Annual Report: Fall 2018 Bottomfish Fishery-independent Survey in Hawai‘i (BFISH)

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Executive Summary

The Bottomfish Fishery-Independent Survey in Hawai‘i (BFISH) is designed to provide estimates of population abundance and biomass of the main Hawaiian islands Deep 7 bottomfish complex that complement and enhance the stock assessment process at the Pacific Islands Fisheries Science Center (PIFSC).

The 2018 BFISH survey, comprising 461 primary sampling units (PSU), was conducted from August to November at depths ranging from 75 to 400 m across the eight main Hawaiian Islands. Sampling operations included cooperative research fishing as well as the MOUSS camera system.

Kalekale was most abundant, followed by ōpakapaka and ehu. Opakapaka had the highest exploited stock biomass followed by kalekale and ehu. Estimated biomass of ōpakapaka and onaga was approximately 1.529 and 0.422 million kg, respectively. Ehu stock biomass was about 0.654 million kg. Coefficients of variation (CV%) for exploited stock biomass ranged from 26.26 to 29.14 for ehu and ōpakapaka, the two main design species.

To improve BFISH precision, future research will focus on (1) refining PSU classification with respect to habitat characteristics (e.g. seafloor hardness and complexity); (2) targeted allocation that better reflects the depth preferences of the design species; and (3) technological innovations that better define the unit sampled area.

Introduction

Commercial and recreational fishing are important to the economy and culture of Hawai‘i (Haight et al. 1993). The Hawaiian deep-slope (100–400 m) fishery consists of seven high value bottomfish species (i.e., six snappers and one grouper), hereafter referred to as Deep 7 (Figure 1) (Western Pacific Regional Fishery Management Council 2010) and accounts for more than 50% of the total insular commercial catch (Western Pacific Regional Fishery Management Council 2010).

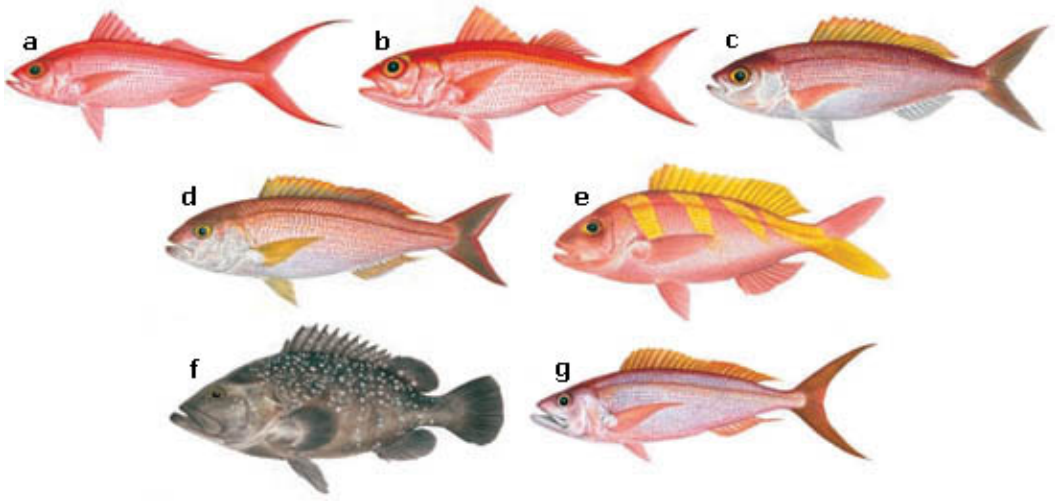

Figure 1. The main Hawaiian Islands "Deep 7" bottomfish complex: (A) Onaga (*Etelis coruscans*), (B) Ehu (*Etelis carbunculus*), (C) Kalekale (*Pristipomoides sieboldii*), (D) Opakapaka (*Pristipomoides filamentosus*), (E) Gindai (*Pristipomoides zonatus*), (F) Hapu‘upu‘u (*Hyporthodus quernus*), and (G) Lehi (*Aphareus rutilans*). Artwork by Les Hata (Hawai‘i DAR/DLNR).

Under the Magnuson-Stevens Fishery Conservation and Management Act (United States Congress, 2007) the National Oceanic and Atmospheric Administration's (NOAA) Pacific Islands Fisheries Science Center (PIFSC) is responsible for conducting formal stock assessments of the Deep 7 complex. These assessments are used to determine stock status and by the Western Pacific Regional Fishery Management Council (WPRFMC) to recommend annual commercial fishery catch limits.

The stock assessment process requires reliable time-series of catches, fishing effort, and life history demographics to estimate stock abundance trends and evaluate sustainability benchmarks (Quinn and Deriso 1999). Until recently, the stock assessment for the main Hawaiian Islands Deep 7 bottomfish complex (Brodziak et al. 2014) relied on trends in fishery-dependent catch per unit effort (CPUE). However, fishery-dependent CPUE can be biased when used as an abundance index due to nonrandom spatiotemporal effort distribution of the fishery, imposed length and catch limits, variable gear types, market forces, and fisher behavior (Hilborn and Walters 1992; Maunder and Punt 2004; Ault et al. 2014).

In its efforts to continually improve data used in the Deep 7 stock assessment, PIFSC has implemented a multi-gear, Bottomfish Fishery-Independent Survey in Hawai‘i (BFISH)

(Richards et al. 2016). Key advantages of fishery-independent surveys are that they employ a formal experimental design, tend to be less influenced by market forces, and obtain similar abundance-at-length data for estimating population indices as fishery-dependent catch sampling programs but with greater statistical rigor (Ault et al. 1999; Smith et al. 2011). Such surveys can also be designed to estimate absolute rather than relative population abundance, providing an important independent estimate of stock abundance for assessment models.

Development and implementation of this survey has been a priority since a series of workshops was convened in 2001–2005 to evaluate existing bottomfish stock assessment methodologies (Mace et al. 2001; Ralston et al. 2004). The BFISH survey was developed through a series of gear trials and calibration studies conducted in the Maui-Nui island region from 2001 through 2015 (Richards et al. 2016). The survey became operational in 2016 and resulting data, including estimates of absolute abundance and biomass (Ault et al. 2018), were incorporated into the 2018 stock assessment for the main Hawaiian islands Deep 7 bottomfish complex (Langseth et al. 2018).

In this report, we present results from the fall 2018 BFISH survey (i.e. BFISH_2018_F).

Methods

The fall 2018 BFISH was conducted throughout the eight main Hawaiian islands using two gear types (i.e. research fishing and MOUSS camera) following the stratified-random experimental design methodology laid out by Richards et al. (2016).

The survey domain encompassed the full extent of mapped bottomfish habitats from 75 to 400 m depths, extending from the island of Hawai‘i 600 km northwest to the island of Ni‘ihau. The survey frame was divided into 500 × 500 m primary sample units (PSU) stratified according to three depth categories (75 to <200 m; 200 to <300 m; 300 to 400 m), and three substrate composition-complexity categories (softbottom-all slopes, hardbottom-low slope, hardbottom-high slope) (Figure 2, Table 1). Analyses of pilot experiments conducted in the Maui- Nui region during 2011–2015 showed that this stratification scheme effectively spatially partitioned the variance of Deep 7 species density (Richards et al. 2016). Samples were allocated among strata following a Neyman scheme (Cochran 1977), and sample units within strata were randomly selected without replacement from a discrete uniform probability distribution to ensure equal probability of selection (Law and Kelton 2000). The “effective survey sample size” represents the number PSUs sampled within the depth range for a given species. Survey mapping and site selection were conducted using ArcGIS (ESRI Inc. 2017) and R (R Development Core Team 2017) software packages.

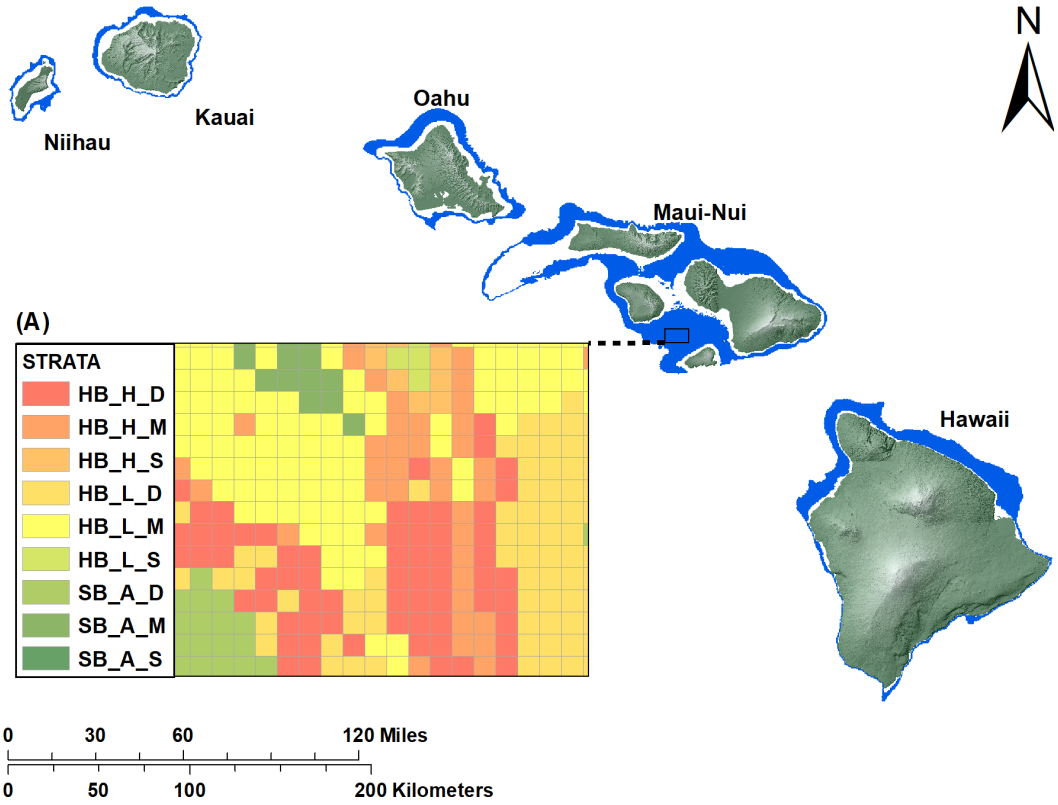

Figure 2. The spatial frame of the Deep 7 bottomfish survey domain (blue shaded region) extending from Niʻihau in the northwest to the island of Hawaiʻi in the southeast. Inset shows a section of the survey frame in the Maui-Nui region (islands of Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe) showing the 500 × 500 m mapped grid cells classified by habitat-depth strata. Definitions of substrate-slope-depth strata in panel (A) are given in Table 1.

Table 1. Number (n) of mapped 500 × 500 m primary sampling units (PSU) by substrate-slope-depth strata within the main Hawaiian Islands BFISH sampling domain.

Substrate	Slope	Depth	Strata Code	n
SB (Softbottom)	A (high & low)	Shallow (s, 75 to < 200 m)	SB_A_S	1,863
HB (Hardbottom)	L (low slope)	Shallow	HB_L_S	4,562
HB	H (high slope)	Shallow	HB_H_S	4,777
SB	A	Medium (M, 200 to < 300 m)	SB_A_M	1,449
HB	L	Medium	HB_L_M	2,688
HB	H	Medium	HB_H_M	2,412
SB	A	Deep (D, 300 to 400 m)	SB_A_D	1,591
HB	L	Deep	HB_L_D	3,801
HB	H	Deep	HB_H_D	2,749
			TOTAL PSU	**25,892**

At each selected PSU within each stratum, species-specific number and length composition were obtained using one of two principal survey gears: (1) research fishing; or (2) stationary MOUSS stereo-video cameras (Richards et al. 2016). A standard research fishing sample was 30 minutes of active hook-line fishing within a PSU by one vessel using two lines, each with four hooks and two bait types (i.e., squid and fish). Each captured fish was identified to species and fork length was measured to the nearest centimeter. For cameras, two replicate, randomized, 15-min

deployments were conducted within each PSU. In-situ footage was analyzed to generate species-level counts by the MaxN method (Cappo et al. 2006) and to measure fork lengths to the nearest millimeter. Replicate counts were averaged for a given sample unit.

Gears were allocated to each PSU based on a combination of logistical constraints as well as gear-specific depth and regulatory restrictions. The MOUSS camera system has a depth limit of approximately 250 m (Amin et al. 2017). While research fishing operations are permitted within the State of Hawai‘i Bottomfish Restricted Fishing Areas (BRFAs), cameras were preferentially allocated to PSU within BRFA. The relative fishing power method of Robson (1961) was used to convert species counts for the hook-line gear to camera species counts based on comparative gear experiments (Richards et al. 2016).

Estimation of Deep 7 population metrics followed standard procedures for stratified random sampling (Cochran 1977; Ault et al. 1999; Lohr 2010; Smith et al. 2011; Ault et al. 2018). The number of fish per sample unit was the principal metric used to develop the statistical sampling design. Estimation of total population biomass B entailed expanding the mean biomass per unit $\overline{U}_B$ to the full survey frame following (Ault et al. 2018),

$$B = \overline{U}_B \frac{A_i}{a_i} G$$

where, A_i is the area of a grid cell sample unit, a_i is the effective sampling area of the camera gear, and G is the number of grid cells in the survey domain. Mean biomass per sample unit was obtained by converting length to weight of each individual fish via an allometric weight-length function and then summing the weights for all observed fish by species. Allometric functions were developed for each Deep 7 species using paired weight-length observations collected in the Hawaiian Islands by scientists at the PIFSC. All computations were carried out using the R software package (R Development Core Team 2017).

Results

This BFISH survey, comprising 461 primary sampling units (PSUs), was conducted in the fall of 2018 (Table 2, 3). Research fishing operations by the Pacific Islands Fisheries Group (PIFG) extended from August 18 to November 26, 2018, at 330 PSUs spanning the island of Hawai‘i to the island of Ni‘ihau (Figure 3, Appendix A). Camera operations by PIFSC scientists extended from September 18 to November 27, 2018, at 153 PSU using the NOAA Ship *Oscar Elton Sette* and associated small boats (Figure 3). Twenty-two (22) PSUs were sampled using both gears.

Table 2. Number of sampled primary sampling units (PSUs) by gear type.

Gear	No. of PSUs
Camera	131
Fishing	308
Fishing & Camera	22
TOTAL	**461**

Table 3. Number of sampled primary sampling units (PSUs) by strata.

Strata Description	Strata Code	No. of PSU	% of Total
Hardbottom, High Slope, Deep	HB_H_D	38	8
Hardbottom, High Slope, Medium	HB_H_M	108	23
Hardbottom, High Slope, Shallow	HB_H_S	139	30
Hardbottom, Low Slope, Deep	HB_L_D	34	7
Hardbottom, Low Slope, Medium	HB_L_M	72	16
Hardbottom, Low Slope, Shallow	HB_L_S	24	5
Softbottom, All Slopes, Deep	SB_A_D	8	2
Softbottom, All Slopes, Medium	SB_A_M	9	2
Softbottom, All Slopes, Shallow	SB_A_S	29	6
	TOTAL	**461**	

During the 2018 BFISH a total of 395 fishes were caught during research fishing operations; those included 194 Deep 7 individuals (Table 4). Ehu made up the majority of the Deep 7 catch (n = 86), followed by kalekale (38), and ōpakapaka (30).

All Deep 7 individuals were retained for subsequent study of age, growth, and maturity by the PIFSC Fisheries Research and Monitoring Division (FRMD) Life History Program (LHP). In addition, PIFSC LHP fishers collected 30 ōpakapaka, 4 ehu, and 1 lehi. The single lehi represented the only individual of that species caught during BFSIH_2018_F fishing operations.

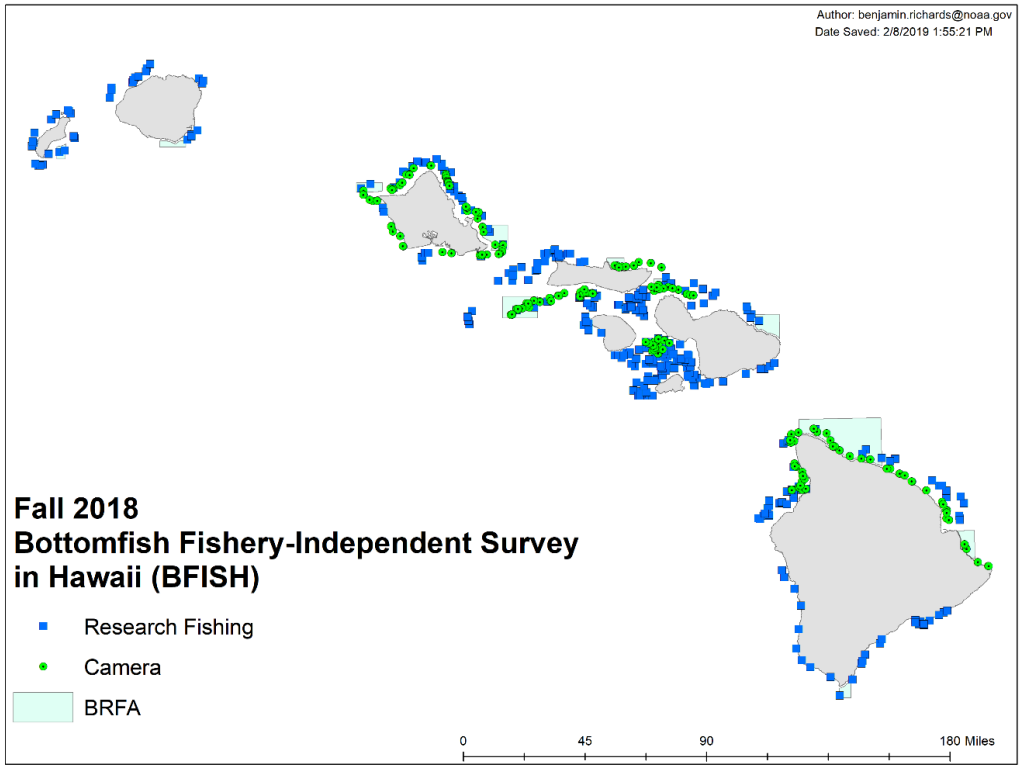

Figure 3. Map showing BFISH sampling locations by gear type. Research fishing operations (blue squares) that extended from the island of Hawai‘i in the southeast to Ni‘ihau in the northwest. Camera operations (green dots) extended from the northern half of the big island of Hawai‘i to O‘ahu.

Table 4. Number (n) of individual fish (Deep 7 and other species) caught during BFISH_2018_F research fishing operations. List represents all species caught over all survey years.

	Species Code	Common Name	Scientific Name	n	
Deep 7	ETCA	**Ehu**	Etelis carbunculus	86	**194**
	PRFI	**Ōpakapaka**	*Pristipomoides filamentosus*	30	
	PRSI	**Kalekale**	*Pristipomoides sieboldii*	38	
	ETCO	**Onaga**	*Etelis coruscans*	15	
	PRZO	**Gindai**	*Pristipomoides zonatus*	15	
	HYQU	**Hapuʻupuʻu**	*Hyporthodus quernus*	10	
	APRU	**Lehi**	*Aphareus rutilans*	0	
Other Species	SQSP	Green Eye Shark	*Squalus sp.*	84	**201**
	SEDU	Kahala	*Seriola dumerili*	51	
	LUKA	Ta'ape	*Lutjanus kasmira*	14	
	CAOR	Yellow spot Papio	*Carangoides orthogrammus*	11	
	POBE	Deep Sea Moi	*Polymixia berndti*	6	
	CAAM	Grey Reef Shark	*Carcharhinus amblyrhynchos*	6	
	MUPF	Weke ula	*Mulloidichthys pfluegeri*	5	
	POMA	Hogo	*Pontinus macrocephalus*	3	
	APVI	Uku	*Aprion virescens*	3	
	BOAL	Table Boss	*Bodianus albotaeniatus*	3	
	SERI	Almaco Jack	*Seriola rivoliana*	2	
	TRMY	Lizardfish	*Trachinocephalus myops*	2	
	PUFF	Pufferfish	*Tetraodontid sp.*	2	
	XACA	Blue lined triggerfish	*Xanthichthys caeruleolineatus*	1	
	SARD	Kitsune	*Sarda sp.*	1	
	PSDE	Butaguchi	*Pseudocaranx cheilio*	1	
	MYSP	Soldierfish	*Myripristis sp.*	1	
	EESP	Puhi	*Anguilliformes sp.*	1	
	COJA	Deep Sea Aweoweo	*Cookeolus japonicus*	1	
	CAME	Omilu	*Caranx melampygus*	1	
	THAL	Yellowfin Tuna	*Thunnus albacares*	1	
	SPHE	Kawelea	*Sphyraena helleri*	1	
	TRIG	Triggerfish	*Balistidae*	0	
	SEDU	Amberjack	*Seriola dumerili*	0	
	NAHE	Opelu Kala	*Naso hexacanthus*	0	
	INPA	Nabeta	*Iniistius pavo*	0	
	FISH	Unknown	*Teleost sp.*	0	
	EUIL	Monchong	*Eumegistus illustris*	0	
	EUAF	Kawakawa	*Euthynnus affinis*	0	
	ERSC	Golden kale	*Erythrocles scintillans*	0	
	CALU	Gunkan Ulua	*Caranx lugubris*	0	
	CAEQ	Whitefin trevally	*Carangoides equula*	0	
	ARBR	Shortfin Ariomma	*Ariomma brevimanus*	0	
	APFU	Wahanui	*Aphareus furca*	0	
	ALSP	Thresher Shark	*Alopias sp.*	0	
	AKUU	Aku	*Katsuwonus pelamis*	0	

Table 5. Number (n) and size (cm FL) of Deep 7 species caught during research fishing operations or observed (MaxN) by MOUSS camera during BFISH_2018_F.

	RESEARCH FISHING					MOUSS CAMERA					
		Fork Length (cm)						Fork Length (cm)			
Species	**n**	**Min**	**Mean**	**Max**	**SD**	**MaxN**	**measured**	**Min**	**Mean**	**Max**	**SD**
Ehu	86	24.0	38.5	53.0	7.1	34	10	31.9	41.0	50.5	5.5
Gindai	15	20.0	32.9	43.0	6.9	1	0	-	-	-	-
Hapuʻupuʻu	10	45.5	62.5	84.0	11.0	6	4	41.7	66.8	91.9	22.8
Kalekale	38	17.5	34.3	44.0	6.2	120	34	12.9	32.3	42.2	8.8
Lehi	0	-	-	-	-	37	8	50.4	60.1	67.6	5.9
Onaga	15	20.0	51.8	78.0	16.4	15	3	42.5	48.5	60.2	10.1
Opakapaka	30	23.5	39.7	77.0	12.8	253	96	11.0	41.6	70.4	17.5
TOTAL Deep 7	**194**					**466**	**155**				

A total of 466 Deep 7 individuals were observed by the MOUSS camera system (Table 5). Ōpakapaka were the most abundant (n = 253), followed by kalekale (n = 120) and lehi (n = 37). Accurate length measurements were obtainable for 155 of the 466 fishes captured (33%). Only a single gindai was observed, but a length measurement was not obtainable.

Coefficients of variation (CV%) for exploited stock biomass ranged from 26.26 to 29.14 for ehu and ōpakapaka, the two main design species. Except for kalekale, survey performance was reduced for all other species, due to low occurrence.

Kalekale was most abundant, followed by ōpakapaka and ehu (Table 6). Opakapaka showed the highest exploited stock biomass followed by kalekale and ehu. Estimated biomass of ōpakapaka and onaga, was approximately 1.529 and 0.422 million kg, respectively. Ehu stock biomass was about 0.654 million kg.

Table 6. BFISH_2018_F descriptive statistics, catch per unit effort (CPUE), and estimated exploited stock abundance and biomass by species.

Species	CPUE	SE	Abundance	SE	Biomass (kg)	SE	CV (%)
Ehu	0.2077	0.0545	561,726	147,495.9	653,564.7	189,002.6	26.3
Gindai	0.0111	0.0046	29,917	12,508.2	36,967.7	13,594.1	41.8
Hapuʻupuʻu	0.0189	0.0079	51,025	21,412.6	261,783.6	106,572.0	42.0
Kalekale	0.2701	0.0694	730,400	187,713.8	705,858.6	173,621.2	25.7
Lehi	0.0168	0.0128	45,498	34,522.6	141,127.1	107,078.3	75.9
Onaga	0.0621	0.0227	167,941	61,318.2	422,101.9	178,842.2	36.5
Ōpakapaka	0.2396	0.0698	647,859	188,760.2	1,529,479.6	415,792.4	29.1
TOTAL					**3,750,883**	**541,980**	

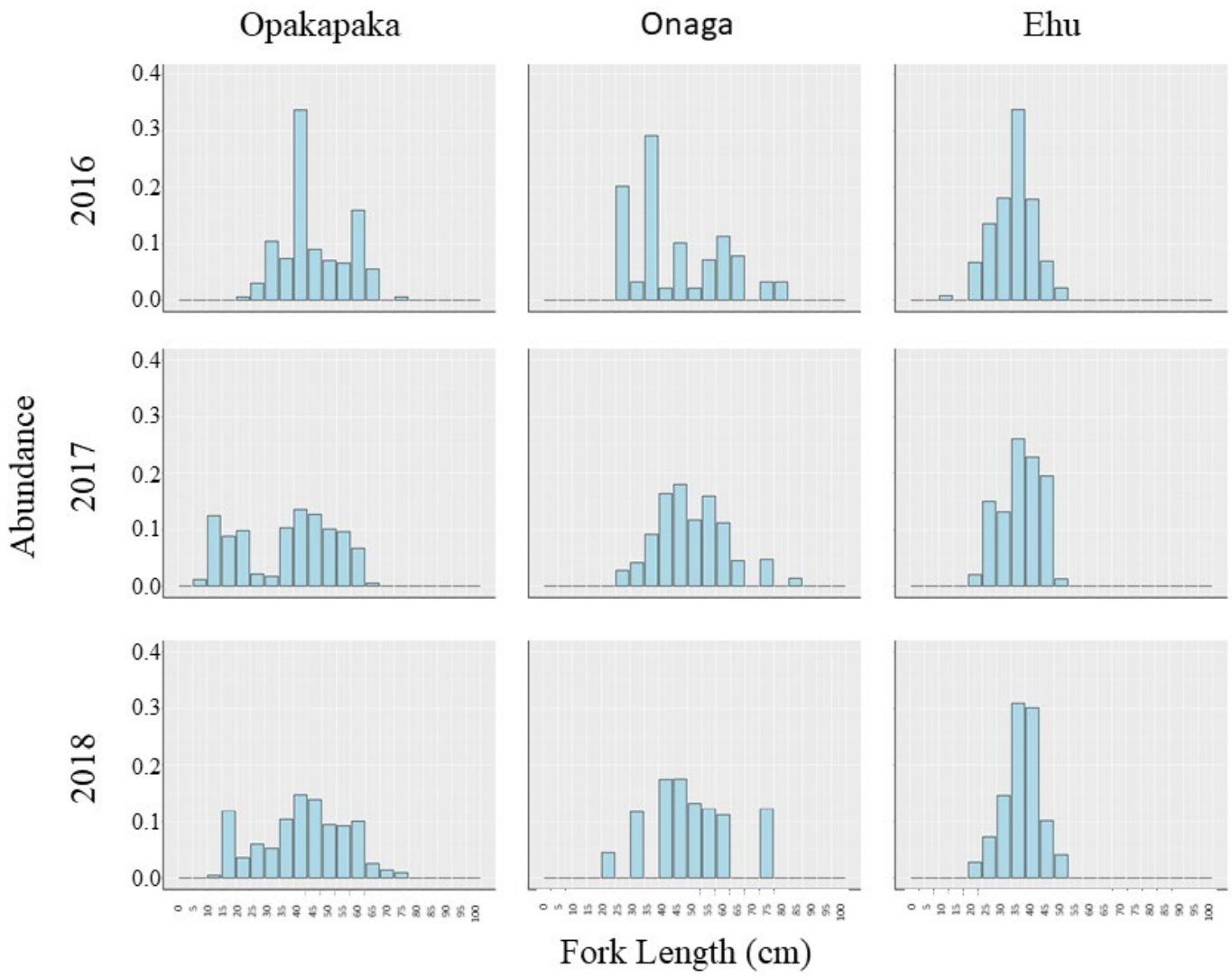

Figure 4. Length frequencies for ōpakapaka, onaga, and ehu during Fall 2016–2018 BFISH surveys.

Population abundance and size-frequency for the three design species are shown in Figure 4. The fall 2018 BFISH showed similar size distributions to those from 2017. Opakapaka size distribution from 2018 shows smaller individuals as compared to 2016 and larger individuals compared to 2017. Onaga size distribution from 2018 shows smaller individuals than all other years.

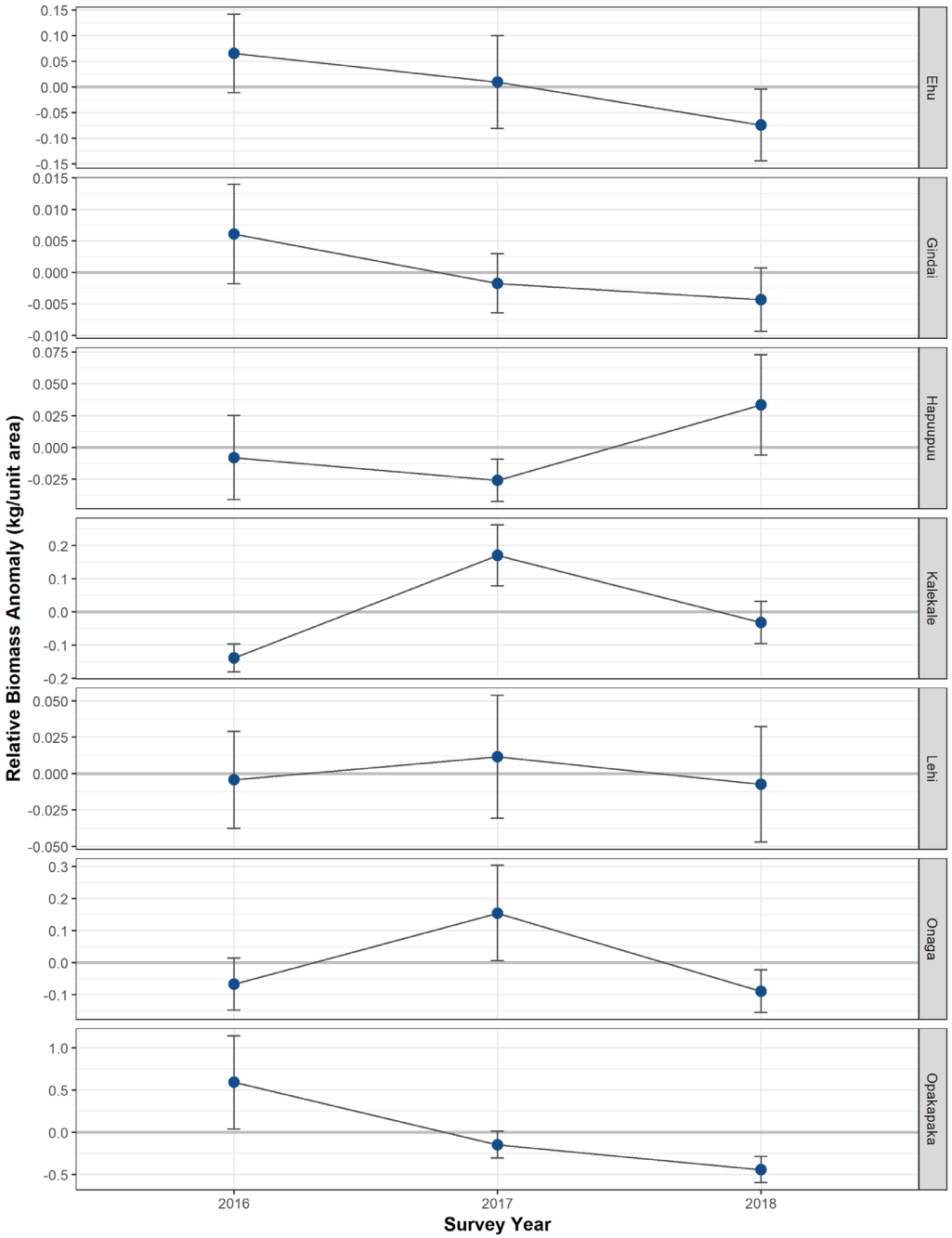

Figure 5. Deep 7 relative biomass (kg) anomalies by species. Values represent deviation from 3-year moving average (solid horizontal line). Data from fall Bottomfish Fishery-Independent Surveys in Hawai‘i. Year-to-year differences are of low magnitude and marginal, if any, significance.

Trends in exploited stock biomass (Figure 5) reflect the trends in population abundance. None of the trends observed are statistically significant.

Survey precision has ranged from 15% to 30% (CV) among survey years for ōpakapaka and ehu, with relatively consistent sampling effort (Figure 6). The effective survey sample size by species has remained similar across years. The disparity between survey performance and the Neyman curve indicates suboptimal sample allocation among strata in most years.

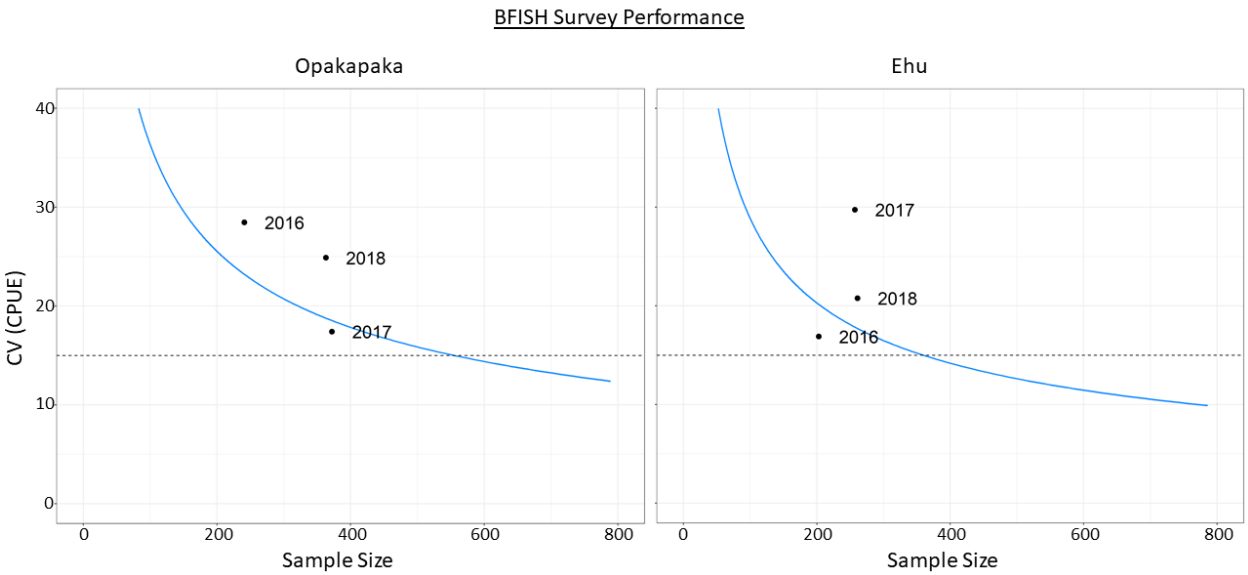

Figure 6. Survey performance (CV of population biomass) dependent on effective sample size by survey year as compared to Neyman (optimal) allocation (blue line): opakapaka (left panel) and ehu (right panel).

Discussion

In 2011 the PIFSC began development of the collaborative multi-gear Bottomfish Fishery-Independent Survey in Hawai‘i (BFISH) among PIFSC scientists and local commercial cooperative research fishers (Richards et al. 2016). The goal of BFISH is to provide reliable fishery-independent bottomfish abundance and biomass estimates for use in Deep 7 bottomfish stock assessments (Ault et al. 2018; Langseth et al. 2018). BFISH became operational and began generating bottomfish population metrics in 2016.

Estimated exploited stock biomass for the Deep 7 complex in 2018 was 3,750,883 kg (8.27 million lb). The annual catch limit was 492,000 lb or about 6% of the exploited stock. While there has been some fluctuation in Deep 7 biomass over the 3 survey years (2016–2018), observed differences in estimated biomass of the principal fishery targets (ōpakapaka and onaga) have been of low magnitude and were rarely significant (**Error! Reference source not found.**). Upon review, the markedly higher biomass for ōpakapaka in 2016 was inflated by two instances in which ōpakapaka were caught by research fishers in softbottom, low-relief habitats. Because of the prevalence of this habitat type within the survey domain, these instances had a substantial effect on our domain-level estimates.

The experimental design for BFISH focuses on ōpakapaka and ehu with a goal of achieving a coefficient of variation (CV) of 15%. Since 2016, survey performance has ranged from 16% to 30% CV for ōpakapaka and ehu.

High CVs in relation to the Neyman curve are indicative of suboptimal sample allocation. The high CVs seen in BFISH surveys to-date are likely due to continued uncertainty in the benthic habitat maps that inform survey stratification, as well as suboptimal allocation with respect to the depth preferences of the species.

To improve BFISH precision, future research will focus on (1) refining PSU classification with respect to habitat characteristics (e.g. seafloor hardness and complexity); (2) targeted allocation, that better reflects the depth preferences of the design species; and (3) technological innovations that better define the unit-sampled area.

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Literature Cited

Amin R, Richards BL, Misa WFXE, Taylor JC, Miller DR, Rollo A, Demarke C, Singh H, Young GC, Childress J, et al. 2017. The Modular Optical Underwater Survey System. Sensors. 17:1–14. doi:10.3390/s17102309.

Ault JS, Diaz GA, Smith SG, Luo J, Serafy JE. 1999. An Efficient Sampling Survey Design to Estimate Pink Shrimp Population Abundance in Biscayne Bay, Florida. North American Journal of Fisheries Management. 19:696–712. doi:10.1577/1548-8675(1999)019<0696:AESSDT>2.0.CO;2.

Ault JS, Smith SG, Browder JA, Nuttle W, Franklin EC, Luo J, DiNardo GT, Bohnsack JA. 2014. Indicators for assessing the ecological dynamics and sustainability of southern Florida's coral reef and coastal fisheries. Ecological Indicators. 44:164–172.

Ault JS, Smith SG, Richards BL, Yau AJ, Langseth BJ, O'Malley JM, Boggs CH, Seki MP, DiNardo GT. 2018. Towards fishery-independent biomass estimation for Hawaiian Islands deepwater snappers. Fisheries Research. 208:321–328. doi:10.1016/j.fishres.2018.08.012.

Brodziak J, Yau A, O'Malley J, Andrews A, Humphreys R, DeMartini E, Pan M, Parke M, Fletcher E. 2014. Stock Assessment Update for the Main Hawaiian Islands Deep7 Bottomfish Complex Through 2013 With projected Annual Catch Limits Through 2016. PIFSC Administrative Report. NMFS-PIFSC-42. doi:10.7289/V5T151M8.

Cappo M, Harvey ES, Shortis MR. 2006. Counting and measuring fish with baited video techniques -- an overview. In: Cutting-Edge Technologies in Fish and Fisheries Science. (Australian Society for Fish Biology). p. 101–114.

Cochran WG. 1977. Sampling Techniques. NY, NY: John Wiley and Sons.

ESRI Inc. 2017. ArcGIS Desktop. ESRI Inc. http://www.esri.com.

Haight WR, Kobayashi DR, Kawamoto KE. 1993. Biology and management of deepwater snappers of the Hawaiian Archipelago. Marine Fisheries Review. 55:20–27.

Hilborn R, Walters CJ. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Boston/Dordrecht/London: Kluwer Academic Publishers (books.google.com).

Langseth B, Syslo J, Yau A, Kapur M, Brodziak, Jon K. T. (Jon Kenton Tarsus). 2018. Stock assessment for the main Hawaiian Islands Deep 7 bottomfish complex in 2018, with catch projections through 2022. Honolulu, HI Report No.: NMFS-PIFSC-69. [Accessed 2019 Mar 8]. ftp://ftp.library.noaa.gov/noaa_documents.lib/NMFS/PIFSC/TM_NMFS_PIFSC/NOAA_Tech_Memo_PIFSC_69.pdf.

Law AM, Kelton WD. 2000. Building valid, credible, and appropriately detailed simulation models. Simulation Modeling and Analysis 3rd ed Singapore: McGraw-Hill.:264–291.

Lohr SL. 2010. Sampling: design and analysis. Boston: Brooks/Cole.

Mace PM, Bartoo NW, Hollowed AB, Kleiber P, Methot RD, Murawski SA, Powers JE, Scott GP. 2001. Marine Fisheries Stock Assessment Improvement Plan. Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments.

Maunder MN, Punt AE. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research. 70:141–159.

Quinn TJ, Deriso RB. 1999. Quantitative fish dynamics. New York: Oxford University Press. [accessed 2018 Sep 28]. http://public.eblib.com/choice/publicfullrecord.aspx?p=430433.

R Development Core Team. 2017. R: A Language and Environment for Statistical Computing. https://cran.r-project.org.

Ralston S, Cox S, Labelle M, Mees C. 2004. Bottomfish Stock Assessment Workshop - Final Report.

Richards BL, Smith, Steven G., Ault JS, DiNardo GT, Kobayashi DR, Domokos R, Anderson J, Taylor JC, Misa W, Giuseffi L, et al. 2016. Design and implementation of a bottomfish fishery-independent survey in the main Hawaiian Islands. Honolulu, HI Report No.: NMFS-PIFSC-53. doi:10.7289/V5/TM-PIFSC-67.

Robson D. 1961. Estimation of the relative fishing power of individual ships.

Smith SG, Ault JS, Bohnsack JA, Harper DE, Luo J, McClellan DB. 2011. Multispecies survey design for assessing reef-fish stocks, spatially explicit management performance, and ecosystem condition. Fisheries Research. 109:25–41. doi:10.1016/j.fishres.2011.01.012.

Western Pacific Regional Fishery Management Council. 2010. Bottomfish Fisheries in the Hawaii Archipelago.

Appendix: Primary Sampling Units sampled during BFISH_2018_F with Location, Strata, and Gear Allocation

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
24	Hawai‘i Island	HB_H_S	M	18.8621898	-155.6807125	Fishing
271	Hawai‘i Island	HB_H_S	NA	18.9466152	-155.607906	Fishing
305	Hawai‘i Island	HB_H_M	NA	18.9623659	-155.7309095	Fishing
449	Hawai‘i Island	HB_H_D	NA	19.0139723	-155.8437828	Fishing
531	Hawai‘i Island	HB_H_M	NA	19.031355	-155.5539949	Fishing
553	Hawai‘i Island	HB_H_S	NA	19.0447982	-155.5489722	Fishing
559	Hawai‘i Island	HB_H_S	NA	19.0553861	-155.8904651	Fishing
638	Hawai‘i Island	HB_H_M	NA	19.0806154	-155.5339921	Fishing
694	Hawai‘i Island	HB_H_M	NA	19.1191148	-155.9225136	Fishing
795	Hawai‘i Island	HB_H_D	NA	19.1376189	-155.4473483	Fishing
858	Hawai‘i Island	HB_H_S	NA	19.1599851	-155.4373731	Fishing
979	Hawai‘i Island	HB_H_M	NA	19.2226551	-155.9063346	Fishing
1064	Hawai‘i Island	HB_H_D	NA	19.2318733	-155.1983498	Fishing
1082	Hawai‘i Island	HB_H_M	NA	19.2369721	-155.2267274	Fishing
1088	Hawai‘i Island	HB_H_M	NA	19.236382	-155.1982458	Fishing
1130	Hawai‘i Island	HB_H_D	NA	19.246381	-155.2455103	Fishing
1163	Hawai‘i Island	HB_H_M	NA	19.2503024	-155.216923	Fishing
1210	Hawai‘i Island	HB_H_S	NA	19.2537222	-155.1645992	Fishing
1230	Hawai‘i Island	HB_H_S	NA	19.2599079	-155.2452021	Fishing
1366	Hawai‘i Island	HB_H_S	NA	19.2841762	-155.1116371	Fishing
1398	Hawai‘i Island	HB_H_S	NA	19.297091	-155.0828291	Fishing
1420	Hawai‘i Island	HB_H_M	NA	19.305698	-155.0636217	Fishing
1490	Hawai‘i Island	HB_H_S	NA	19.3487502	-155.8896978	Fishing
1704	Hawai‘i Island	HB_H_S	NA	19.4396384	-155.9260315	Fishing
1870	Hawai‘i Island	HB_H_M	NA	19.5037695	-155.9819391	Fishing
1980	Hawai‘i Island	HB_H_S	NA	19.540106	-155.9955469	Fishing
2071	Hawai‘i Island	HB_H_S	NA	19.5393748	-154.8248972	Camera
2164	Hawai‘i Island	HB_H_S	NA	19.563329	-154.8861226	Camera

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
2417	Hawai‘i Island	HB_H_M	L	19.6368445	-154.9461252	Camera
2486	Hawai‘i Island	HB_H_S	L	19.659595	-154.9550738	Camera
3279	Hawai‘i Island	HB_H_S	NA	19.7923319	-155.0422543	Camera
3292	Hawai‘i Island	HB_L_D	NA	19.7909484	-154.9803483	Fishing
3300	Hawai‘i Island	HB_H_D	NA	19.8174014	-156.1143752	Fishing
3356	Hawai‘i Island	HB_H_D	NA	19.8220681	-156.1238306	Fishing
3390	Hawai‘i Island	HB_H_S	NA	19.8016635	-155.0563187	Camera
3406	Hawai‘i Island	HB_L_D	NA	19.7999629	-154.9801216	Fishing
3540	Hawai‘i Island	HB_H_M	NA	19.8351423	-156.0949738	Fishing
3547	Hawai‘i Island	HB_H_S	NA	19.8345953	-156.0615931	Fishing
3586	Hawai‘i Island	HB_L_D	NA	19.813592	-154.9845439	Fishing
3609	Hawai‘i Island	HB_H_S	NA	19.8391077	-156.06151	Fishing
3730	Hawai‘i Island	HB_H_M	NA	19.8485243	-156.0851891	Fishing
3828	Hawai‘i Island	SB_A_S	NA	19.8332173	-155.0555393	Camera
4042	Hawai‘i Island	HB_L_S	NA	19.8467403	-155.0552049	Camera
4140	Hawai‘i Island	HB_L_D	NA	19.8753645	-156.0703844	Fishing
4346	Hawai‘i Island	HB_H_D	NA	19.8887446	-156.0605948	Fishing
4508	Hawai‘i Island	HB_H_S	NA	19.8960851	-155.9602531	Fishing
4528	Hawai‘i Island	HB_L_S	NA	19.8787157	-155.073483	Camera
4570	Hawai‘i Island	HB_H_M	NA	19.901326	-156.003099	Fishing
4626	Hawai‘i Island	HB_H_D	NA	19.8805529	-154.954254	Fishing
4646	Hawai‘i Island	HB_H_S	NA	19.9055963	-155.9887027	Fishing
4747	Hawai‘i Island	SB_A_S	NA	19.8923441	-155.0779146	Camera
4777	Hawai‘i Island	HB_H_D	NA	19.9158191	-156.0600944	Fishing
5032	Hawai‘i Island	HB_H_S	NA	19.9270116	-155.9214824	Fishing
5134	Hawai‘i Island	SB_A_D	NA	19.9143548	-155.0535284	Fishing
5227	Hawai‘i Island	HB_L_D	NA	19.9170429	-154.9723981	Fishing
5249	Hawai‘i Island	HB_H_S	NA	19.940547	-155.9212199	Fishing
5379	Hawai‘i Island	HB_H_S	NA	19.9495707	-155.9210448	Fishing
5577	Hawai‘i Island	HB_L_D	NA	19.9637649	-155.9589574	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
5674	Hawai‘i Island	SB_A_S	NA	19.9529261	-155.1670479	Camera
5698	Hawai‘i Island	HB_L_D	NA	19.9504157	-155.0526315	Fishing
5723	Hawai‘i Island	HB_H_M	NA	19.9722953	-155.9301509	Camera & Fishing
5735	Hawai‘i Island	HB_H_S	NA	19.9712942	-155.8728869	Camera & Fishing
5810	Hawai‘i Island	HB_H_S	NA	19.9753832	-155.8489382	Camera & Fishing
5933	Hawai‘i Island	HB_H_M	NA	19.985165	-155.8917089	Camera
5995	Hawai‘i Island	HB_H_M	NA	19.9896767	-155.8916203	Fishing
6060	Hawai‘i Island	HB_L_M	NA	19.9940205	-155.8819865	Camera
6099	Hawai‘i Island	SB_A_D	NA	19.9784126	-155.0948689	Fishing
6103	Hawai‘i Island	SB_A_D	NA	19.977991	-155.0757968	Fishing
6364	Hawai‘i Island	HB_L_M	NA	20.0165786	-155.8815417	Fishing
6366	Hawai‘i Island	HB_H_M	NA	20.0164101	-155.8719952	Camera
6379	Hawai‘i Island	SB_A_S	NA	20.0042547	-155.2469276	Camera
6534	Hawai‘i Island	HB_H_S	NA	20.0296908	-155.8574065	Camera
6734	Hawai‘i Island	HB_H_S	NA	20.0479064	-155.8665955	Camera
6750	Hawai‘i Island	SB_A_S	NA	20.0367218	-155.2891147	Camera
6842	Hawai‘i Island	SB_A_S	NA	20.0463386	-155.3175302	Camera
6928	Hawai‘i Island	HB_H_S	NA	20.0660372	-155.8710116	Camera
7140	Hawai‘i Island	SB_A_S	NA	20.0748721	-155.3884838	Camera
7144	Hawai‘i Island	SB_A_S	NA	20.0744803	-155.3693937	Camera
7231	Hawai‘i Island	HB_L_D	NA	20.0939473	-155.9182303	Fishing
7234	Hawai‘i Island	HB_H_S	NA	20.0936964	-155.9039031	Camera
7286	Hawai‘i Island	HB_H_M	NA	20.0983755	-155.9133661	Camera
7287	Hawai‘i Island	HB_H_S	NA	20.0982919	-155.9085902	Camera
7453	Hawai‘i Island	HB_H_S	NA	20.1119106	-155.9131005	Camera
7678	Hawai‘i Island	HB_L_D	NA	20.1150629	-155.368457	Fishing
7806	Hawai‘i Island	SB_A_M	K	20.1264074	-155.4828321	Camera
7875	Hawai‘i Island	SB_A_S	K	20.1318647	-155.5304804	Camera
7915	Hawai‘i Island	HB_H_D	NA	20.127997	-155.3395001	Fishing
7980	Hawai‘i Island	HB_L_D	K	20.1340782	-155.4157839	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
8090	Hawai‘i Island	SB_A_S	K	20.1467004	-155.5970405	Camera
8323	Hawai‘i Island	SB_A_D	K	20.15883	-155.5251061	Fishing
8580	Hawai‘i Island	HB_H_S	K	20.1793732	-155.6536787	Camera
8677	Hawai‘i Island	HB_H_D	K	20.1810005	-155.5055002	Fishing
8833	Hawai‘i Island	SB_A_S	K	20.2026503	-155.6914198	Camera
8835	Hawai‘i Island	HB_H_S	K	20.2024699	-155.6818638	Camera
8917	Hawai‘i Island	HB_H_D	NA	20.2212736	-155.9731043	Fishing
8961	Hawai‘i Island	HB_L_S	NA	20.2250379	-155.9299977	Camera
8992	Hawai‘i Island	HB_L_D	NA	20.2298832	-155.949029	Fishing
9036	Hawai‘i Island	HB_H_S	NA	20.2337255	-155.9107002	Camera
9067	Hawai‘i Island	HB_H_M	NA	20.2388235	-155.9440725	Fishing
9069	Hawai‘i Island	HB_L_M	NA	20.2386566	-155.9345119	Camera
9089	Hawai‘i Island	HB_H_M	K	20.2344949	-155.7050885	Camera
9388	Hawai‘i Island	HB_L_M	NA	20.2701548	-155.9291102	Camera
9522	Hawai‘i Island	HB_L_S	NA	20.2784178	-155.8859003	Camera
9556	Hawai‘i Island	HB_L_M	K	20.2754503	-155.7233524	Camera
9609	Hawai‘i Island	HB_L_M	K	20.2807614	-155.7662833	Camera
9841	Hawai‘i Island	HB_L_M	K	20.2994211	-155.7993784	Camera
10304	Maui Nui	HB_L_D	NA	20.4909399	-156.7966973	Fishing
10306	Maui Nui	HB_L_D	NA	20.490818	-156.7871147	Fishing
10315	Maui Nui	HB_H_M	NA	20.490263	-156.7439935	Fishing
10321	Maui Nui	SB_A_S	NA	20.4898871	-156.7152469	Fishing
10396	Maui Nui	HB_H_S	NA	20.4997249	-156.7774018	Fishing
10510	Maui Nui	SB_A_S	NA	20.5083835	-156.7485208	Fishing
10562	Maui Nui	HB_H_M	NA	20.5134526	-156.7915824	Fishing
10616	Maui Nui	HB_L_D	NA	20.5183912	-156.8250633	Fishing
10951	Maui Nui	HB_H_S	NA	20.5446864	-156.7623709	Fishing
10984	Maui Nui	HB_H_M	NA	20.5407338	-156.4748292	Fishing
11045	Maui Nui	HB_L_M	NA	20.5453172	-156.479547	Fishing
11131	Maui Nui	HB_H_D	NA	20.5487698	-156.4075939	Fishing
11203	Maui Nui	HB_H_M	NA	20.5534265	-156.4171017	Fishing
11233	Maui Nui	HB_L_D	NA	20.5632971	-156.8052498	Fishing
11299	Maui Nui	SB_A_S	NA	20.5575086	-156.3882735	Fishing
11410	Maui Nui	HB_H_S	NA	20.560848	-156.3115255	Fishing
11435	Maui Nui	HB_H_M	NA	20.5715249	-156.7428013	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
11443	Maui Nui	SB_A_S	NA	20.5710204	-156.7044524	Fishing
11639	Maui Nui	HB_H_S	NA	20.5798578	-156.689936	Fishing
11665	Maui Nui	HB_H_M	NA	20.5769827	-156.4838213	Fishing
11772	Maui Nui	HB_H_S	NA	20.581146	-156.459782	Fishing
11868	Maui Nui	HB_H_M	NA	20.5863571	-156.5076396	Fishing
11872	Maui Nui	HB_L_M	NA	20.5860797	-156.4884664	Fishing
11938	Maui Nui	HB_L_M	NA	20.5940348	-156.7376748	Fishing
12070	Maui Nui	HB_H_S	NA	20.5974634	-156.656104	Fishing
12093	Maui Nui	HB_H_S	NA	20.5954536	-156.5122864	Fishing
12219	Maui Nui	HB_H_M	NA	20.5994111	-156.4738636	Fishing
12372	Maui Nui	HB_H_S	NA	20.5994032	-156.1814088	Fishing
12456	Maui Nui	HB_H_S	NA	20.6088565	-156.5024785	Fishing
12795	Maui Nui	HB_H_M	NA	20.6246138	-156.6604845	Fishing
12800	Maui Nui	HB_H_M	NA	20.6242873	-156.6365094	Fishing
13138	Maui Nui	HB_H_S	NA	20.6250479	-156.0946344	Fishing
13142	Maui Nui	HB_H_S	NA	20.6247242	-156.075463	Fishing
13206	Maui Nui	HB_L_M	NA	20.6380914	-156.655482	Fishing
13215	Maui Nui	HB_H_M	NA	20.6374998	-156.6123235	Fishing
13220	Maui Nui	SB_A_M	NA	20.6371664	-156.5883472	Fishing
13365	Maui Nui	HB_L_S	NA	20.6406601	-156.5163479	Fishing
13424	Maui Nui	HB_L_D	NA	20.6491982	-156.8136133	Fishing
13455	Maui Nui	HB_L_M	NA	20.64725	-156.6649351	Fishing
13490	Maui Nui	SB_A_S	NA	20.6448967	-156.4970939	Fishing
13517	Maui Nui	SB_A_S	NA	20.6376884	-156.0416521	Fishing
13588	Maui Nui	HB_H_M	NA	20.6511083	-156.6169077	Fishing
13709	Maui Nui	HB_H_M	NA	20.6557547	-156.6264291	Fishing
13787	Maui Nui	HB_L_D	NA	20.6629845	-156.8326068	Fishing
13804	Maui Nui	HB_L_M	NA	20.6619403	-156.751063	Fishing
13813	Maui Nui	HB_H_M	NA	20.6613719	-156.7078948	Fishing
13934	Maui Nui	HB_L_M	NA	20.6658862	-156.7078271	Fishing
13977	Maui Nui	HB_H_S	NA	20.6630209	-156.5015938	Fishing
13999	Maui Nui	HB_H_S	NA	20.6553233	-156.0173348	Fishing
14090	Maui Nui	HB_H_S	NA	20.6678116	-156.5207035	Fishing
14096	Maui Nui	HB_H_S	NA	20.6673953	-156.4919283	Fishing
14168	Maui Nui	HB_H_M	NA	20.6751058	-156.722082	Fishing
14171	Maui Nui	HB_H_M	NA	20.674915	-156.7076915	Fishing
14199	Maui Nui	HB_L_M	NA	20.6730763	-156.5733882	Fishing
14202	Maui Nui	HB_L_M	NA	20.6728731	-156.5589994	Fishing
14412	Maui Nui	HB_L_M	NA	20.6842612	-156.7315415	Fishing
14455	Maui Nui	HB_H_S	NA	20.6814218	-156.5252799	Fishing
14521	Maui Nui	HB_H_M	NA	20.6897694	-156.8082338	Fishing
14522	Maui Nui	HB_H_M	NA	20.6897083	-156.8034362	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
14575	Maui Nui	HB_H_M	NA	20.6862785	-156.5491895	Fishing
14633	Maui Nui	HB_L_M	NA	20.6953029	-156.8897331	Fishing
14685	Maui Nui	HB_H_M	NA	20.6920652	-156.6402588	Fishing
14806	Maui Nui	HB_L_M	NA	20.6972302	-156.6881624	Fishing
14940	Maui Nui	HB_L_M	NA	20.7014857	-156.6689037	Fishing
14949	Maui Nui	HB_H_M	NA	20.7008956	-156.6257269	Fishing
15016	Maui Nui	HB_H_M	NA	20.709314	-156.9279338	Fishing
15020	Maui Nui	HB_H_S	NA	20.7090818	-156.9087396	Fishing
15027	Maui Nui	HB_L_M	NA	20.7086705	-156.8751503	Fishing
15104	Maui Nui	HB_H_S	NA	20.7037136	-156.5057255	Fishing
15163	Maui Nui	HB_L_M	NA	20.7128274	-156.8462963	Fishing
15201	Maui Nui	HB_H_S	NA	20.7104491	-156.6639678	Fishing
15207	Maui Nui	HB_H_S	NA	20.7100559	-156.6351815	Fishing
15215	Maui Nui	HB_H_S	NA	20.7095242	-156.5968008	Fishing
15233	Maui Nui	HB_H_S	NA	20.7082967	-156.5104487	Fishing
15329	Maui Nui	HB_H_M	NA	20.7151581	-156.6782925	Camera & Fishing
15347	Maui Nui	HB_H_S	NA	20.7139711	-156.591932	Fishing
15422	Maui Nui	HB_L_M	NA	20.7220366	-156.8605649	Fishing
15469	Maui Nui	HB_H_M	NA	20.7190841	-156.6350414	Fishing
15557	Maui Nui	SB_A_M	NA	20.7263115	-156.8413059	Fishing
15717	Maui Nui	HB_H_S	NA	20.7289589	-156.6972797	Camera & Fishing
15728	Maui Nui	HB_H_S	NA	20.728244	-156.6444976	Fishing
15844	Maui Nui	HB_H_S	NA	20.7336654	-156.7116073	Camera & Fishing
15956	Maui Nui	HB_H_S	NA	20.7391847	-156.7883227	Fishing
15974	Maui Nui	HB_H_S	NA	20.7380517	-156.7019418	Fishing
15979	Maui Nui	HB_H_S	NA	20.7377293	-156.6779482	Camera
15984	Maui Nui	HB_H_S	NA	20.7374035	-156.653955	Camera & Fishing
15988	Maui Nui	HB_H_S	NA	20.7371405	-156.6347608	Fishing
16095	Maui Nui	HB_H_S	NA	20.7422435	-156.6778793	Camera & Fishing
16110	Maui Nui	HB_H_S	NA	20.741256	-156.605899	Fishing
16192	Maui Nui	HB_H_S	NA	20.7476525	-156.7449977	Fishing
16202	Maui Nui	HB_H_S	NA	20.7470161	-156.6970063	Camera & Fishing
16218	Maui Nui	HB_H_S	NA	20.7459699	-156.6202241	Fishing
16221	Maui Nui	HB_H_S	NA	20.74577	-156.6058279	Fishing
16310	Maui Nui	HB_H_S	NA	20.751466	-156.6921388	Camera & Fishing
16479	Maui Nui	HB_H_M	NA	20.7644594	-157.0088034	Fishing
16516	Maui Nui	HB_H_S	NA	20.7606874	-156.7064001	Camera & Fishing
16647	Maui Nui	HB_H_S	NA	20.7630817	-156.5527529	Fishing
16709	Maui Nui	HB_H_S	NA	20.7700349	-156.730263	Camera & Fishing
16720	Maui Nui	HB_H_S	NA	20.7693288	-156.6774654	Camera & Fishing
16832	Maui Nui	HB_H_S	NA	20.7729875	-156.6150003	Camera & Fishing
16904	Maui Nui	HB_H_S	NA	20.7793165	-156.7493288	Camera & Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
16914	Maui Nui	HB_H_S	NA	20.7786804	-156.7013274	Camera & Fishing
17117	Maui Nui	HB_H_S	NA	20.7869275	-156.6435879	Camera & Fishing
17290	Maui Nui	HB_L_S	NA	20.7964141	-156.6770509	Camera & Fishing
17779	Maui Nui	SB_A_S	NA	20.8321313	-157.0031113	Fishing
18005	Maui Nui	HB_L_D	NA	20.846502	-157.0749813	Fishing
18574	Maui Nui	HB_L_D	NA	20.8739161	-157.1034619	Fishing
18646	Maui Nui	HB_H_S	NA	20.8844312	-157.756935	Fishing
18789	Maui Nui	HB_L_S	NA	20.8826246	-157.0745212	Fishing
19004	Maui Nui	HB_H_M	NA	20.8918171	-157.0888204	Fishing
19071	Maui Nui	HB_H_M	NA	20.9025334	-157.7615929	Fishing
19179	Maui Nui	HB_H_M	J	20.8824013	-156.099315	Fishing
19688	Maui Nui	SB_A_S	NA	20.9012585	-156.1469852	Fishing
19699	Maui Nui	HB_H_D	NA	20.9251522	-157.7662149	Fishing
19754	Maui Nui	HB_L_M	NA	20.9189629	-157.0932828	Fishing
19784	Maui Nui	HB_H_S	NA	20.9156228	-156.8145779	Fishing
19963	Maui Nui	HB_H_S	NA	20.9193894	-156.7568547	Fishing
20070	Maui Nui	HB_H_S	F	20.9322371	-157.5209588	Camera
20261	Maui Nui	HB_H_M	F	20.9366699	-157.5112998	Camera
20401	Maui Nui	HB_H_D	NA	20.9192271	-156.1418411	Fishing
20733	Maui Nui	HB_L_M	NA	20.9377612	-156.7806124	Fishing
21015	Maui Nui	HB_H_S	NA	20.9565942	-157.7419135	Fishing
21290	Maui Nui	HB_H_D	F	20.9590398	-157.4870363	Fishing
21370	Maui Nui	HB_L_M	NA	20.9516157	-156.8044419	Fishing
21379	Maui Nui	HB_H_S	NA	20.9510532	-156.7611896	Fishing
21465	Maui Nui	HB_H_D	NA	20.9421891	-156.1654286	Fishing
21526	Maui Nui	HB_H_M	F	20.9635561	-157.4869909	Camera
21528	Maui Nui	HB_H_M	F	20.9634704	-157.4773747	Camera
21596	Maui Nui	HB_H_S	NA	20.9568633	-156.8620496	Fishing
21773	Maui Nui	HB_H_S	F	20.9677702	-157.4532878	Camera
22024	Maui Nui	HB_H_M	F	20.9719328	-157.4147751	Camera
22030	Maui Nui	HB_H_M	F	20.971662	-157.3859259	Fishing
22049	Maui Nui	HB_H_M	NA	20.9681418	-157.0493884	Fishing
22090	Maui Nui	HB_L_S	NA	20.9657718	-156.8523082	Fishing
22091	Maui Nui	HB_L_S	NA	20.9657112	-156.8475018	Fishing
22298	Maui Nui	HB_L_M	NA	20.9726571	-157.0493298	Fishing
22343	Maui Nui	HB_H_M	NA	20.970043	-156.8330173	Fishing
22344	Maui Nui	HB_L_M	NA	20.9699818	-156.8282108	Fishing
22450	Maui Nui	HB_H_D	NA	20.9603182	-156.1698922	Fishing
22520	Maui Nui	HB_L_M	F	20.9810987	-157.4291054	Camera
22544	Maui Nui	SB_A_D	NA	20.9773368	-157.0636937	Fishing
22591	Maui Nui	HB_H_M	NA	20.9746187	-156.8377589	Fishing
22633	Maui Nui	SB_A_S	NA	20.9698039	-156.4869161	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
22770	Maui Nui	HB_H_M	F	20.9854811	-157.4146321	Camera
22828	Maui Nui	HB_H_S	NA	20.9799744	-156.9049919	Fishing
22829	Maui Nui	HB_H_S	NA	20.9799152	-156.9001848	Fishing
23273	Maui Nui	HB_H_S	F	20.9946471	-157.4289637	Camera
23275	Maui Nui	HB_H_M	F	20.994558	-157.4193457	Camera
23304	Maui Nui	HB_L_D	NA	20.9911002	-157.0827509	Fishing
23369	Maui Nui	HB_L_M	NA	20.9872944	-156.7702654	Fishing
23414	Maui Nui	HB_L_S	NA	20.9822649	-156.4146048	Fishing
23806	Maui Nui	HB_H_M	NA	21.0029515	-157.3519222	Camera
23815	Maui Nui	HB_H_M	NA	21.0025269	-157.3086411	Fishing
24063	Maui Nui	HB_H_M	F	21.0077902	-157.3855375	Camera
24083	Maui Nui	HB_H_M	NA	21.0068505	-157.2893539	Camera
24626	Maui Nui	HB_H_M	NA	21.0159303	-157.2940602	Fishing
24712	Maui Nui	HB_L_M	NA	21.0101174	-156.7891607	Fishing
24907	Maui Nui	HB_H_M	NA	21.0204461	-157.2940088	Camera
24994	Maui Nui	HB_L_M	NA	21.0147565	-156.7987099	Fishing
25211	Maui Nui	HB_H_D	NA	21.0231898	-157.1256286	Fishing
25229	Maui Nui	HB_L_M	NA	21.0222135	-157.0390665	Fishing
25270	Maui Nui	HB_L_M	NA	21.0198257	-156.8419166	Fishing
25500	Maui Nui	HB_H_M	NA	21.027652	-157.1207628	Camera & Fishing
25579	Maui Nui	HB_L_M	NA	21.0230286	-156.7408805	Fishing
25776	Maui Nui	HB_H_S	NA	21.033504	-157.245756	Camera
25777	Maui Nui	HB_L_S	NA	21.0334542	-157.2409462	Camera
25790	Maui Nui	HB_L_M	NA	21.0321674	-157.1207062	Fishing
25810	Maui Nui	HB_H_S	NA	21.0310768	-157.024521	Fishing
25860	Maui Nui	HB_L_M	NA	21.0281125	-156.7840861	Fishing
25864	Maui Nui	HB_L_M	NA	21.0278607	-156.7648532	Fishing
25945	Maui Nui	HB_L_M	NA	21.0220711	-156.3610312	Fishing
26159	Maui Nui	HB_L_M	NA	21.0326895	-156.7888278	Fishing
26206	Maui Nui	HB_L_S	NA	21.0295303	-156.5580441	Camera
26220	Maui Nui	HB_L_M	NA	21.0285499	-156.4907404	Camera
26224	Maui Nui	HB_L_M	NA	21.0282649	-156.4715115	Camera
26523	Maui Nui	HB_L_M	NA	21.0333462	-156.5098946	Camera
26684	Maui Nui	HB_L_S	NA	21.0466999	-157.2119261	Camera
26711	Maui Nui	HB_L_M	NA	21.0452291	-157.0772482	Camera
26716	Maui Nui	SB_A_M	NA	21.0449552	-157.0531998	Camera
26717	Maui Nui	HB_L_M	NA	21.0449	-157.0483902	Camera & Fishing
27007	Maui Nui	SB_A_M	NA	21.0502288	-157.1204796	Camera
27014	Maui Nui	HB_L_M	NA	21.049853	-157.08681	Camera
27078	Maui Nui	HB_H_S	NA	21.0461073	-156.7790101	Fishing
27168	Maui Nui	SB_A_M	NA	21.0398984	-156.3462918	Fishing
27314	Maui Nui	HB_L_M	NA	21.0544763	-157.0963723	Camera

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
27693	Maui Nui	HB_L_M	H	21.0540471	-156.6971236	Camera
27730	Maui Nui	HB_L_M	NA	21.051541	-156.5192105	Fishing
27968	Maui Nui	HB_H_S	NA	21.0593977	-156.7595722	Fishing
28010	Maui Nui	HB_L_M	NA	21.0566123	-156.5576023	Camera
28193	Maui Nui	SB_A_S	NA	21.0680222	-157.0962	Camera
28262	Maui Nui	HB_L_M	H	21.0626814	-156.6681304	Camera
28314	Maui Nui	SB_A_D	NA	21.0590624	-156.4180889	Fishing
28534	Maui Nui	HB_L_M	H	21.0668633	-156.6440145	Camera
28545	Maui Nui	HB_L_M	NA	21.0661208	-156.5911162	Camera
28615	Maui Nui	HB_H_S	NA	21.0823974	-157.654229	Camera
28782	Maui Nui	HB_H_M	H	21.0719071	-156.6824175	Camera
28796	Maui Nui	HB_L_M	NA	21.0709742	-156.6150886	Camera
29026	Maui Nui	HB_L_M	NA	21.0768129	-156.7112047	Camera
29283	Maui Nui	HB_H_M	H	21.0802713	-156.6341822	Fishing
29287	Maui Nui	HB_L_M	NA	21.0800019	-156.6149446	Fishing
29507	Maui Nui	HB_H_M	H	21.0853176	-156.672588	Camera
29508	Maui Nui	HB_L_M	H	21.0852515	-156.6677782	Camera
29906	Maui Nui	HB_L_D	NA	21.0933398	-156.600299	Fishing
29926	Maui Nui	HB_L_D	NA	21.0914521	-156.4704431	Fishing
30179	Maui Nui	HB_H_S	NA	21.1180209	-157.5913293	Fishing
30196	Maui Nui	HB_H_S	NA	21.1173209	-157.5095045	Fishing
30316	Maui Nui	HB_H_S	NA	21.1210078	-157.4180095	Fishing
30639	Maui Nui	HB_L_D	NA	21.125343	-156.6286557	Fishing
30744	Maui Nui	HB_L_S	NA	21.1443757	-157.5044196	Fishing
30825	Maui Nui	HB_L_S	NA	21.1488919	-157.5043743	Fishing
30979	Maui Nui	HB_H_M	NA	21.1581354	-157.5283558	Fishing
31238	Maui Nui	SB_A_S	NA	21.1702729	-157.3741507	Fishing
31302	Maui Nui	HB_H_M	NA	21.1759891	-157.5041019	Fishing
31331	Maui Nui	HB_L_S	NA	21.174696	-157.364472	Fishing
31634	Maui Nui	HB_H_D	NA	21.1891044	-157.4558118	Fishing
31694	Maui Nui	HB_H_S	G	21.183078	-156.897328	Camera
31745	Maui Nui	HB_L_M	NA	21.1798453	-156.651856	Camera
31832	Maui Nui	HB_H_S	G	21.1873519	-156.8780092	Camera
31836	Maui Nui	HB_H_S	NA	21.187109	-156.8587545	Camera
31958	Maui Nui	HB_H_S	G	21.1924052	-156.92127	Camera
31961	Maui Nui	HB_H_S	G	21.1922269	-156.9068281	Camera
31981	Maui Nui	HB_H_S	NA	21.1910065	-156.8105525	Camera
32324	Maui Nui	SB_A_D	NA	21.2108229	-157.3640743	Fishing
32445	Maui Nui	HB_H_M	NA	21.2032736	-156.7140756	Camera
32520	Maui Nui	SB_A_S	NA	21.21278	-157.1184288	Fishing
32584	Maui Nui	HB_H_M	NA	21.208687	-156.7814015	Camera
32648	Maui Nui	SB_A_M	NA	21.2194289	-157.3206304	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
32690	Maui Nui	SB_A_S	NA	21.2170251	-157.0942948	Fishing
32783	Oʻahu	HB_H_D	NA	21.2294784	-158.0238578	Fishing
33346	Oʻahu	HB_L_D	NA	21.2475744	-158.0285571	Fishing
33415	Maui Nui	HB_L_S	NA	21.2413724	-157.2577586	Fishing
33419	Maui Nui	SB_A_S	NA	21.2411722	-157.2384925	Fishing
33520	Oʻahu	HB_H_D	NA	21.2497733	-157.6864411	Fishing
33671	Oʻahu	HB_H_M	NA	21.2543273	-157.691219	Camera & Fishing
33673	Oʻahu	HB_H_M	NA	21.2542522	-157.6815832	Camera
33726	Maui Nui	HB_L_S	NA	21.2501024	-157.2287517	Fishing
33832	Oʻahu	HB_H_S	NA	21.2587687	-157.681543	Camera
33838	Oʻahu	HB_H_S	NA	21.2585401	-157.6526348	Camera
33868	Maui Nui	SB_A_M	NA	21.2555068	-157.315404	Fishing
34011	Oʻahu	HB_H_S	NA	21.2625037	-157.5851408	Camera
34012	Oʻahu	HB_L_M	NA	21.2624631	-157.5803228	Camera
34025	Maui Nui	HB_L_M	NA	21.2601186	-157.3249872	Fishing
34042	Maui Nui	HB_L_S	NA	21.2592847	-157.2430948	Fishing
34053	Maui Nui	SB_A_S	NA	21.2587239	-157.1901078	Fishing
34056	Maui Nui	HB_H_S	NA	21.2585681	-157.1756571	Fishing
34092	Oʻahu	HB_L_M	NA	21.2700473	-158.009133	Fishing
34096	Oʻahu	HB_H_D	NA	21.2699329	-157.9898571	Fishing
34124	Oʻahu	HB_H_S	NA	21.2690699	-157.8549298	Camera
34191	Maui Nui	SB_A_S	NA	21.2643931	-157.300849	Fishing
34273	Oʻahu	HB_H_M	NA	21.2739386	-157.9079028	Camera
34335	Oʻahu	HB_L_M	NA	21.2713733	-157.5657815	Camera
34672	Maui Nui	HB_L_S	NA	21.2775965	-157.2669689	Fishing
34793	Oʻahu	HB_L_S	E	21.284922	-157.5656501	Camera
34821	Maui Nui	SB_A_S	NA	21.2820127	-157.2572803	Fishing
35195	Oʻahu	HB_H_S	NA	21.3068748	-158.1342176	Camera
35418	Oʻahu	SB_A_S	E	21.3123439	-157.6039439	Camera
35427	Oʻahu	HB_H_M	E	21.3119783	-157.5605676	Camera & Fishing
35865	Oʻahu	HB_H_S	NA	21.3611544	-158.1483658	Camera
36110	Oʻahu	HB_H_S	E	21.3806367	-157.6708095	Camera
36117	Oʻahu	HB_H_D	E	21.3803659	-157.6370556	Fishing
36121	Oʻahu	HB_H_S	NA	21.3884719	-158.1916166	Camera
36250	Oʻahu	HB_H_D	E	21.3985094	-157.6465333	Fishing
36301	Oʻahu	HB_H_S	E	21.4077733	-157.6753875	Camera
36307	Oʻahu	HB_H_S	NA	21.4156211	-158.2011156	Camera
36627	Oʻahu	HB_H_S	NA	21.4531638	-157.7039264	Camera
36755	Oʻahu	HB_H_D	NA	21.4665243	-157.6796822	Fishing
36923	Oʻahu	HB_H_S	NA	21.4847412	-157.6988212	Camera
36931	Oʻahu	HB_H_S	NA	21.4926147	-158.2441361	Fishing
36963	Oʻahu	HB_H_M	NA	21.4893697	-157.7132581	Camera

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
36995	O‘ahu	HB_H_S	NA	21.4942509	-157.761477	Camera
37041	O‘ahu	HB_H_M	NA	21.4986231	-157.7421346	Fishing
37043	O‘ahu	HB_H_D	NA	21.4985501	-157.7324826	Fishing
37121	O‘ahu	HB_H_D	NA	21.5152222	-158.2488467	Fishing
37144	O‘ahu	HB_H_M	NA	21.5123526	-157.7661506	Camera
37169	O‘ahu	HB_H_M	NA	21.5169047	-157.7709391	Camera
37354	O‘ahu	HB_H_S	NA	21.5516105	-158.3066035	Camera
37359	O‘ahu	HB_H_M	NA	21.5515083	-158.2824606	Camera
37380	O‘ahu	HB_H_M	NA	21.5486614	-157.789984	Fishing
37386	O‘ahu	HB_H_M	NA	21.5562069	-158.3258971	Camera
37532	O‘ahu	HB_L_D	NA	21.5667625	-157.7946625	Fishing
37615	O‘ahu	HB_H_M	NA	21.5759342	-157.8139026	Fishing
37625	O‘ahu	HB_H_M	NA	21.5834436	-158.3595795	Camera
37991	O‘ahu	HB_H_M	NA	21.5986872	-157.8378661	Fishing
38005	O‘ahu	HB_H_M	D	21.6060297	-158.3594801	Camera
38119	O‘ahu	HB_H_S	NA	21.6098335	-158.1952231	Camera
38200	O‘ahu	HB_H_S	NA	21.6143271	-158.1903676	Camera
38231	O‘ahu	HB_L_S	NA	21.6124039	-157.8619078	Fishing
38243	O‘ahu	HB_L_D	D	21.6196365	-158.3739132	Fishing
38364	O‘ahu	HB_L_M	NA	21.6233375	-158.1854864	Fishing
38486	O‘ahu	HB_H_D	NA	21.6257866	-157.8376495	Fishing
38564	O‘ahu	HB_H_M	NA	21.6305033	-157.8665969	Camera
38565	O‘ahu	HB_L_M	NA	21.6304703	-157.8617663	Fishing
38656	O‘ahu	HB_L_D	D	21.6420138	-158.3206679	Fishing
38728	O‘ahu	HB_L_D	NA	21.6460163	-158.2046862	Camera
38790	O‘ahu	HB_L_M	NA	21.6502704	-158.1515124	Fishing
38793	O‘ahu	HB_L_M	NA	21.6501957	-158.1370174	Camera
38818	O‘ahu	HB_H_S	NA	21.6486353	-157.8761184	Fishing
38819	O‘ahu	HB_L_M	NA	21.6486026	-157.8712872	Camera
38870	O‘ahu	HB_L_M	NA	21.6531192	-157.871252	Camera
38918	O‘ahu	SB_A_M	NA	21.6576685	-157.8760484	Camera
39067	O‘ahu	HB_H_M	NA	21.671251	-157.8807754	Camera
39216	O‘ahu	HB_H_M	NA	21.6848333	-157.8855033	Camera
39235	O‘ahu	HB_L_M	NA	21.6907207	-158.1126104	Camera
39239	O‘ahu	HB_H_S	NA	21.6906161	-158.0932785	Camera
39267	O‘ahu	HB_H_M	NA	21.6893499	-157.8854685	Fishing
39319	O‘ahu	HB_H_M	NA	21.6938665	-157.8854338	Camera
39387	O‘ahu	HB_L_D	NA	21.7043229	-158.1221943	Fishing
39435	O‘ahu	HB_L_D	NA	21.7027021	-157.8563661	Fishing
39440	O‘ahu	HB_L_D	NA	21.7088907	-158.1318341	Fishing
39546	O‘ahu	HB_H_S	NA	21.7119976	-157.8949614	Fishing
39683	O‘ahu	HB_L_M	NA	21.726617	-158.0688814	Camera

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
39808	O‘ahu	HB_L_M	NA	21.7357048	-158.0784921	Fishing
39843	O‘ahu	HB_H_M	NA	21.7346767	-157.9092913	Fishing
39858	Ni‘ihau	HB_H_M	NA	21.7382171	-160.2300237	Fishing
39860	Ni‘ihau	HB_H_M	NA	21.7382886	-160.2203556	Fishing
39897	O‘ahu	HB_L_S	NA	21.7395954	-157.972104	Camera
39929	Ni‘ihau	HB_H_S	NA	21.7429113	-160.2058911	Fishing
39985	Ni‘ihau	HB_H_S	NA	21.747105	-160.2494379	Fishing
40040	O‘ahu	HB_L_D	NA	21.7482265	-157.909189	Fishing
40088	O‘ahu	HB_H_S	NA	21.7531755	-157.9768425	Fishing
40144	O‘ahu	HB_L_M	NA	21.7578399	-158.0009857	Fishing
40194	O‘ahu	HB_L_D	NA	21.7626416	-158.0493072	Fishing
40391	O‘ahu	HB_L_D	NA	21.775515	-157.9379975	Fishing
40641	Ni‘ihau	HB_H_S	NA	21.8018683	-160.1725283	Fishing
40719	Ni‘ihau	HB_H_M	B	21.8113358	-160.1097255	Fishing
40797	Ni‘ihau	HB_H_D	B	21.8205614	-160.080773	Fishing
40942	Ni‘ihau	HB_H_M	NA	21.8417998	-160.2696104	Fishing
41162	Ni‘ihau	HB_H_S	NA	21.8599391	-160.2600939	Fishing
41312	Ni‘ihau	HB_H_M	NA	21.8689345	-160.2650115	Fishing
41576	Kaua‘i	HB_H_S	NA	21.8823993	-159.3746426	Fishing
41694	Ni‘ihau	HB_H_M	NA	21.8886809	-160.0232101	Fishing
41835	Ni‘ihau	HB_H_M	NA	21.8976839	-160.0281143	Fishing
41870	Kaua‘i	HB_H_D	NA	21.9005216	-159.3504872	Fishing
41980	Kaua‘i	HB_H_M	NA	21.9095561	-159.3505093	Fishing
42035	Ni‘ihau	HB_H_D	NA	21.914171	-160.2557302	Fishing
42231	Kaua‘i	HB_H_D	NA	21.9322111	-159.3166734	Fishing
42937	Ni‘ihau	HB_H_S	NA	21.9871436	-160.159516	Fishing
43213	Ni‘ihau	HB_H_D	NA	22.0144448	-160.1306754	Fishing
43278	Ni‘ihau	HB_H_S	NA	22.0195087	-160.0483674	Fishing
43397	Ni‘ihau	HB_H_S	NA	22.0329959	-160.0581557	Fishing
43434	Ni‘ihau	HB_H_S	NA	22.037481	-160.0630337	Fishing
43853	Kaua‘i	HB_H_M	NA	22.1066259	-159.8211941	Fishing
44109	Kaua‘i	HB_H_M	NA	22.1473251	-159.8117327	Fishing
44208	Kaua‘i	SB_A_D	NA	22.1608754	-159.8118104	Fishing
44360	Kaua‘i	HB_H_M	NA	22.17621	-159.2784175	Fishing
44443	Kaua‘i	HB_H_S	NA	22.1852274	-159.2881358	Fishing
44467	Kaua‘i	HB_H_S	NA	22.188535	-159.6907162	Fishing
44579	Kaua‘i	HB_H_D	NA	22.1987873	-159.2833127	Fishing
44590	Kaua‘i	HB_H_D	NA	22.202106	-159.685932	Fishing
44697	Kaua‘i	HB_L_S	NA	22.2122946	-159.3075957	Fishing
44704	Kaua‘i	HB_H_M	NA	22.2156972	-159.6762958	Fishing
44755	Kaua‘i	HB_H_D	NA	22.2202935	-159.6569127	Fishing
45153	Kaua‘i	HB_H_M	NA	22.2475653	-159.6133697	Fishing

PSU	Island	Strata	BRFA	Latitude	Longitude	Gear
45374	Kaua‘i	HB_H_M	NA	22.2656511	-159.6085956	Fishing
45512	Kaua‘i	HB_H_D	NA	22.2883071	-159.589279	Fishing