Pilot Surveys of Shore Fishing on Oahu, Hawaii

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Abstract

In response to recommendations from a recent review of the Hawaii Marine Recreational Fishing Survey (HMRFS), we designed a roving effort and catch survey for non-commercial shore fishing. The on-the-ground roving effort survey was complemented by an aerial survey and a mail-in survey to cover private and remote shoreline areas and night fishing activities. The roving survey was stratified by region (rural or urban), shift (three 4-hour periods during the day), and day type (weekday or weekend). Each region included three non-overlapping coastal segments (sampling units). All of these surveys were field tested in January-April 2015. Results from the pilot mail survey indicate that night fishing accounted for more than one third of the total trips for rod and reel (the major gear type). Over 20% of night fishing was reported in private and restricted areas. Results from the aerial survey indicate that up to 20% of all anglers counted in daylight hours were from remote areas. Thus the effort and catch estimates from the ground-based roving survey need to be appropriately adjusted for under coverage in time (night fishing) and space (remote and private/restricted areas).

Keywords: Hawaii Marine Recreational Fishing Survey, roving creel survey, aerial fishing survey, shore fishing gear, fishing effort, recreational fish catch

1. Introduction

The design of the Hawaii Marine Recreational Fishing Survey (HMRFS) was originally modelled after the Marine Recreational Fisheries Statistics Survey (MRFSS) with two complimentary surveys: the access point intercept survey for catch rate and the coastal household telephone survey (CHTS) for fishing effort. The National Research Council's review of MRFSS recommended that a more efficient and comprehensive sampling frame for fishing effort be established (NRC 2006). In response, the National Saltwater Angler Registry (NSAR) was created. After several years of pilot testing (Andrews et al. 2014), NOAA Fisheries implemented a new fishing effort survey for the Atlantic and Gulf States in 2015. A mail survey using the NSAR combined with other frames has been conducted along with CHTS.

In Hawaii, a fishing license is not required for non-commercial saltwater fishing. For compliance, Hawaii fishermen fishing in federal waters who do not have a commercial license are required to register with the NSAR. Those who are involved only with shore fishing or with boat fishing in state waters only are exempt from the NSAR requirement. Due to the current lack of registered non-commercial anglers in Hawaii (currently less than 100), the NSAR does not provide sufficient coverage for Hawaiian fishing effort surveys. Following a review of HMRFS by a panel of survey experts in 2012, the fishing

effort data collection by the CHTS was identified as insufficient due to the decreasing number of landline telephones and increasing non-response rate (Breidt et al. 2012). A pilot study was necessary to investigate alternative surveys of shore fishing effort and a hybrid method which incorporates a combination of roving survey, aerial survey, and mail survey was proposed (Ma et al. 2014). These pilot surveys were subsequently designed and tested in 2015. The objectives were to pilot test the feasibility of the proposed alternative shoreline survey methods and compare pilot data to data collected concurrently from regular HMRFS and CHTS survey methods.

2. Materials and Methods

The roving survey was conducted on the island of Oahu during daylight hours from January-April 2015. Two surveys were conducted; one for fishing gear counts (effort survey) and the other for catch interviews (catch survey). Both effort and catch surveys were stratified by region (rural or urban, Figure 1), day type (weekday or weekend), and shift (morning 6:30-10:30, midday 10:30-14:30, and afternoon 14:30-18:30). For each survey type, 30 segment and shift combinations (sampling units) per month were selected. Two replicate samples were allocated for weekend strata and three samples for week day strata (Table 1). Instantaneous counts of fishing gears were acquired during the effort survey. For the catch survey, fishers were intercepted/interviewed regardless of whether the fishing trip was in progress or completed. The catch, as well as number, type, and hours fished per gear were recorded during the interview. Only one type of survey (catch or effort survey) was conducted for a given survey assignment.

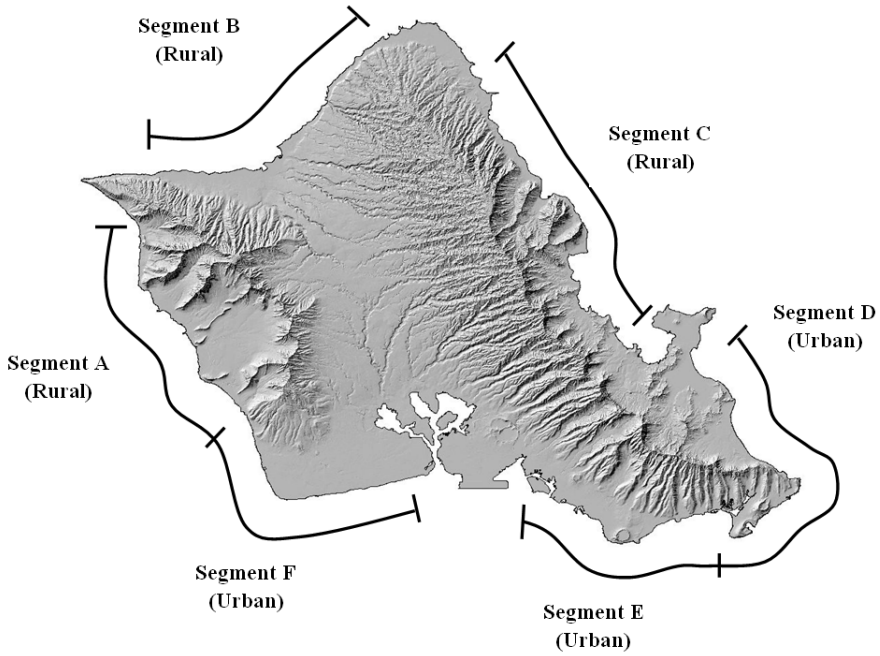


Figure 1. Roving survey segments on Oahu. Segments A-C are in the rural region and segments D-F in the urban region.

Table 1. Sample allocations among strata for each survey type (effort survey or catch survey) in January-April 2015. There were 9 weekend days and 22 weekdays in January, 8 weekend days and 20 weekdays in February, 9 weekend days and 22 weekdays in March, and 8 weekend days and 22 weekdays in April. The numbers in the parentheses for individual strata are the number of possible units (segment days) in the sampling frame.

Shift	Region	January		February		March		April	
		Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday
06:30-10:30	Rural	2 (27)	3 (66)	2 (24)	3 (60)	2 (27)	3 (66)	2 (24)	3 (66)
	Urban	2 (27)	3 (66)	2 (24)	3 (60)	2 (27)	3 (66)	2 (24)	3 (66)
10:30-14:30	Rural	2 (27)	3 (66)	2 (24)	3 (60)	2 (27)	3 (66)	2 (24)	3 (66)
	Urban	2 (27)	3 (66)	2 (24)	3 (60)	2 (27)	3 (66)	2 (24)	3 (66)
14:30-18:30	Rural	2 (27)	3 (66)	2 (24)	3 (60)	2 (27)	3 (66)	2 (24)	3 (66)
	Urban	2 (27)	3 (66)	2 (24)	3 (60)	2 (27)	3 (66)	2 (24)	3 (66)

In conjunction with the roving surveys, two other alternative/supplemental fishing effort surveys were also conducted during the same period. An aerial survey was scheduled two times a month, one weekday and one weekend day per month, from January-April, 2015. The aerial survey days were selected to coincide with at least one roving effort survey assignment. From a fixed-wing aircraft, continuous orthographic digital images (2.5 and 5 cm resolution) were taken of the shoreline area of Oahu (Figure 2). Individual images were then stitched together to form mosaic tiles from which gear and angler counts could be conducted. The aerial survey was used to get a more comprehensive snapshot of daytime shore fishing activity over a broader spatial scale, covering remote and private/restricted areas that may be inaccessible to the ground-based surveyors.

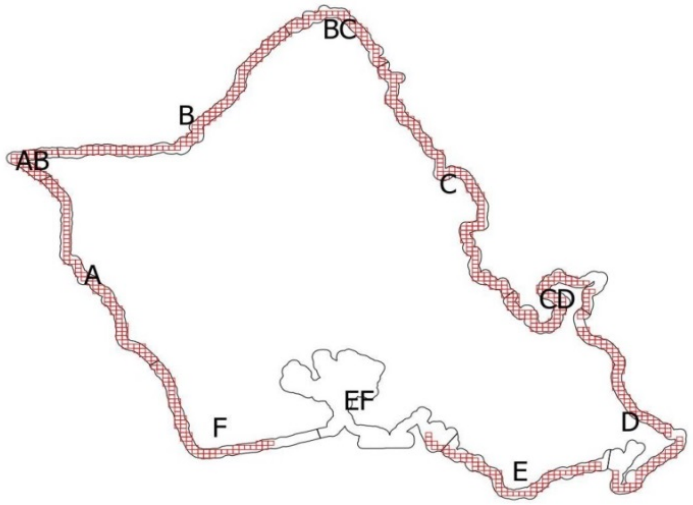


Figure 2. A sample of aerial survey coverage (in red). A-C and D-F are the segments in rural and urban regions of the roving survey, respectively (cf. Figure 1). AB, BC, CD, and EF are the segment boundaries between roving survey segments that are not covered by the roving survey.

The second supplemental survey, an address-based mail-in survey, asked respondents about non-commercial fishing effort from all shorelines including remote and private/restricted areas, as well as during night fishing trips. The mail survey targeted fishing activity during the first two months of 2015. A simple random sample of 3,000 household addresses were drawn from a total of 315,186 Oahu addresses in the sampling frame excluding drop, traditional P.O. Box, seasonal, and vacant addresses. The survey consisted of a pre-letter, two questionnaire mailings, and postcard reminders and the mailing structure was modified from the tailored design methods of Dillman (2000). Seven hundred one fishing and non-fishing households responded to the survey (two households called and stated that they did not fish). Fishermen were specifically asked about the number of days and nights fished from private and restricted areas.

The main objectives of the mail survey were to estimate (1) the proportion of night fishing activities which were not covered by the roving and aerial surveys and (2) the proportion of fishing activities from private and restricted areas that would be missed by the roving survey. The data from the mail survey were also used to estimate the gear hours (during day and night time) per Oahu household. Assuming that there was no non-response error, the mean gear hours per household was expanded to an estimated total gear hours on Oahu to compare with results from the roving survey.

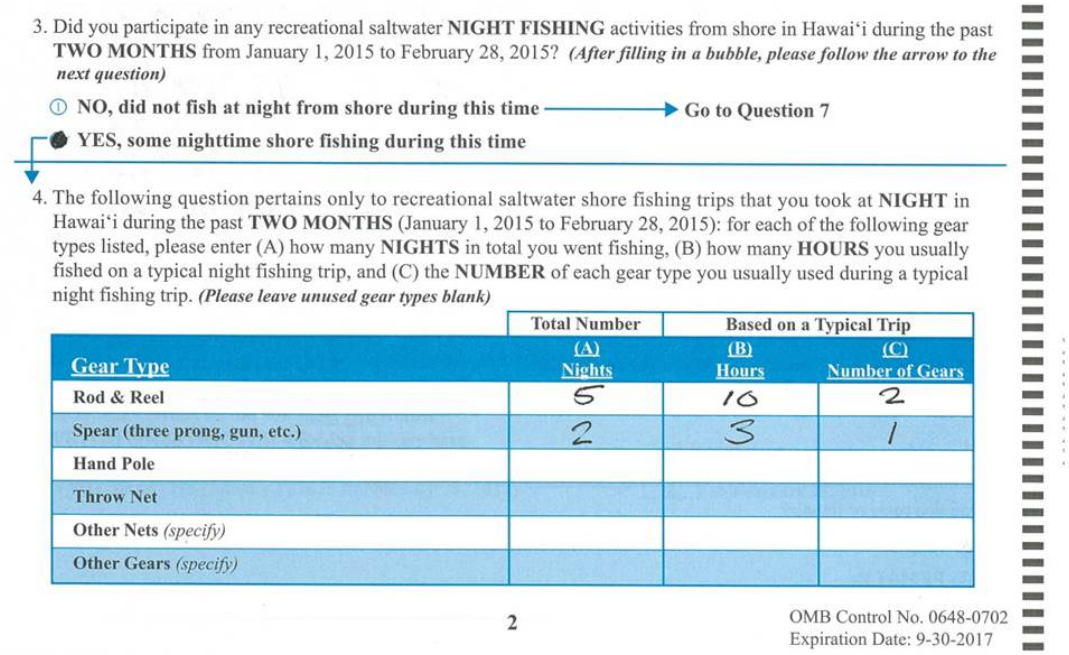
For roving effort survey, the gear and angler counts in a segment from a survey run represent the number of gears and anglers present within the segment at any moment during the shift (4 hour period). Hoenig et al. (1993) used T to denote the duration of the interval under study and C for instantaneous counts. The estimated effort was expressed as $C \times T$ (Hoenig et al. 1993; Pollock et al. 1994). In this study, 2 effort survey runs were assigned for weekend strata and 3 for week day strata each month (Table 1). The mean counts from multiple runs in a stratum (in a month) were expanded to a region (rural or urban) by multiplying a factor of 3 since there were three segments in a region. The mean counts for a region were multiplied by 4 (4 hours in a shift) to get the shift effort estimates (gear hours or anglers hours) for one day in a stratum (there are 12 strata each month, i.e. 2 regions × 2 day types × 3 shifts). The daily effort estimates were further expanded to a monthly estimate based upon number of weekdays or weekend days in a given month.

3. Results

3.1 Mail Survey

Of the 3,000 questionnaires mailed out to Oahu households, 132 were undeliverable and 701 households (including fishing and non-fishing households) responded with household fishing information/data. The overall response rate was 24.4%. Based on the responses, 16.0 % (112 out of 701) of households had anglers who fished in the past year and 10.3 % (72 out of 701) had anglers who fished in the past two months. A total of 55 fishing nights and 65 fishing days were from private and restricted areas (Table 2). For fishing nights and days in all areas combined, fishers were asked for number of fishing nights and days by gear type, the typical trip length, and the typical number of each gear used. In the example shown (Figure 3), we defined the gear with the most number of nights as ‘main gear type’ (5 nights for rod and reel). The sum of nights fished from all gears (7 nights total) was defined as ‘gear nights’. The number of fishing nights would fall between ‘main gear nights’ and total gear nights (i.e., between 5 and 7 nights for this particular fisher given that more than one gear type may be used during a fishing trip). The total number of ‘main gear nights’ was 192.5 and the total number of ‘gear nights’ was 238.5 for all fishers who responded to the survey (Table 2). For the same group, the

total number of 'main gear days' was 379.5 and the total number of 'gear days' was 448. The proportion of fishing nights from private/restricted areas would be 23.1-28.6%, i.e. between 55/238.5 (of total gear nights) and 55/192.5 (of total main gear nights) based on Table 2. The proportion of fishing days from private/restricted areas would be in the range of 14.5-17.1% (between 65/448 and 65/379.5) of the total daytime fishing.



3. Did you participate in any recreational saltwater **NIGHT FISHING** activities from shore in Hawai'i during the past **TWO MONTHS** from January 1, 2015 to February 28, 2015? ***(After filling in a bubble, please follow the arrow to the next question)***

○ **NO, did not fish at night from shore during this time** → **Go to Question 7**

● **YES, some nighttime shore fishing during this time**

4. The following question pertains only to recreational saltwater shore fishing trips that you took at **NIGHT** in Hawai'i during the past **TWO MONTHS** (January 1, 2015 to February 28, 2015): for each of the following gear types listed, please enter (A) how many **NIGHTS** in total you went fishing, (B) how many **HOURS** you usually fished on a typical night fishing trip, and (C) the **NUMBER** of each gear type you usually used during a typical night fishing trip. ***(Please leave unused gear types blank)***

	Total Number	Based on a Typical Trip	
Gear Type	**(A) Nights**	**(B) Hours**	**(C) Number of Gears**
Rod & Reel	5	10	2
Spear (three prong, gun, etc.)	2	3	1
Hand Pole			
Throw Net			
Other Nets *(specify)*			
Other Gears *(specify)*			

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Figure 3. Part of a completed questionnaire showing gear-specific data for night fishing including number of nights, typical trip hours, and number of gears used.

Table 2. Number of fishing nights, fishing days, gear nights and gear days from 701 households that responded to the mail survey.

	Private & Restricted Areas	**All Areas**	**Nights/(Nights + Days)**
Fishing nights	55		45.8%
Fishing days	65		
Gear nights		238.5	34.7%
Gear days		448	
Main gear nights		192.5	33.7%
Main gear days		379.5	

For individual gear types, the total number of nights and days fished are shown in Table 3. For rod & reel and hand pole, night-time fishing accounted for 37% and 46% of the total gear days and nights. For spear fishing and throw netting, night fishing accounted for 10% of the total gear days and nights.

Table 3. Number of fishing days, fishing nights, and gear hours during day and night time for individual gears (from 701 Oahu households). For spear fishing, only one gear was assumed to be actively used at a time even though an angler may have several spear gears available on a trip.

Gear	Gear Nights	Gear Days	Gear Hours (night)	Gear Hours (day)	% Nights	% Night Hours
Rod & Reel	186.5	317	1,822	2,401.8	37.0%	43.1%
Spear	8	70	50	282	10.3%	15.1%
Hand Pole	21	25	157	147	45.7%	51.6%
Thownet	1	9.5	12	44.3	9.5%	21.3%
Other Net	22	23	206	208	48.9%	49.8%
Other Gears	0	2.5	0	6.3	0.0%	0.0%

Assuming that the responses from 701 houses represented all Oahu households, gear days/nights and gear hours in Table 3 were expanded to total Oahu households by a factor of 315,816/701 (Figure 4 for gear hours).

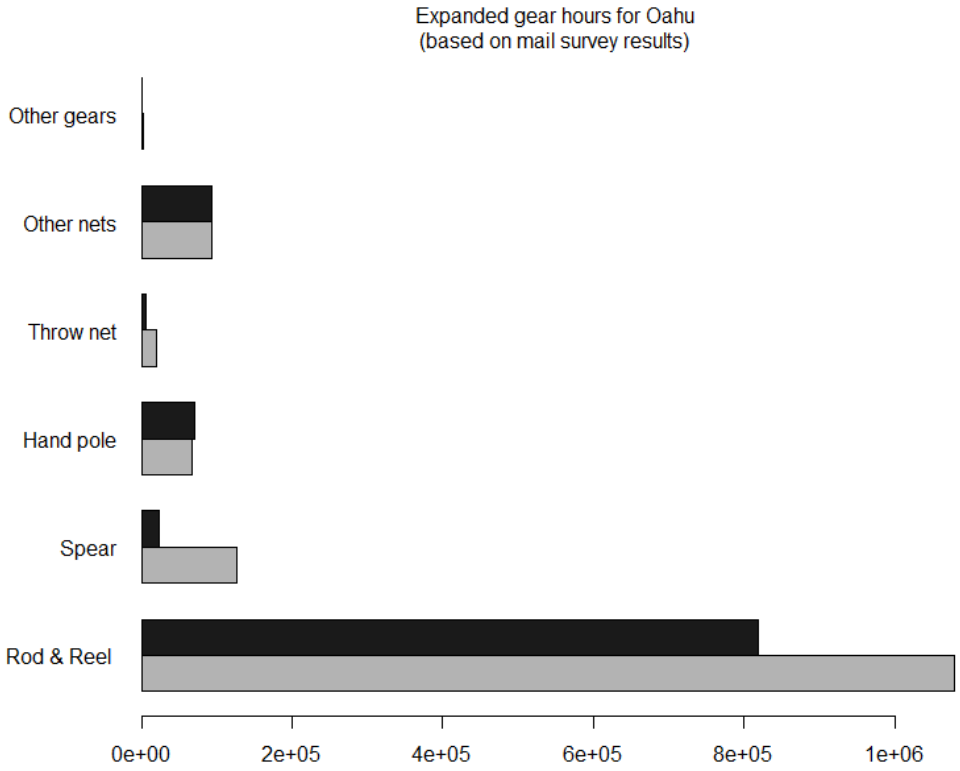


Figure 4. Estimated gear hours during day (gray bars) and night (black bars) for all households on Oahu.

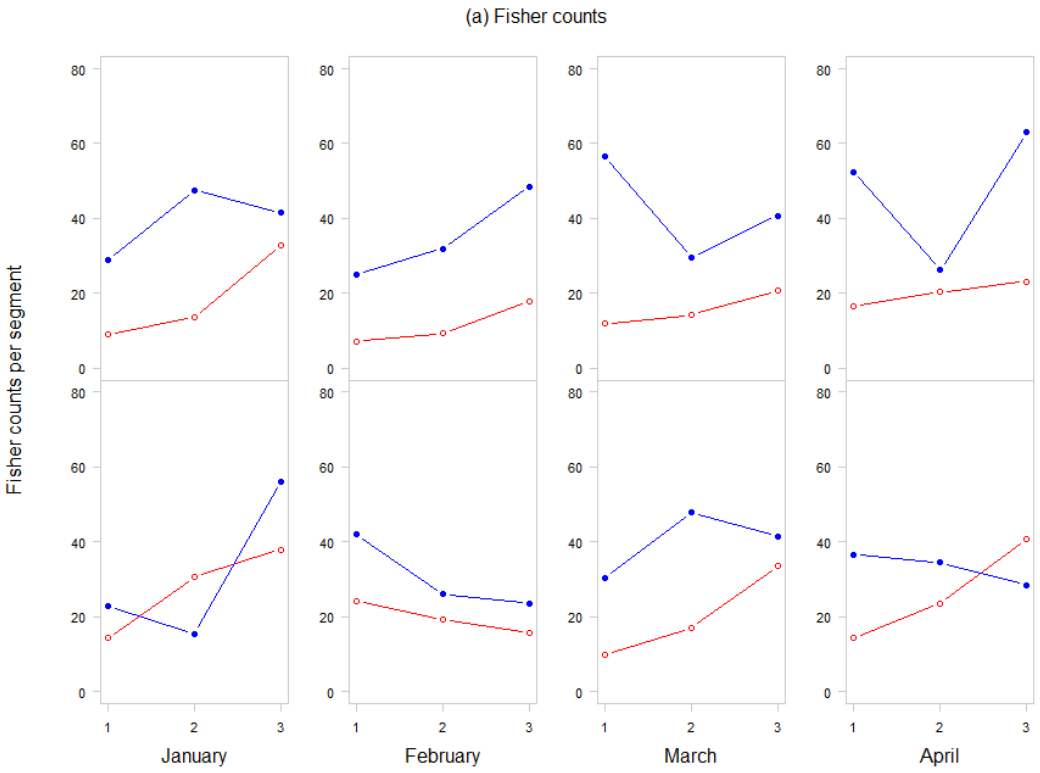
In the mail survey, anglers were also asked about the motive of their fishing trips. There were answers from 189 anglers, of which 50% fished primarily for pleasure and never sold any catch, 44% fished primarily for food and did not sell any catch, 2% fished primarily for commercial profit, and 4% fished for other non-commercial purposes.

3.2 Roving survey

Thirty survey assignments (with different segment and shift combinations) were allocated for each roving survey type (effort survey or catch survey) per month. A few assignments were missed each month due to logistic constraints (Table 4). Mean counts of anglers and gears per segment were higher during the weekend (Figure 5). During weekend days, the mean counts appeared higher in the rural region.

Table 4. Roving survey assignment completion summary. The numbers in parentheses are the target number of assignments.

2015	Catch	Effort	Total
January	27 (30)	30 (30)	57 (60)
February	28 (30)	31 (30)	59 (60)
March	29 (30)	29 (30)	58 (60)
April	28 (30)	30 (30)	58 (60)
Total	112 (120)	120 (120)	232 (240)



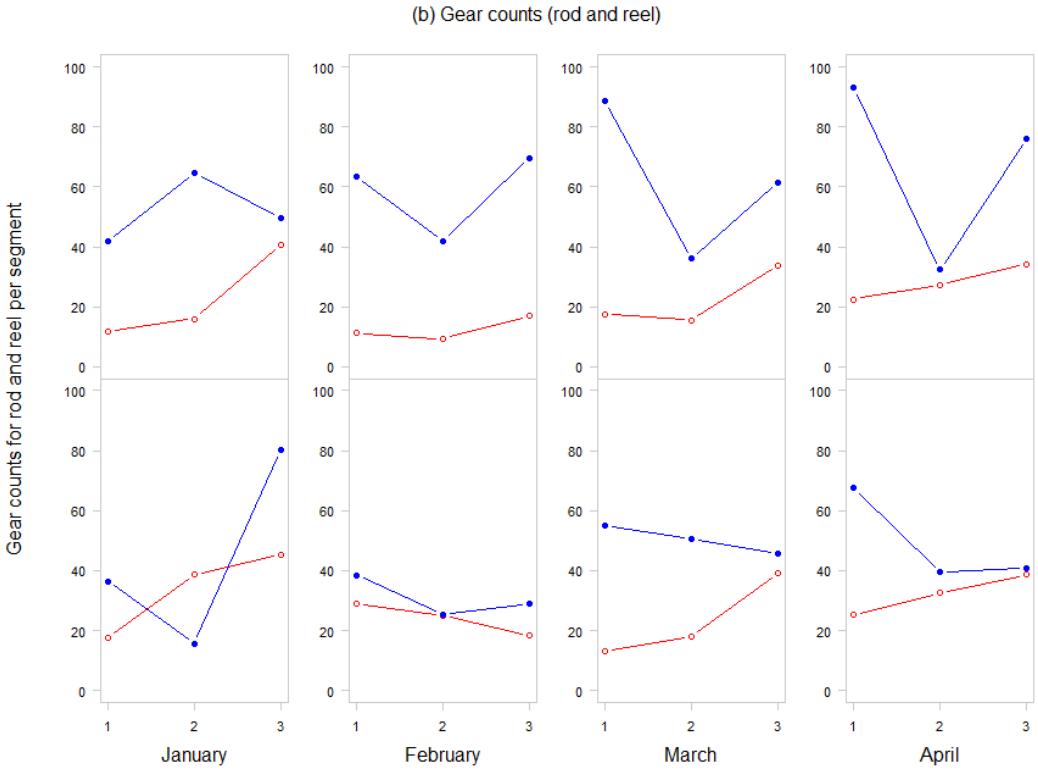


Figure 5. Angler (a) and gear (b) counts per segment in shifts 1, 2, and 3. Gear counts are only shown for rod and reel, the major gear type. Open circles (red) represent weekdays and filled circles (blue) weekends. The upper panels are for rural region and the bottom for urban.

The mean counts per segment in each stratum (Figure 5) were expanded to gear or fisher hours in 12 individual strata in a month. Table 5 contains the sum of gear hours and fisher hours from 12 strata each month.

Table 5. Expanded gear hours and angler hours in each month from January to April 2015.

	January	**February**	**March**	**April**
Rod & Reel	76,034.8	52,100.9	72,586	81,188
Spear	4,590	4,194	5,201	2,808
Hand Pole	2,464.3	1,725.7	3,705	3,052
Thownet	1,143.3	464	284	1,044
Other Net	88	190	669	164
Other Gears	396	0	0	0
Anglers	59,527.9	41,422	55,029	59,873.6

3.3 Aerial survey

Due to issues with insurance liability coverage for the aerial survey contract, the aerial surveys in January were delayed. It was decided that two additional surveys were to be

conducted in February (Table 6). Air traffic (especially during the afternoon and weekend), scheduled activities at military bases, and adverse weather conditions sometimes limited or restricted flight patterns for the aerial surveys. Determination of gear types using the lower resolution images (5 cm) were largely inconclusive so only the higher resolution images (2.5 cm) were used to conduct gear and angle counts.

Table 6. Aerial survey assignment summary. Aerial surveys were conducted on days when roving effort surveys were also scheduled. For roving surveys, the letter indicates survey segment and the number indicates shift (1= 6:30 – 10:30 AM, 2 = 10:30 AM – 2:30 PM, 3 = 2:30 – 6:30 PM).

Month	Weekend Aerial (day)	Weekend Roivng (segment)	Weekday Aerial	Weekday Roving
February	15th	B3	19th	C1, E1, E2
February	28th	B2, C1, E2	27th	B1, F3
March	29th	A1, C3, D1	23rd	A2, C2
April	11th	C1, D2	10th	B2, D1

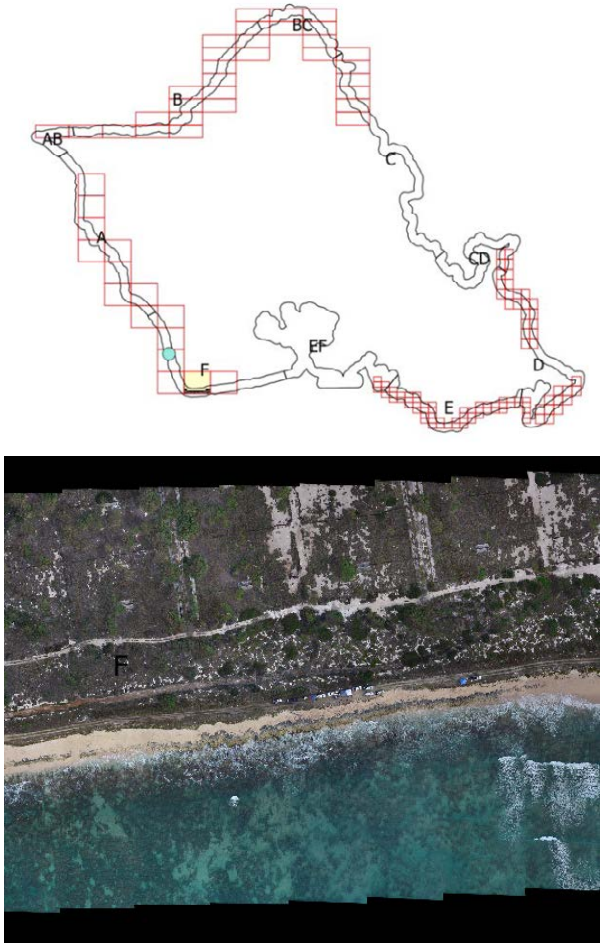


Figure 6. Aerial survey sample on February 28, 2015. The tiles outlined in red contain stitched orthographic images each capturing an approximately 200 m wide swath (see magnified sample, bottom image). The gaps found in some of the segments (e.g.,

segments C, CD, D, and EF) were areas not covered by the aerial survey due to air traffic restrictions and adverse weather conditions.

Table 7. Angler counts (a) and gear counts (b) in areas covered by the aerial survey but not covered by the ground-based roving surveys (defined as "remote" in the table including segments AB, BC, CD, and EF). Segments that were not covered or only partially covered (less than 50% of the whole segment, labeled 0.5 in the parenthesis) by the aerial survey are listed in the last column. Due to coverage variability of the aerial survey, percentages of anglers and gears in the remote areas are approximations. WD = weekday and WE = weekend.

(a) Angler counts

Day	Time	Remote	Total	% Remote	Not covered
Feb 15 (WE)	12:00-13:15	10	157	6.4	EF (0.5E)
Feb 28 (WE)	8:30-10:00	4	63	6.3	CD, EF (0.5C)
Feb 19 (WD)	9:00-10:00	1	5	20	CD, E, EF (0.5 C&D)
Feb 27 (WD)	8:40-10:18	6	31	19.2	CD, EF
Mar 23 (WD)	9:40-11:00	3	63	4.8	CD, EF
Mar 29 (WE)	10:00-11:30	1	110	0.9	AB, B, BC, EF (0.5C)
Apr 10 (WD)	11:20-12:41	14	99	14.1	CD, EF
Apr 11 (WE)	8:50-10:20	33	207	15.9	EF

(b) Rod and Reel counts (all gears in parenthesis)

Day	Time	Remote	Total	% Remote	Not covered
Feb 15 (WE)	12:00-13:15	14(16)	276(286)	5.1(5.6)	EF (0.5E)
Feb 28 (WE)	8:30-10:00	1(4)	88(102)	1.1(3.9)	CD, EF (0.5C)
Feb 19 (WD)	9:00-10:00	1(1)	12(12)	8.3(8.3)	CD, E, EF (0.5 C&D)
Feb 27 (WD)	8:40-10:18	11(11)	41(48)	26.8(22.9)	CD, EF
Mar 23 (WD)	9:40-11:00	4(4)	83(97)	4.8(4.1)	CD, EF
Mar 29 (WE)	10:00-11:30	3(3)	171(190)	1.8(1.6)	AB, B, BC, EF (0.5C)
Apr 10 (WD)	11:20-12:41	50(50)	265(268)	18.9(18.7)	CD, EF
Apr 11 (WE)	8:50-10:20	90(98)	481(519)	18.7(18.9)	EF

Table 8. Comparison of gear and anger counts between aerial and roving effort surveys with overlapping sample days. Counts are summarized only for specific segments covered by both surveys. Surveys with overlapping sample times and relatively good aerial survey coverage are shaded. Note that the aerial sample times are not segment-specific and represent the total sampling period for the entire island of Oahu.

Date	Segment	Aerial Survey					Roving Survey			
		Time	Rod & Reel	Other Gears	Total Fishers	Coverage	Time	Rod & Reel	Other Gears	Total Fishers
Feb 15	B	12:00-13:15	82	0	43	good	14:30-18:08	98	1	60
Feb 19	C	09:00-10:00	0	0	0	poor	06:30-09:30	4	3	5.5
	E					none	06:30-10:30	44	9	40
	E					none	10:45-14:30	34.3	4.6	24
Feb 27	B	08:40-10:18	1	2	3	good	06:30-10:15	20.5	0	10
	F		20	1	10	good	14:35-18:20	35	3	23
Feb 28	B	08:30-10:00	9	1	8	good	10:30-14:06	50	7	44
	C		1	3	4	poor	06:30-10:30	38	8	19
	E		4	2	6	good	10:30-14:30	42	4	44
Mar 23	A	09:40-11:00	12	1	10	good	10:30-14:30	11	5	13
	C		2	3	5	good	10:30-14:22	17	8	14
Mar 29	A	10:00-11:30	45	8	34	good	06:30-10:02	119	2	64
	C		12	0	10	poor	14:45-18:16	64	8.5	39.5
	D		35	1	22	good	06:30-10:25	55	2.5	30.5
Apr 10	B	11:20-12:40	38	0	18	good	10:30-14:05	55	7	35
	D		50	0	17	good	06:45-10:30	10	0	4
Apr 11	C	08:50-10:20	33	5	19	good	06:30-10:04	87	3	40
	D		77	0	34	good	10:40-13:59	79	2	35

4. Comparisons and Discussion

4.1 Mail Survey vs CHTS

The percentage of households with two-month fishers in wave 1 of 2015 was 10.3% based upon the pilot mail survey on Oahu and 2.9% based on the CHTS for the same period. These two percentages are significantly different. The percentage from the mail survey was larger than the percentages from the telephone surveys in any waves (two-month periods) in the past 14 years (as shown in the box plots, Figure 7).

Based on mean gear days per household from the mail survey (Table 2), the estimated gear days and main gear days were 201,431 and 170,632, respectively, for Oahu in January and February 2015. The estimated number of fishing days (fishing during day time) in wave 1 on Oahu based on the mail survey were thus between 170,632 and 201,431. The estimated number of angler trips for shore fishing on Oahu from CHTS during the same period was 100,332 which was lower than the number of fishing days estimated from the mail survey. The estimated angler trips from CHTS (defined as fishing during part or all of one waking day) include some fishing trips that began and ended at night. The angler trip estimates from the CHTS are expected to be higher than the number of trips taken during day time only, which were estimated by fishing days from the mail survey.

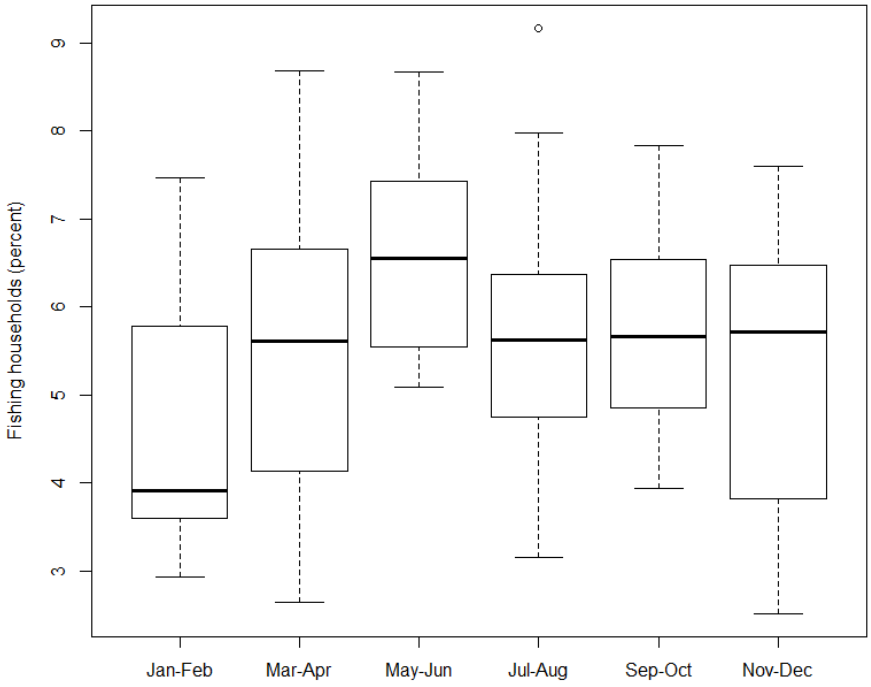


Figure 7. Percentage of Oahu households with anglers who fished in the past two months, based on the coastal household telephone survey data in years 2001-2015.

4.2 Mail Survey vs Roving Survey

The estimated day time gear hours for rod and reel (the major gear type) on Oahu were 128,136 for wave 1 (the first two month) in 2015 based on the roving survey and 1,079,882 based on the mail survey. Effort estimates from the roving survey were anticipated to be lower than the estimates from the mail survey. The roving survey missed the remote areas and did not cover some private and restricted areas.

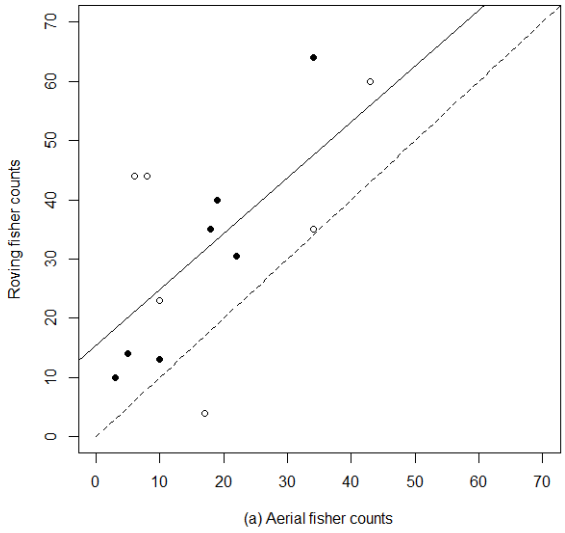
The fishing days from private and restricted areas were 65 for all mail survey respondents. The fishing days from these responding households were between 379.5 and 448 (Table 2). Thus, the proportion of fishing days in private and restricted areas was between 14.5-17.1%. The aerial survey showed that the percentage of angler and gear counts from the remote areas could reach up to 27% of total rod and reel counts (Table 7). Combined angler or gear counts from private/restricted and remote areas comprised less than 50% of the total on Oahu. Anglers and gears from accessible public areas perhaps accounted for more than 50% of the island total.

The degree of coverage of various fishing activities by the roving survey of public and non-remote areas is unknown. Surveyor routes were not always along the shoreline where fishers would be visible. Surveyors stopped at pre-designated sites (10 vantage points or less, per segment) to count anglers and gears. The coastline sub-segments that could be viewed from the designated stopping points may not account for 100% of the coastal line in a segment. However, comparisons of gear and angler counts from roving survey and aerial survey at the same segments did not show higher counts from aerial survey (see next section for more details).

Approximately one quarter of the households contacted for the mail survey had responded. In both the pre-letter and cover letter, potential respondents were asked to reply even if they did not fish for recreation or subsistence, so that the responses would not be biased toward fishing households or non-fishing households. It is still unknown if the responding households (701) were similar to the other households that did not respond (>2000). If the households that responded were not representative of general households on Oahu, the expanded gear hours from the mail survey at the island level would be unreliable. For instance, if non-fishing households were less responsive to the survey, the gear hours would be overestimated. In an extreme scenario, the estimates based on the responding households would be four times the true value if all non-responding households (~75% of the households contacted for the survey) did not fish. The proportion estimates (% night fishing and % fishing from private/restricted areas) from the mail survey are less vulnerable to potential non-response bias because these estimates are determined by the responses from fishing households. For a proportion estimate the bias present in both numerator and denominator can be evened out.

4.3 Aerial Survey vs Roving Survey

The angler and rod and reel gear counts from the roving survey and the aerial surveys showed some linear relationships (Figure 8(a) and (b)). The R-squared values were 0.407 (p value = 0.019) for fisher counts and 0.389 (p value = 0.023) for rod and reel counts. No significant linear relationships were present for other gear counts combined (Figure 8(c)). In most cases, the counts for anglers and rod and reel from the roving survey were larger than those on the same segments from the aerial survey (Figure 8 (a) and (b)). Some fishers and gears were likely missed in the images captured during the aerial survey. The high resolution images from the aerial survey had a swath of ~200 m; anglers and gears beyond the 200 m swath would thus be missed in the images. Because the major shoreline gear type is rod and reel, the images were focused on the shoreline areas and may not have adequately captured anglers/gears further seaward (e.g. spear fishers, gill netter, and thrown netters). Even at relatively high resolution, fishing gears were sometime difficult to discern and may not have been counted due to conservative identification and enumeration procedures.



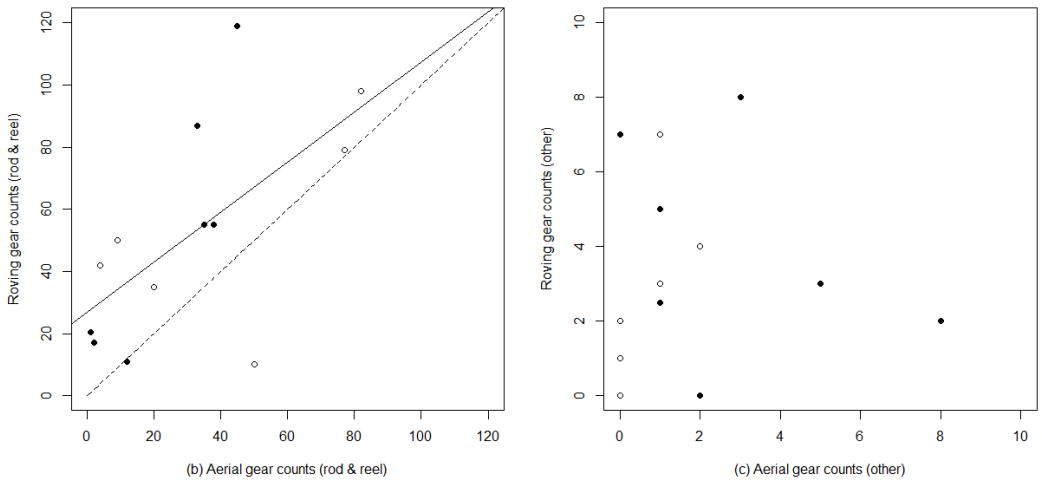


Figure 8. Fisher (a), rod and reel (b), and other gear (c) counts at individual segments from roving and aerial surveys. The solid lines are linearly fitted lines. The filled circles represent counts where sample times of roving and aerial surveys overlapped (see Table 8). Other gears include spear, hand pole, throw net, other nets, and other gears.

5. Summary

The mail survey suggested that for rod and reel (the major gear type), night fishing accounted for more than one third of total trips (day and night trips using rod and reel). For all gear types combined, night fishing trips also accounted for more than one third of total day and night trips. Night fishing trips from private and restricted areas were in the range of 23.1-28.6% of the total fishing trips at night according to the mail survey (in the range of 14.5-17.1% for daytime fishing trips). The aerial survey indicated that up to 20% of all anglers and up to 23% for all gears counted in daylight hours were from remote areas. The differences in the gear hour estimates between mail and roving surveys are likely due to potential non-response biases in the mail survey and the under coverage of roving survey for fishing activity at remote, private/restricted, and even accessible public areas. The estimated proportions of night fishing and fishing from private/restricted areas would be more resistant to potential non-response bias in the mail survey. It may be more efficient if the mail survey was also used to estimate the proportion of fishing in remote areas, rather than using an additional aerial survey. These proportion estimates from supplement surveys help adjust the coverage for areas and durations missed by roving surveys during the day. Data from these pilot surveys will be evaluated further to identify potential methods for improving HMRFS.

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