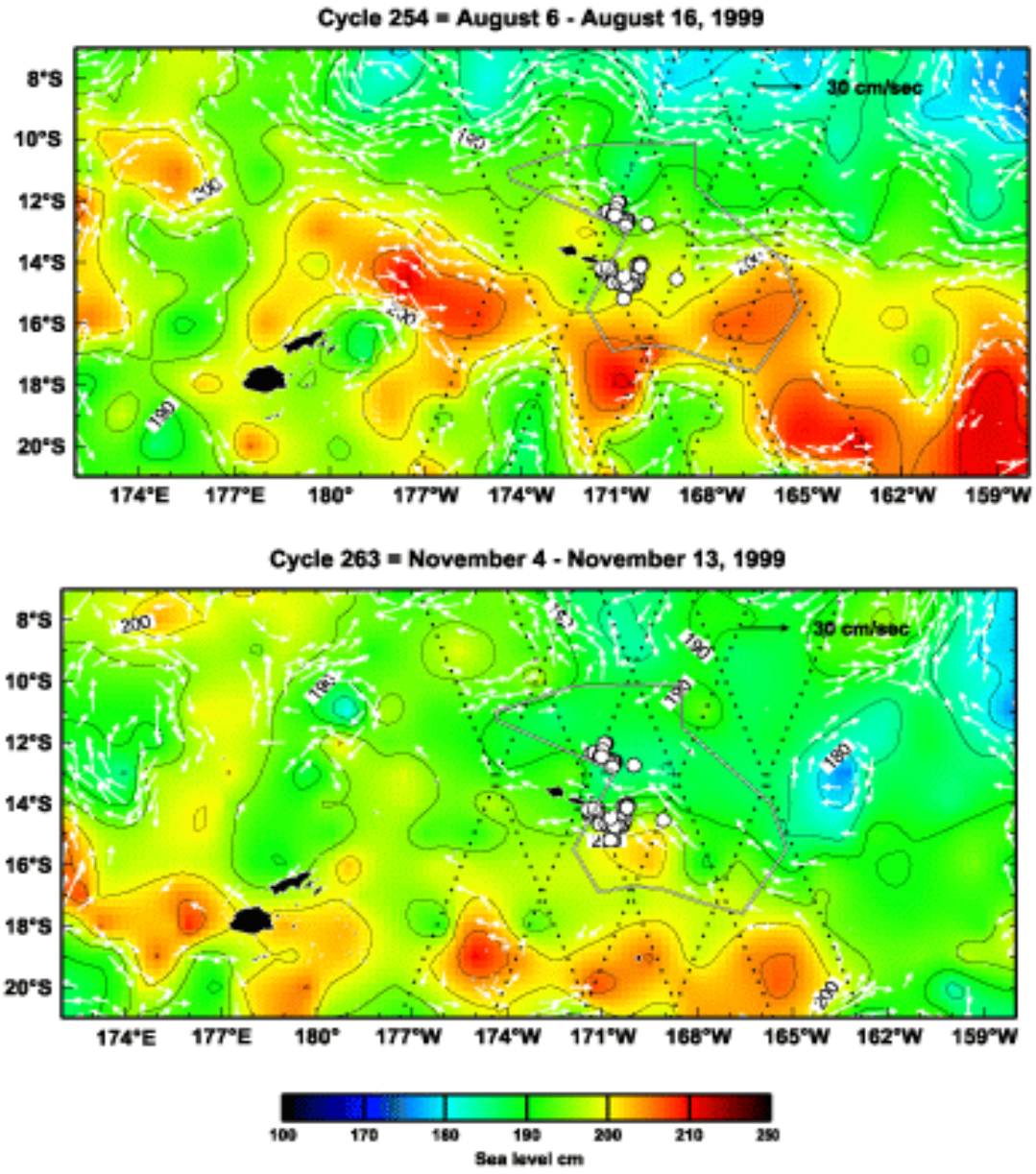

Figure 2. Map of sea level height (with the Levitus long term mean dynamic height at 1000 m added) from the altimeter aboard TOPEX/POSEIDON for (a) cycle 254, 6-16 August 1999 and (b) cycle 263, 4-13 November 1999. Color shading and 5 cm contours represent altimetry gridded at 0.1° resolution and a smoothing radius of 6.5°. Corresponding geostrophic current velocities (vectors) are presented for 0.5° spatial resolution; only velocities >30 cm sec-1 are shown. Dotted lines designate passover paths for altimeter carrying satellites JASON -1 and TOPEX/POSEIDON. White circles designate location of longline sets for the one month period centered on the cycle dates. The highlighted polygon depicts the Exclusive Economic Zone around American Samoa

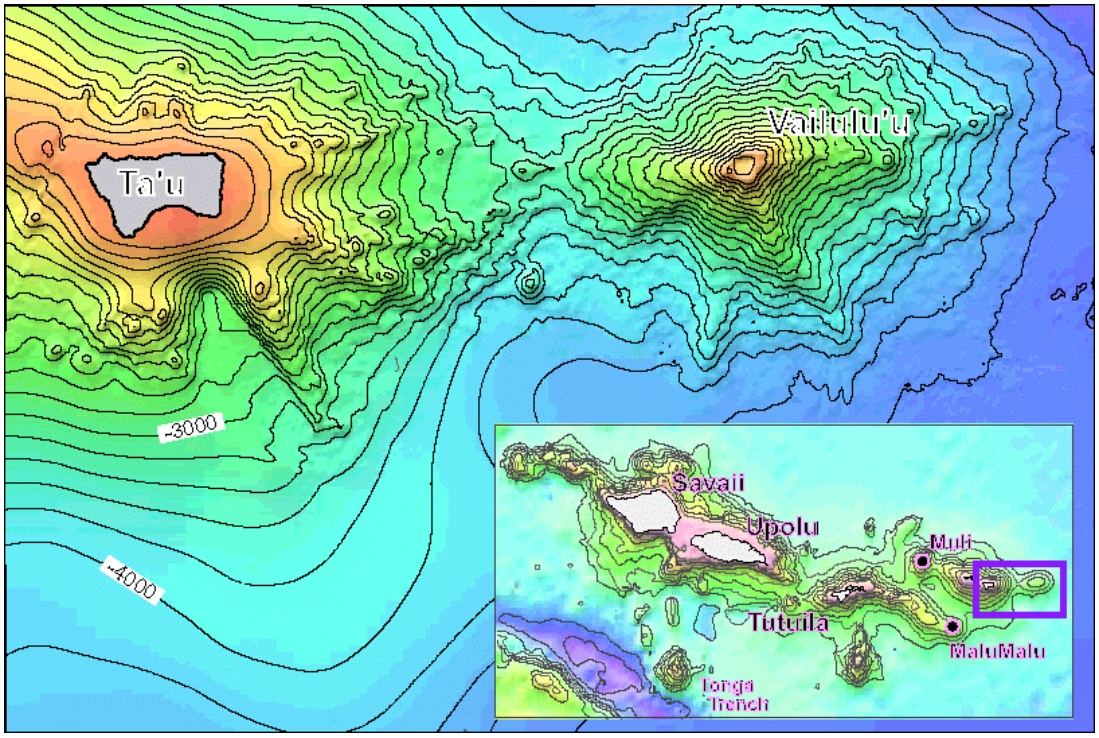

Figure 3. Bathymetry of Vailulu'u and nearby Ta'u Island. The inset depicts the location of the undersea volcano and the Tonga Trench in relation to the Samoa Archipelago (from Hart et al., 2000).