Final Creel Survey Report for Ka‘ūpūlehu Creel Survey Project, North Kona, Hawai‘i Island

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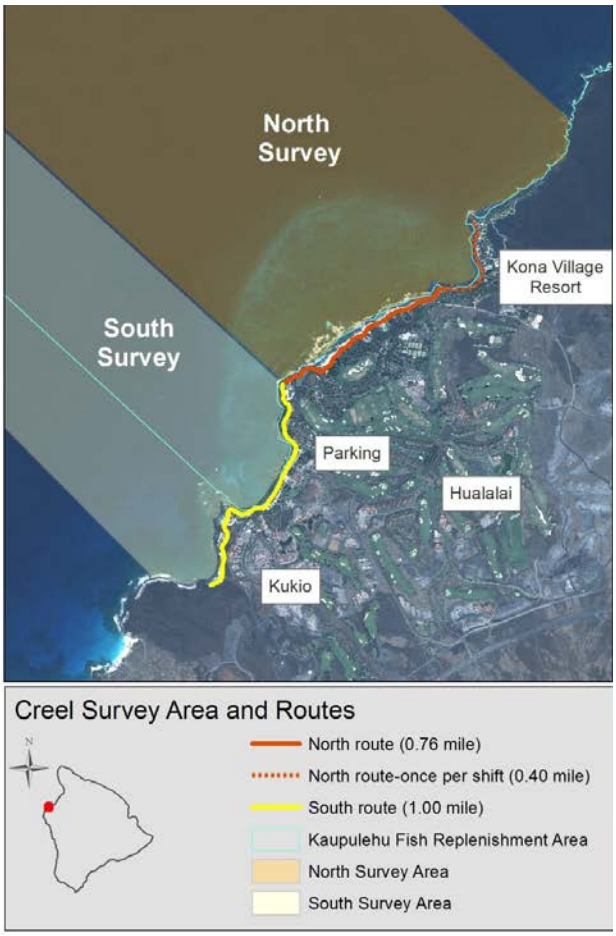


March 31, 2015

Final Report

Submitted to
The Nature Conservancy

Executive Summary

Survey Effort

- TNC staff and local fishers conducted 2,880 hours of observation- and interview-based creel surveys along 2.16 miles of coastline between August 2013 and August 2014.

Number of Fishers

- Surveyors recorded 2,941 fishing observations in Kaʻūpūlehu creel survey area.
- 240 interviews fisher interviews were conducted.

Annual Fishing Effort

- Estimated annual total fishing effort was 12,051 gear-hours.
- Spear fishing, rod and reel fishing, and throw net fishing were the three dominant fishing methods at Kaʻūpūlehu .
- Spear fishing accounted for 38% of the total fishing effort. Rod and reel fishing (whipping, slide baiting, and dunking) accounted for 39% and thrownet accounted for 10% of the total fishing effort.
- Fishing effort during weekends/holidays was significantly higher than weekdays.
- Fishing effort and catch were consistent across seasons.

Fishing Location

- Fishing effort was most intense along the shallow reef zone followed by the intertidal zone. However, gear types were different, with spear fishing dominant in the reef zone and rod and reel fishing dominant in the intertidal zone.

Catch (Species and biomass)

- Kaʻūpūlehu ’s total annual catch is estimated at of 10,139 lbs of fishes and marine invertebrates, which is about 74% of reported commercial catch of the same area.
- 55 species were recorded in the catch.
- The top three species caught by weight were uku (*Aprion virescens*), heʻe (*Octopus* cyanea), and ʻopihi (*Cellana sp.*).
- The most efficient gear type (highest CPUE) was gleaning followed by spear gun fishing.

Utility

- The adjacent Kiholo Bay area was 23% of Kaʻūpūlehu 's creel survey area, but had an estimated total annual landing that was 60% greater.
- The overall CPUE of Kaʻūpūlehu was lower than that of adjacent Kiholo Bay, but the fishing effort was 50% greater, which decreased the potentially difference in the annual catch between the two sites.

Species Code Table

Species Code	Common Name	Scientific Name
ABSO	kupipi	*Abudefduf sordidus*
ACAC	pa¯ku‘iku‘i	*Acanthurus achilles*
ACBL	pualu	*Acanthurus blochii*
ACDU	palani	*Acanthurus dussumieri*
ACLE	ma¯ikoiko	*Acanthurus leucopareius*
ACNF	ma¯i'i'i	*Acanthurus nigrofuscus*
ACNR	maiko	*Acanthurus nigroris*
ACOL	na'ena'e	*Acanthurus olivaceus*
ACTR	manini	*Acanthurus triostegus*
ACXA	pualu	*Acanthurus xanthopterus*
ALSC	--	*Aluterus scriptus*
ALSP	oio	*Albula sp*
APVI	**uku**	***Aprion virescens***
AUCH	nu¯nu¯	*Aulostomus chinensis*
BOBI	--	*Bodianus bilunulatus*
BOMA	pa¯ki'i	*Bothus mancus*
BOSP	--	*Bothus sp*
CACA	--	*Calotomus carolinus*
CAIG	'ulua aukea	*Caranx ignobilis*
CAME	'omilu	*Caranx melampygus*
CAOR	ulua, papa ulua	*Carangoides orthogrammus*
CEAR	roi	*Cephalopholis argus*
CIPI	po'o pa'a	*Cirrhitus pinnulatus*
CTHA	--	*Ctenochaetus hawaiiensis*
CTST	kole	*Ctenochaetus strigosus*
He'e	tako	*Octopus cyanea*
KUSP	aholehole	*Kuhlia sp*
KUXE	aholehole	*Kuhlia xenopus*
KYSP	nenue	*Kyphosus species*
LUFU	to'au, toau	*Lutjanus fulvus*
MENI	humuhumu'el'ele	*Melichthys niger*
MESP	--	*Melichthys sp*
MOGR	mu	*Monotaxis grandoculis*
MUCE	--	*Mugil cephalus*
MUFL	weke	*Mulloidichthys flavolineatus*
MUVA	weke 'ula	*Mulloidichthys vanicolensis*
MYBE	'u¯'u¯	*Myripristis berndti*
MYSP	--	*Myripristis species*
NAHE	kala holo	*Naso hexacanthus*
NALI	umaumalei	*Naso lituratus*
NAUN	kala	*Naso unicornis*
NELE	--	*Neomyxus leuciscus*
Nerita picea	pipipi	*Nerita picea*

‘opihi	‘opihi	*Cellana sp*
PACY	moano kea	*Parupeneus cyclostomus*
PAIN	two saddle goat fish	*Parupeneus insularis*
PAMU	moano	*Parupeneus multifasciatus*
Species Code	Common Name	Scientific Name
Panularis spp	lobster	*Panularis spp*
PAPO	ku¯mu¯	*Parupeneus porphyreus*
PRME	'a¯weoweo	*Priacanthus meeki*
SASP	'ala'ihi	*Sargocentron spiniferum*
SCLY	lai	*Scomberoides lysan*
SCPS	uhu	*Scarus psittacus*
SCRU	pa¯lukaluka	*Scarus rubroviolaceus*
SECR	akule, halalu	*Selar crumenophthalmus*
SPSP	kaku	*Sphyraena sp*
SUFR	humuhumumimi	*Sufflamen fraenatus*
THDU	hi¯na¯lea lauwili	*Thalassoma duperrey*
ZACO	kihikihi	*Zanclus cornutus*

I. Introduction

Marine resources in Hawai‘i are important for subsistence, culture, and identity. In ancient times, management of these resources involved adapting harvest based on annual and inter-annual cycles (*e.g.*, seasons), and likely also observations of abundance and decline. The Hawaiian system of eco-system-based fishery management ensured sufficient near-shore productivity to support landings at the turn of the 20th century that cannot be matched today, even with technological improvements in fishing gear.

Today, many local leaders with deep connections to land and water, and a feeling of responsibility for their well-being, are pursuing methods of co-management with the State of Hawai‘i, including independently developing fishing rules to halt and reverse marine life depletion. These processes depend upon sufficient data to justify the need for the measures, and data on fish abundance, biomass, and distribution are vital to legitimize these efforts in a modern context. The keen observations of Hawaiians with the responsibility of caring for coastal and marine life and cultural landscapes, supported by rigorous science, are stronger than either those observations or the science alone.

Ka‘ūpūlehu Marine Life Advisory Committee (KMLAC) has a mandate to ensure healthy and abundant resources in Ka‘ūpūlehu and Kūki‘o. They have requested an administrative rule to “rest” the Ka‘ūpūlehu coral reef from fishing for 10 years to increase fish abundance and while a long-term sustainable fishery plan is developed. In order to evaluate their management decision, KMLAC requested TNC to assess its current level of fishing to allow future comparison.

A creel survey is one of the suitable methods to record fishing activities in Hawaii, since it captures any fishing activities of the area regardless of its gear, objective, and target species. By documenting fishing efforts and catch in a statistically robust way, it allows evaluation and monitoring of marine resource condition.

The project site also covered both inside and outside of the existing Ka‘ūpūlehu Fish Replenishment Area (FRA), which has been protected from commercial aquarium fishing since 2000 and if the area into which the new community-proposed rules are to be enacted. This will allow an evaluation of the spillover effect from protected areas in the future (*e.g.*, see Stamoulis and Friedlander, 2012). Furthermore, another creel survey has been conducted at neighboring Kiholo Bay area, thus allowing comparisons between sites (in fishing effort, catch, species abundance, etc.) during and after the enactment of the 10-year rest period.

II. Method

Project Site

The Ka‘ūpūlehu creel survey area lies across the ahupua‘a (historic land divisions) of Ka‘ūpūlehu and Kūki‘o, and encompasses fishing areas within and immediately adjacent to the existing Ka‘ūpūlehu FRA. The North side of the site is characterized by lava terrain from an 1859 eruption while the south is a sandy shoreline interspersed with lava

benches and tide pools. Access to the northern end of the survey area is difficult, requiring a hike over rough terrain, but access is easier to the south via three public parking lots and well-maintained access paths (Figure 1).

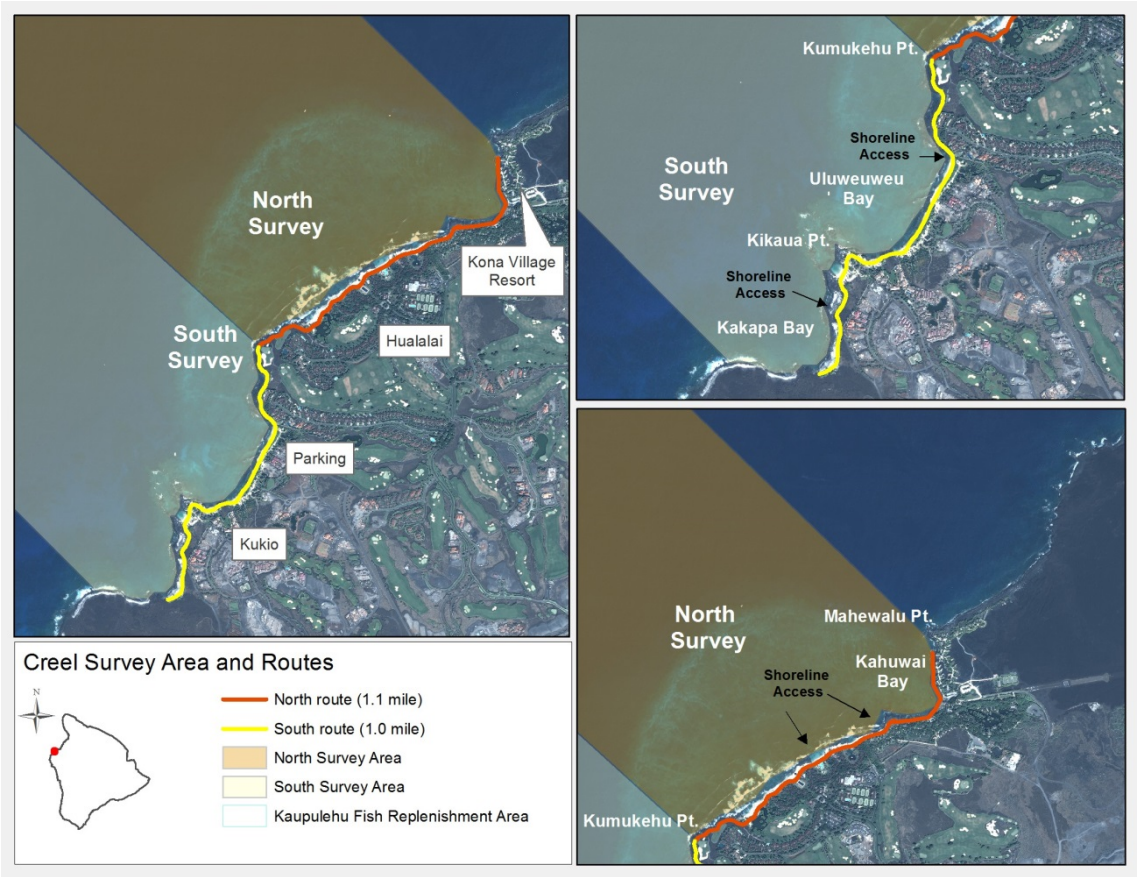


Figure 1. Aerial view of the Kaʻūpūlehu creel survey area. The blue line delineates the south boundary of the current Kaʻūpūlehu FRA. .

Pre-survey Analysis

In order to design a statistically robust creel survey, a frame survey was conducted between May 23, 2013 and May 29, 2013 to collect preliminary information on locations, gear types, frequency, and length of fishing events. The frame survey showed significant differences in fishing effort between weekdays (WD) and weekends/holidays (WE&H); thus it was concluded that creel survey effort should be stratified by these two categories to reflect each strata's fishing effort and ratio of WD and WE&H within the month.

Creel Survey

Based on the pre-survey analysis, the creel survey was designed to account for weekly variation where weekdays (WD) were considered as one stratum and weekends/holidays (WE&H) as another. Since the coast line was considered too long (2.16 miles) for one person to survey with adequate frequency, the site was split into two areas, north and south, and one person surveyed the area north of Kumukehu point and another

simultaneously surveyed the south (Figure 1). For each north/south survey area, the total survey effort (10 days/month) was divided among each strata, where 4-5 days/month were randomly distributed among the WD and the remaining distributed for the WE&H strata. The survey period was from 6am to 6pm covering the entire coastal extent, with all fishing activity conducted within the designated survey area during that time recorded.

Two types of creel surveys were conducted to document fishing activities (Appendix B). (1) An observational survey that did not make contact with fishers was used to collect fishing effort information for each fishing event. Data collected for each fishing event included: number of fishers, gear types, number of gears, fishing location, and fishing start/end time (if the fishing event spanned longer than the survey time, the start/end time was recorded as the survey start/end time except over-night fishing which was then recorded as the average fishing hour of corresponding gear type). (2) An interview-based survey that engaged fishers recorded catch data (species identification, number/weight of the catch). The interview survey was carried out simultaneously with the observational survey, where surveyors attempted to interview fishers from every fishing event observed. Interviewees were asked to provide information related to fisher origin, motivation, frequency, history of use, observations of decline, target species, intention, awareness of rules in their ahupua‘a , and suggestions to improve fishing. For fishers who declined to take part in the interview-based survey, only the observational survey data was collected.

The collected data were analyzed by season to account and test for expected seasonal differences. The seasons were separated into wet (Oct. 23-Apr.18) and dry (Apr.19-Oct.22) season based on the Hawaiian calendar which is known to be adapted for local fishery planning. Since the survey started in the middle of dry season, we grouped dates between Aug. 10, 2013 – Oct. 22, 2013 and Apr. 19, 2014- Jul. 28, 2014 as dry season and Oct 23, 2013 – Apr 18, 2014 as wet season.

Creel Data Analysis
-fishing effort estimation
Daily mean fishing effort for each gear type per season for each WD and WE&H strata was estimated using equation:

$$\bar{E} = \frac{\sum_{i=1}^{d}\sum_{j=1}^{N_i} E_{ij}}{d} \quad \ldots\ldots \text{(eq. 1)}$$

where d was the number of days surveyed for each season, N was the number of fishing events observed on day i, and E_{ij} is the observed fishing effort in gear-hours of fishing event j on day i, where i=1…d, j=1….N_i. Gear hours were calculated by multiplying the fishing time (in hours) and number of gears for each type. Total seasonal fishing effort, E, was estimated by multiplying the daily mean fishing effort ($\bar{E}$) with total number of days for each season.

-catch per unit effort (CPUE) estimation
Average catch per unit effort (CPUE) for each gear type was estimated using the following equation:

$$CPUE = \frac{\sum_{i=1}^{d}\sum_{j=1}^{n_i}\frac{c_{ij}}{E_{ij}}}{\sum_{i=1}^{d} n_i} \quad \text{…….. (eq. 2)}$$

where n_i was the number of fishing events on day i and c_{ij} was catch (in lbs) of fishing event j on day i, where i = 1…d and j = 1…n_i. The fishing effort E_{ij} is the observed fishing effort in gear-hours of fishing event j on day i, where i=1…d, j=1….N_i.

-catch estimation
Total catch was estimated as a product of the total fishing effort and CPUE for each gear type, quarter, and weekday/weekend strata. The trophic group composition for each gear type was calculated by multiplying each group's proportion of the gear sample to the corresponding gear's expanded catch.

III. Result

The creel survey was conducted between August 10, 2013 and July 28, 2014 to capture the full annual fishing effort. A total of 118 days were surveyed. Fishing activity was observed on 102 days (86.4%). During this survey period, a total of 618 fishing events were observed and 338 events (54.6%) included a corresponding interview survey with the fisher. Five days of survey data were dropped from the analysis due to incomplete survey information.

Table 1. Number of survey days (after deletion) for each season and WD and WE&H strata.

Season	WD	WE&H
Dry (Aug 10, 2013 – Oct 22, 2013 & Apr 19, 2014- July 28, 2014)	24	30
Wet (Oct 23, 2013 – Apr 18, 2014)	26	33

Fishing Effort
The total annual fishing effort estimated for Kaʻūpūlehu was 12,051 gear-hours. Three gear types dominated the fishing effort, constituting 87% of total effort: spearfishing accounted for 38%, rod and pole (whipping, slide baiting, and dunking) accounted for 39%, and thrownet accounted for 10%.

Table 2. The detailed annual fishing effort estimated in gear-hours.

Gear Type	Season		Total
	Dry	Wet	
Speargun	1738	1034	**2772**
3 Prong	1013	802	**1815**
Whipping	1087	1219	**2305**
Slide Bait	582	623	**1205**
Dunking	781	369	**1149**
Thrownet	744	402	**1146**
Gleaning	282	491	**774**
Bamboo	100	185	**285**
Trolling	26	111	**137**
Scoop Net	173	0	**173**
Handpole	145	0	**145**
Others	5	140	**145**

Fishing effort data was log transformed to improve normality prior to statistical analysis. The transformation was done on gear-minute instead of gear-hour data to avoid negative values. Tukey's range test showed significant difference ($p<0.001$) in daily average fishing effort between WD and WE&H strata but not between seasons ($p>0.1$) (Figure 2).

When we tested differences of daily average fishing effort between seasons for the major gear types, all gear except speargun showed a higher fishing effort during the dry season compared to the wet season (Figure 3). However, none of these differences were statistically significant based on Tukey's range test ($p>0.1$).

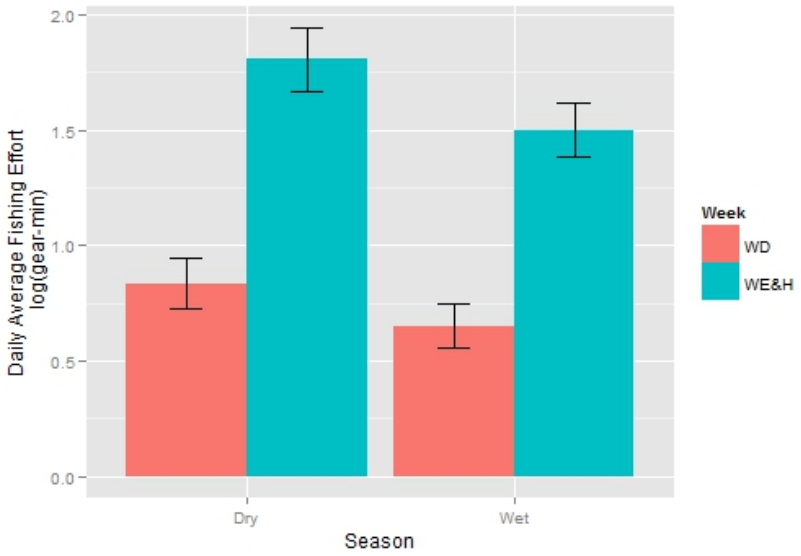


Figure 2. Daily average fishing effort (in gear-minute) by season and week strata for weekdays (WD) and weekends/holidays (WE&H). Error bars are standard errors.

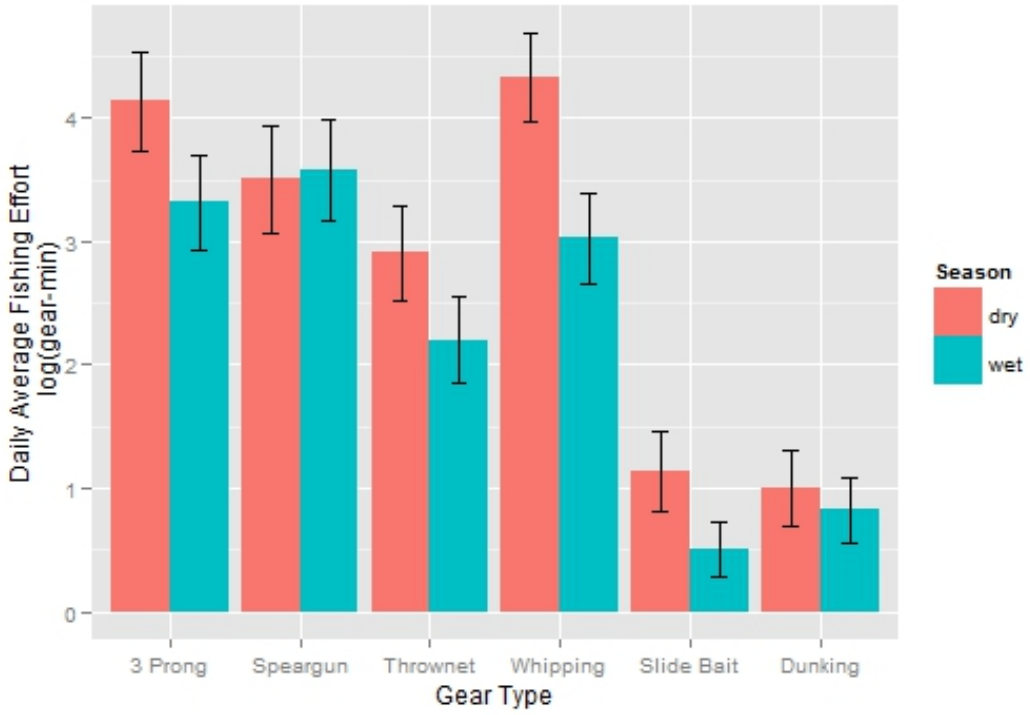


Figure 3. Daily average fishing effort (in gear-minutes) between seasons for each major fishing gear observed at Kaʻūpūlehu creel. Error bars are standard errors.

Fishing Location

The location of fishing effort was categorized into three zones based on habitat, as followed: intertidal (shoreline that accounts for 2 feet of tidal fluctuation), shallow reef (seaward edge of the intertidal zone to 6-10 ft depth), and outer reef (6-10 ft to the edge of reef habitat). Sixty percent of fishing effort occurred in the intertidal zone, whereas 38% of the effort occurred in the shallow reef zone. Ninety-six percent of the fishing effort in shallow reef zone was spear fishing, whereas the intertidal zone was fished with a combination of rod and reel and net fishing (Figure 4). The outer reef zone was rarely fished other than by trollers.

Fifty-one species were caught in shallow reef zone, and 40 species from intertidal zone. Sixty-three percent of the species were caught in both zones, indicating a large species overlap between spear fishing and other fishing methods.

Gear Efficiency (CPUE)

Gleaning was the most efficient method of fishing in the Kaʻūpūlehu survey area followed by spear gun and scoop net fishing (Figure 5). Ninety-nine percent of the catch from gleaning was ʻopihi, and the high CPUE indicates high efficiency with which ʻopihi

can be harvested in the area (Figure 6). Spearfishers used two types of spearfishing gear. Band-powered spearguns comprised of a solid stock and a mechanical firing mechanism,

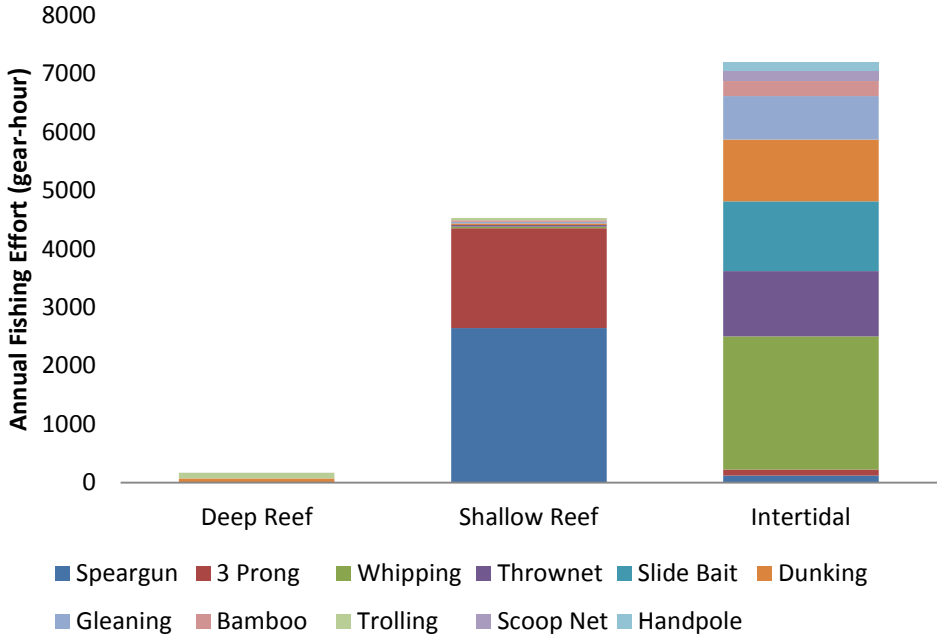


Figure 4. Annually expanded fishing effort (in gear-hours) for each habitat zone (intertidal, shallow reef, and deep reef) at Kaʻūpūlehu creel study area.

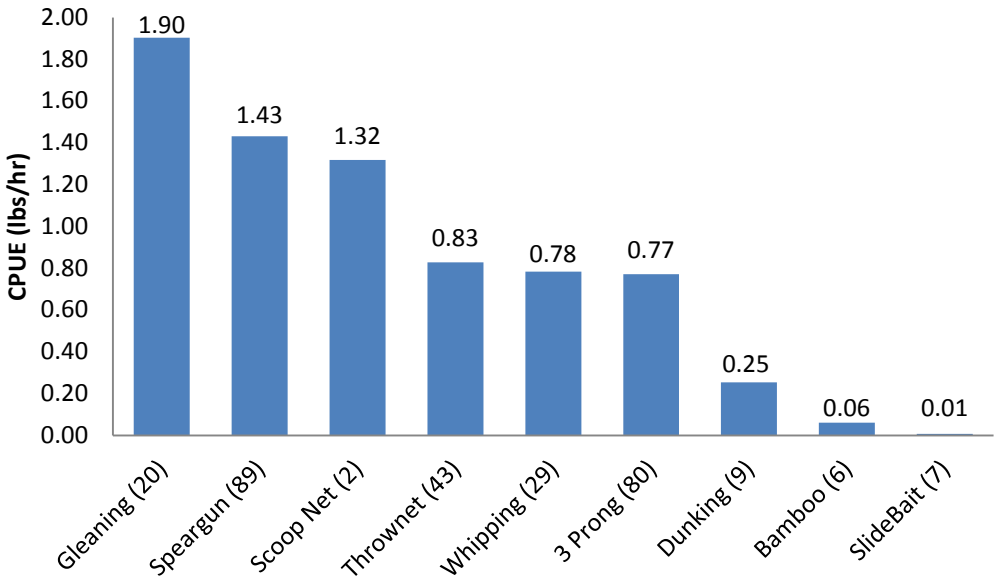
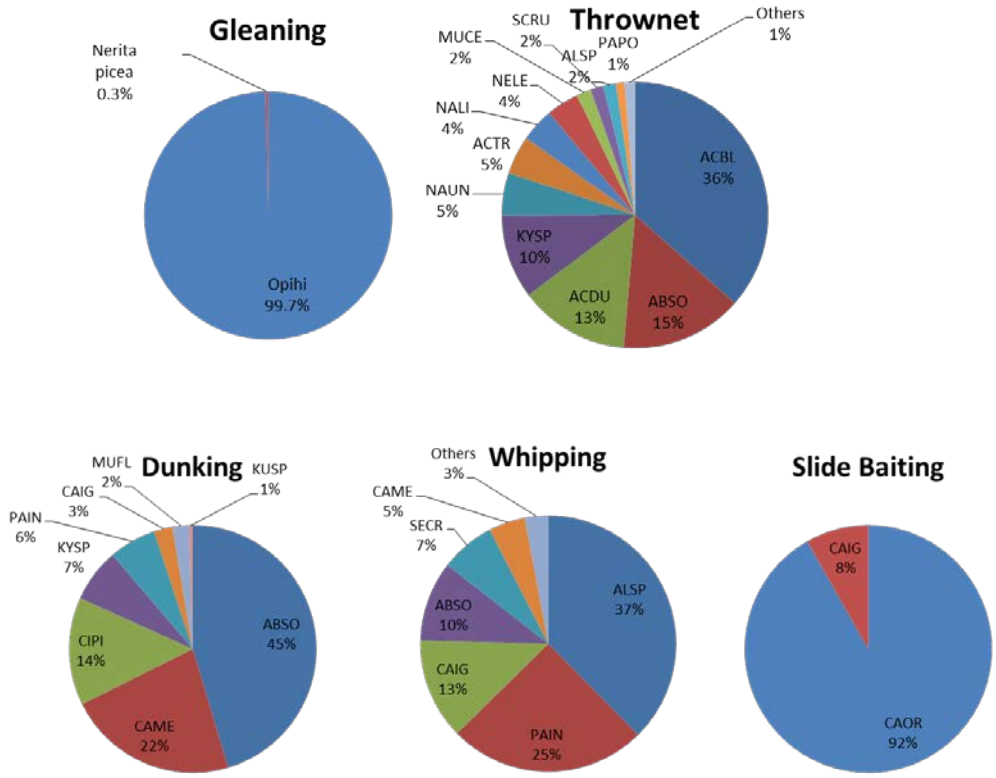


Figure 5. Catch per unit effort (in lbs/gear-hour) for the main gear types observed at Kaʻūpūlehu . Number on the top of the bar is the CPUE value and numbers in parenthesis next to gear types are the number of records used for calculation.

and 3-prongs consisting of a single shaft powered by a rubber band. Speargun caught the most diverse array of species (43 species) including seven apex predators. The 3-prongs did not catch any apex predators. Spearguns typically have longer range than 3-prongs, enabling them to strike fish that may maintain a greater distance from divers. 3-prongs are the preferred gear type for species that are easy to approach or shelter in holes, as indicated by the high proportion of he'e in the 3-prong catch.



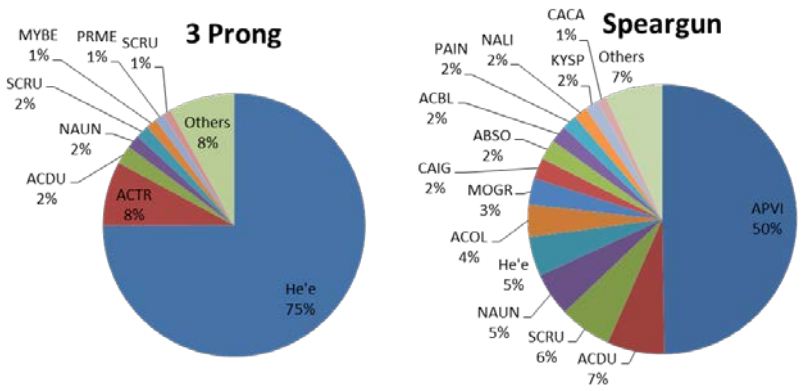


Figure 6. Species catch composition by biomass for each gear type/fishing method. For species names, refer to the species code table on page 2.

Within rod and reel fishing, whipping landed the highest diversity of species followed by dunking and slide baiting (Figure 6). Slide baiting exclusively landed apex predators, whereas whipping and dunking caught both secondary consumers and herbivores. Thrownet caught the second-most diverse array species (after spear fishing), with 70% of its catch being herbivorous species.

Catch (Species and biomass)

A total of 10,139 lbs of marine animals consisted of 55 species are caught annually at Kaʻūpūlehu (Table 3 & Appendix A). Spearguns were responsible for catching 39% of the biomass followed by whipping (18%), 3 prong (14%), and throw netting (9%). Uku were the most commonly caught fish (by biomass), accounting for 1,974 lbs, or 19% of the total biomass taken in Kaʻūpūlehu. Uku were caught exclusively using spearguns.

Two invertebrate species, ʻopihi and he'e, were the next most commonly caught marine animals, accounting for 14% and 12% of the total biomass, respectively, extracted from Kaʻūpūlehu survey area (Table 3).

Commercial catch comparison

More than half (57%) of the commercially targeted species were also caught by recreational fishing at Kaʻūpūlehu creel survey area (Table 4). Among the overlapping species, day tako and uku were heavily targeted by both fishing efforts. The size of Kaʻūpūlehu creel survey area was only 5% of the commercial catch report grid (Figure 7), yet our creel survey revealed that the Kaʻūpūlehu area alone has extracted about the same amount for these species as the reported commercial catch for the entire grid. This could be due to two factors: 1) commercial catch is being under-reported, and/or 2) recreational shore fishing extracts much more than commercial activity due to the much greater number of recreational fishers. It is also important to note that half of the species of the recreational catch at Kaʻūpūlehu are not commercially reported species. These species include 3 apex predators such as ʻomilu (*Caranx melampygus*) and lai (*Scomberoides lysan*), 19 secondary consumers such as ʻoio (*Albula sp*.), goat fish (*Mulloidichthys vanicolensis, Parupeneus cyclostomus*), and kala (*Naso hexacanthus*), and 20 herbivores such as kupipi (*Abudefduf sordidus*) and pualu (*Acanthurus blochii*).

IV. Discussion

The objective of this project was to document the baseline fishery at Kaʻūpūlehu in a statistically robust way to allow for future evaluation of the area's management action (the community-proposed 10-year resting period within the Kaʻūpūlehu FRA). The creel survey confirmed efficient fishing activity was occurring at Kaʻūpūlehu , where the annual landing was estimated to be 10,139 lbs and consisted of 55 reef species. Although no commercial fishing was reported fishers during the creel survey, the biomass extracted was comparable to or exceeded what was reported by commercial fishery landings for the same area and same species. Additionally, this survey shows that commercially catch reports do not always reflect what is caught in the nearshore area; at Kaʻūpūlehu, half of the biomass caught consisted of species that were not fished or reported by commercial fishers.

Table 3. Estimated biomass (lbs) extracted annually from Kaʻūpūlehu for major species. Numbers in parentheses are percentage of the total biomass caught.

Species	Trophic	Speargun	Whipping	Gleaning	3- Prong	Throw net	Dunking	Scoopnet	Bamboo Pole	SlideBait	Grand Total
Uku	Apex	1973.5									1973.5 (19)
ʻopihi	Hervivore			1466.6							1466.6 (14)
He'e	Secondary	187.4			1048.8						1236.1 (12)
Oio	Secondary		679.2			14.8					694.0 (7)
Kupipi	Hervivore	97.2	183.1		1.2	141.2	132.5	0.8	16.6		572.6 (6)
Munu	Secondary	71.5	452.6		2.2		18.0				544.3 (5)
Pualu	Hervivore	81.4			12.5	346.7					440.6 (4)
Palani	Hervivore	273.4			32.1	126.8					432.2 (4)
'ulua aukea	Apex	99.8	229.4				7.1			0.7	337.0 (3)
Pa¯lukaluka (parrot fish)	Hervivore	250.2			36.8	14.9					301.8 (3)
Others	--	932.6	261.6	4.4	265.8	305.4	134.4	227.2	1.4	7.3	2140.3 (21)

Table 4. Comparison between annual catch reported from commercial fishing and creel survey for the area encompassing Kaʻūpūlehu.

Species	Commercial Annual Landing (lbs)	Kaʻūpūlehu Annual Catch (lbs)
Aawa	20	0
Akule	387.6	124.9
Aweoweo	26	17.5
Day tako	673.1	1236.1
Kahala	560.2	0
Kaku	35	16.0
Kamanu	42	0
Kona crab	612.4	0
Kumu	40	21.2
Laenihi	282.6	0
Menpachi	319.2	0
Moana kale	9	0
Mu	31	125.0
Opelu	4881.8	0
Opelu kala	57	0
Palani	21	432.2
Roi	60	16.2
Taape	58.5	0
Toau	13	2.3
Uhu	248	301.8
Uku	2408	1973.5
Weke nono	68.5	0
Weke ula	29.5	2.8
White ulua	154.5	337.0
Others	0	5532.7
Grand Total	11037.85	10139.2

The annual catch at Kiholo Bay, adjacent to Kaʻūpūlehu, was estimated at 16,211 lbs annually (Kittinger et al. *In press*), which is 60% more than the landing estimated for Kaʻūpūlehu. The overall CPUE was higher at Kiholo Bay, but the total fishing effort was 50% higher in the Kaʻūpūlehu, thus reducing the potential difference in total annual catch between the areas. Higher CPUE could indicate a more productive environment in Kiholo Bay or potentially a difference in fishing skill between two sites. The preferred gear type was also different between the two sites: at Kīholo Bay the most common gear types were hand pole (2745 gear-hr), rod and reel (2259 gear-hr), and thrownet (1434 gear-hr) (Kittinger et al. *In press*) whereas at Kaʻūpūlehu the were spear (4587 gear-hr), rod and reel (4659 gear-hr), and thrownet (1146 gear-hr).

Subsequent surveys of Kakapa Bay, which is outside of the Kaʻūpūlehu FRA, will be useful for evaluating the extent to which spillover is benefiting shoreline fishers. We recommend repeating this survey every 5 years throughout the 10-year rest period. Additionally, we recommend conducting similar creel surveys in both Kaʻūpūlehu and the adjacent Kiholo Bay area, since we expect an increase in fishing effort due to the

displacement of effort from the rest area, followed by an increase in CPUE caused by spillover from the rest area. Repetition of the creel survey within Kaʻūpūlehu rest area after it is re-opened will also demonstrate any improvements as a result of management action.

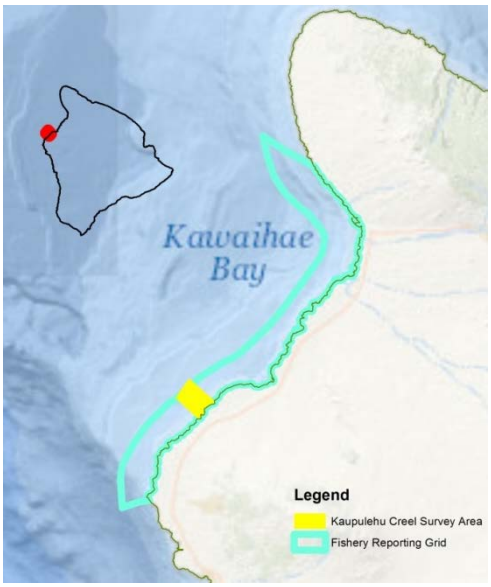


Figure 7. Area delineating Kaʻūpūlehu creel survey area and commercial fishery reporting grid.

V. **References**

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Appendix A. Expanded Catch by Species for each gear type

Scientific Name	Common Name	Trophic Level	Speargun	Whipping	Gleaning	3-Prong	Throw net	Dunking	Scoopnet	Bamboo Pole	SlideBait	Total
Aprion virescens	uku	Apex	1973.5									1973.5
Cellana sp	opihi	Herb.			1466.6							1466.6
Octopus cyanea	he'e	2nd	187.4			1048.8						1236.1
Albula sp	oio	2nd		679.2			14.8					694.0
Abudefduf sordidus	kupipi	Herb.	97.2	183.1		1.2	141.2	132.5	0.8	16.6		572.6
Parupeneus insularis	munu	2nd	71.5	452.6		2.2		18.0				544.3
Acanthurus blochii	pualu	Herb.	81.4			12.5	346.7					440.6
Acanthurus dussumieri	palani	Herb.	273.4			32.1	126.8					432.2
Caranx ignobilis	'ulua aukea	Apex	99.8	229.4				7.1			0.7	337.0
Scarus rubroviolaceus	pa¯lukaluka	Herb.	250.2			36.8	14.9					301.8
Naso unicornis	kala	Herb.	207.1			34.1	49.3					290.5
Cirrhitus pinnulatus	po'o pa'a	2nd		8.8				41.1	221.0	1.4		272.3
Kyphosus species	nenue	Herb.	64.0			4.8	97.0	20.5				186.3
Acanthurus triostegus	manini	Herb.	15.4			113.6	44.5		1.2			174.7
Acanthurus olivaceus	na'ena'e	Herb.	153.8			4.8						158.6
Caranx melampygus	'omilu	Apex	6.0	83.4				65.2				154.6
Monotaxis grandoculis	mu	2nd	125.0									125.0
Selar crumenophthalmus	akule, halalu	2nd		124.9								124.9
Naso lituratus	umaumalei	Herb.	64.2			7.3	38.5					110.0
Parupeneus multifasciatus	moano	2nd	27.5	9.9		13.9						51.2

Calotomus carolinus	--	Herb.	44.2			2.7					46.9
Neomyxus leuciscus	--	2nd	2.1			1.2	37.5		5.0		45.7
Myripristis berndti	'u¯'u¯	2nd	23.3			19.0					42.3
Sargocentron spiniferum	'ala'ihi	2nd	35.3			0.9					36.2
Aulostomus chinensis	nu¯nu¯	2nd	33.1								33.1
Naso hexacanthus	kala holo	2nd	30.3								30.3
Ctenochaetus strigosus	kole	2nd	15.5			6.8					22.3
Parupeneus porphyreus	ku¯mu¯	2nd	4.3	7.1			9.8				21.2
Bothus mancus	pa¯ki'i	2nd	21.0								21.0
Mugil cephalus	--	2nd	2.3				16.9				19.2
Mulloidichthys flavolineatus	weke	2nd	5.0				6.9	6.1			18.0
Priacanthus meeki	'a¯weoweo	2nd	2.0			15.5					17.5
Cephalopholis argus	roi	Apex	16.2								16.2
Sphyraena sp	kaku	Apex	6.5	9.5							16.0
Acanthurus xanthopterus	pualu	Herb.	2.7			11.2					14.0
Melichthys niger	humuhumu'el'ele	Herb.	5.1	6.0		1.1					12.2
Thalassoma duperrey	hi¯na¯lea lauwili	2nd		12.1							12.1
Carangoides orthogrammus	ulua, papa ulua	Apex	4.5							7.3	11.8
Panularis spp	lobster	2nd				10.6					10.6
Bodianus bilunulatus	--	Herb.	6.7								6.7
Nerita picea	pipipi	Herb.			4.4						4.4
Kuhlia sp	aholehole	Herb.					2.8	1.6			4.4

Mulloidichthys vanicolensis	weke 'ula	2nd	1.2			1.6						2.8
Scomberoides lysan	lai	Apex	2.4									2.4
Lutjanus fulvus	to'au, toau	2nd	1.8			0.6						2.3
Acanthurus nigroris	maiko	Herb.	0.9				1.2					2.1
Parupeneus cyclostomus	moano kea	2nd				1.8						1.8
Ctenochaetus hawaiiensis	--	2nd	0.9			0.7						1.7
Aluterus scriptus	--	Herb.	0.6			1.0						1.6
Myripristis species	--	2nd	1.0									1.0
Sufflamen fraenatus	humuhumumimi	2nd				0.7						0.7
Acanthurus achilles	paˉkuʻikuʻi	Herb.	0.5			0.2						0.7
Acanthurus leucopareius	maˉikoiko	Herb.					0.7					0.7
Acanthurus nigrofuscus	maˉi'i'i	Herb.	0.2				0.4					0.6
Kuhlia xenopus	aholehole	Herb.				0.2						0.2
Unknown	--	--				11.6						11.6
Total	--	--	3967.1	1806.0	1471.0	1399.4	949.7	292.0	228.0	18.0	8.0	10139.2

Appendix B. Survey Data Sheets

Observational Survey Data Sheet:

Kaupulehu remote fishing survey (frame survey)

Date_____ Observer_____ GPS_____ North South

Survey time frame	6-10	10-2	2-6	
Weather conditions	Sunny	Rainy	Overcast	
Wind strength	0-5 kts	5-15 kts	15-25 kts	25+ kts
Wind direction	North	East	South	West
Surf height	0-1 ft	1-3 ft	3-6 ft	6 ft +

Gear types

(Pole fishing)- **Hand pole, Whipping, Dunking, Slide baiting, Snagging**

(Boat)- **Trolling, Bottom fish** (Net)- **Scoop net, Crab net, Throw net, Lay net**

(Gleaning)- **Opihi, Aama crab, Limu, Shells** (Spear)- **3 prong, Spear gun**

Other-

Fishing Areas

S= Shore
R= Reef or < 60' deep
D= Deep or >60' deep

Fisher remote entry #	(24hr) Start time (Act/Est)	(24hr) End time (Act/Est)	Zone (Waypoint)	# of fishers	Gear type (one line per gear type)	# of gear per type	interview? (circle one)	Boat based?	Fishing area (circle one)
1							yes no	yes no	S R D
2							yes no	yes no	S R D
3							yes no	yes no	S R D
4							yes no	yes no	S R D
5							yes no	yes no	S R D
6							yes no	yes no	S R D
7							yes no	yes no	S R D
8							yes no	yes no	S R D
9							yes no	yes no	S R D
10							yes no	yes no	S R D
11							yes no	yes no	S R D
12							yes no	yes no	S R D
13							yes no	yes no	S R D
14							yes no	yes no	S R D
15							yes no	yes no	S R D
16							yes no	yes no	S R D
17							yes no	yes no	S R D
18							yes no	yes no	S R D
19							yes no	yes no	S R D
20							yes no	yes no	S R D
21							yes no	yes no	S R D
22							yes no	yes no	S R D
23							yes no	yes no	S R D
24							yes no	yes no	S R D
25							yes no	yes no	S R D
26							yes no	yes no	S R D
27							yes no	yes no	S R D
28							yes no	yes no	S R D
29							yes no	yes no	S R D
30							yes no	yes no	S R D

Notes-

Interview Data Sheet:

Kaupulehu fisher interview

Date_____ Interviewer_____

Fisher remote entry # _____ Refusal? (check) ☐
Interview start time_____ End time_____
What time did you begin fishing today?_____ est. actual (circle one)
What time will you fish till today?_____ est. actual (circle one)

Can I take a look at your catch? No No catch Yes (please fill out below)

Species	# caught	Length (in.) (Act/Est)	Weight (lbs.) (Act/Est)	Gear caught with	Comments

Bonus Questions

Where are you from?_____
Why do you choose to fish here?_____
How often do you fish in this area?_____ x month x year (circle one)
When did you or your family first start fishing in this area?_____
Have you noticed a change in the fish populations? Yes No (if yes) + or - (circle one)
What are you going for today?_____
What will you do with the fish you catch?_____
Are you aware of any "Kapu" or rules set by the Kupuna in your ahupua'a or area? Yes No
If yes, what?_____
Do you have any sugestions to improve the fishing here?_____

Notes-