A Review of the Current Sampling and Estimation Methods of the Hawaii Marine Recreational Fishing Survey

FY 2012 Proposal

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1. Overview

1.1. Sponsor
Joshua DeMello

1.2. Focus Group
Survey Design and Evaluation

1.3. Background
Hawaii is the only island area under the Marine Recreational Information Program (MRIP) /Marine Recreational Fisheries Statistics Survey (MRFSS) in the Western Pacific region. Presently, Hawaii follows the standard dual-frame design that was re-initiated with MRFSS in 2001. The on-site intercept surveys (for catch rate) in Hawaii are conducted by the Hawaii Marine Recreational Fishing Survey (HMRFS), a project managed by the State of Hawaii's Division of Aquatic Resources (HDAR). The coastal household telephone survey (CHTS, for fishing effort) in Hawaii is currently conducted by a local contractor and managed by a mainland company that runs the CHTS for the Atlantic and Gulf States. The review of MRFSS by the National Research Council (NRC) provided recommendations for improving intercept surveys and telephone surveys (NRC 2006). The alternative method for catch rate estimation developed by MRIP (Breidt et al., 2011) was one of the major responses to the NRC's recommendations. The new MRIP estimation procedures were mainly based on data from Atlantic and Gulf States. A review of HMRFS intercept survey data indicated that the available historical data files were not adequate for the new estimation procedures (Ma et al., 2011). Since early 2011, HMRFS sampling protocols and programs have been more similar to the Atlantic and Gulf States. Although the new estimation methods are currently applicable to HMRFS data, the new estimation procedures still need to be modified to re-estimate catch from HMRFS prior to 2011. The coastal household telephone survey (CHTS) uses the random-digital-dialing method to collect information about fishing trips taken by anglers. As a response to the recommendations by the National Research Council panel (NRC, 2006), the National Saltwater Angler Registry (NSAR) was created to provide a more efficient sampling frame for conducting fishing effort surveys. Most states/territories have applied for exemptions based upon pre-existing state angler registries or other alternative databases. Marine licensing/registration are not required by Hawaii State law for most recreational fishermen (except for bottom fishing). Currently, Hawaii is the only state where recreational fishermen are required to register with NSAR. There are no anadromous fish in Hawaii, and shoreline anglers and boat fishermen only fishing within 3 miles from the shore are exempted from NSAR. Therefore, the NSAR from Hawaii is an incomplete sampling frame for boat fishing effort surveys and the registry does not contain anglers who are involved in shoreline fishing only. In another MRIP proposal to be submitted for FY 2012, the vessel registry maintained by the State of Hawaii's Division of Boating and Ocean Recreation (DBOR) will be tested as a potential sampling frame for boat fishing effort surveys. A sampling frame for shoreline anglers, however, is still unavailable. In response to NOAA's Next-Generation Strategic Plan, all US coastal states are to evaluate current sampling protocols and, as needed, provide reasonable modifications/alternatives for review by MRIP that would improve the quality and precision of non-commercial fishing data for the state. MRIP has recently funded efforts to review sampling and estimation methods for the Oregon Recreational Boat Survey (ORBS), the Washington Ocean Sampling Program (OSP), and the California Recreational Fishery Survey (CRFS). The reviews of these survey programs have been very effective in improving those surveys as well as further standardizing the data on a national level. We are proposing a similar review of the current HMRFS sampling design and estimation methods by MRIP statistical consultants and are seeking their evaluation of options to modify/improve HMRFS.

1.4. Project Description
The current and historic sampling design and estimation of the Hawaii Marine Recreational Fishery Survey (HMRFS) and the Costal Household Telephone Survey (CHTS) in Hawaii will be reviewed by the MRIP statistical consulting team. Two of the consulting team members had participated in the MRFSS review (NRC, 2006) and the sampling design and estimation methodology of HMRFS were modeled after original MRFSS survey designs. The review of HMRFS can focus on the Hawaii specific components of the design and estimation (including estimation methods and estimates). NMFS and HMRFS will provide necessary documents/data files to the consultants at the beginning of the project study. Then a face-to-face working meeting (mainly among consulting team members, NMFS staff, and HMRFS staff) will be hosted to evaluate the present survey methods and alternative options. After the consultant report is drafted, a workshop can be hosted later with NMFS/Council staff (mostly local), local resource managers, fishermen, and the fishing community to collect additional input and feedback on the results and recommendations from the review/evaluation.A separate MRIP proposal will be submitted to test a mail survey (for boat fishing effort) using the DBOR boat registry. As part of the current proposal, the pros and cons of alternative survey methods for shoreline fishing will be evaluated by the consulting team. While an access point survey is practical for shoreline fisheries where many of the target areas have a single access point (e.g. piers, jetties, etc), the shoreline fisheries in Hawaii are characterized predominantly by natural coastlines where multiple access points along a given coastline are more typical. In Hawaii, shoreline anglers tend to spread out along a broad stretch of coastline as opposed to clustering around man-made fishing structures. A roving survey may be better suited for the topography of the coastline as well as the nature of the shoreline fisheries in Hawaii (Pollock et al., 1994). The feasibility and possible constraints of alternative survey methods will be investigated.

1.5. Public Description

1.6. Objectives
The objectives of this project are to: 1) identify issues with current HMRFS including sampling design, estimation, and regional data needs; 2) evaluate alternative survey options for HMRFS such as a) survey methods used in NC pilot studies, b) roving survey or mail survey as an alternative to the current telephone survey for shoreline fishing effort, and c) mail survey using the DBOR vessel registry for private boat mode; 3) provide guidance on how to proceed with re-estimation of catch from historic HMRFS survey data where necessary data files were inadequate and an early version of the sampling draw program was used; 4) make suggestions for future projects to test recommended options or to modify existing methods.

1.7. References
1) Breidt, F. J., H. Lai, J.D. Opsomer, and D.A. Van Voorhees. 2011. Improved estimation methods for the access point angler intercept survey component o the Marine Recreational Fishery Statistics Survey (MRIP project report, externally reviewed). 2) Ma, H., D. Hamm, L. Johansen, T. Sminkey, and T. Ogawa. 2011. Hawaii pilot study to improve intercept survey (MRIP project report). 3) NRC (National Research Council). 2006. Review of recreational fisheries survey methods. The National Academies Press, Washington, D.C. 4) Pollock, K.H., C.M. Jones, and T.L. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publication 25.

2. Methodology

2.1. Methodology
The reviews will be conducted by a team of survey statisticians who have been hired under contract as consultants by NMFS MRIP.The review of the HMRFS will be planned cooperatively by NMFS, State of Hawaii Division of Aquatic Resources (HDAR), and the Western Pacific Regional Fishery Management Council (Council) to address the priorities of MRIP, the State of Hawaii, and the Council. NMFS and HMRFS staff will provide documentation on the current HMRFS methods and will take the lead on presenting those methods to the consultants. The review will be conducted through meetings and conference calls with NMFS and HMRFS and will culminate in a workshop, hosted in Hawaii, to review the findings and collect additional input from partner agencies, fishermen, and the fishing community. NMFS will facilitate the reviews and work with HMRFS to schedule and plan the meetings.Depending on the MRIP consultants' recommendations, the logistics (driving time/distance between different sections of an island, identification and sectioning of active fishing areas) can be examined for each of the survey methods recommended. Existing HMRFS surveyors can be used for the investigation because of their experience in the field. Details of roving surveys currently employed by the Western Pacific Fisheries Information Network (WPacFIN) in other US island territories in the Western Pacific will be explored as a potential alternative. Currently, a statistician contracted by the Council is finalizing a review for the WPacFIN whereby a draft report for the review will be available during the time frame of the proposed project study.

2.2. Region
Western Pacific Islands

2.3. Geographic Coverage
The Main Hawaiian Islands of Hawaii, Maui, Lanai, Molokai, Oahu, and Kauai.

2.4. Temporal Coverage
2003 to Present

2.5. Frequency

2.6. Unit of Analysis

2.7. Collection Mode
Survey data collected through intercept surveys and telephone surveys

3. Communication

3.1. Internal Communication
Bimonthly conference calls (or as needed) and more frequent email communications will made among project team members. Documents/data will be distributed/shared via email and can be posted to MRIP Collaboration Tool as well.

3.2. External Communication
Monthly updates of the project will be reported to MRIP and a final project report will be submitted.

4. Assumptions/Constraints

4.1. New Data Collection
N

4.2. Is funding needed for this project?

4.3. Funding Vehicle
Transfer to NMFS PIFSC and some funding can be added to existing grant with HDAR

4.4. Data Resources
HMRFS data and statistics for 2003 to present

4.5. Other Resources
Consultant labor and travel will be needed to perform the reviews, provide reports of recommendations, and support development of new project proposals to address those recommendations.Partners' travel will be needed to attend the meeting/workshop on the review/evaluation of the current methods and future options. HMRFS staff will need assistance for compiling the data that may be requested by the consultants.

4.6. Regulations

4.7. Other

5. Final Deliverables

5.1. Additional Reports
MRIP statistical consultant report

5.2. New Data Set(s)

5.3. New System(s)

6. Project Leadership

6.1. Project Leader and Members

First Name	Last Name	Title	Role	Organization	Email	Phone 1	Phone 2
Jay	Breit	Professor	Team Member	Colorado State University			
Joshua	DeMello	Recreational Fisheries Coordinator	Team Member	WPRFMC			
David	Hamm	Branch Chief	Team Member	NMFS PIFSC			
Chris	Hawkins	Social Scientist	Team Member	NMFS PIRO			
Virginia	Lesser	Professor	Team Member	Oregon State University			
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First Name	Last Name	Title	Role	Organization	Email	Phone 1	Phone 2
Tom	Ogawa	HMRFS project manager	Team Member	HDAR			
Jean	Opsomer	Professor	Team Member	Colorado State University			
Tom	Sminkey	Statistician	Team Member	NMFS S&T			
Dave	Van Voorhees	Division Chief	Team Member	NMFS S&T			

7. Project Estimates

7.1. Project Schedule

Task #	Schedule Description	Prerequisite	Schedule Start Date	Schedule Finish Date	Milestone
1	Prepare documents and compile necessary data for review		05/01/2012	05/31/2012	
3	Have a face-to-face working meeting among consultants and NMFS and HMRFS staff	2	07/02/2012	07/06/2012	Y
4	Produce draft report of recommendations for HMRFS improvements	3	07/07/2012	08/31/2012	
5	Review the draft report with partners and fishing communities for additional discussion and feedback	4	09/05/2012	09/06/2012	
6	Produce final report of recommendations for HMRFS improvements	5	09/15/2012	10/31/2012	Y
9	Final report including consultant report	6,7	11/01/2012	12/31/2012	Y
2	Conduct initial review of HMRFS and plan meetings	1	06/01/2012	06/30/2012	

Task #	Schedule Description	Prerequisite	Schedule Start Date	Schedule Finish Date	Milestone
7	Feasibility and logistics evaluations for HMRFS improvement options	3	09/01/2012	10/31/2012	
8	Develop new MRIP proposal(s) for Hawaii recreational fishing surveys	6,7	11/01/2012	12/31/2012	

7.2. Cost Estimates

Cost Name	Cost Description	Cost Amount	Date Needed
Workshop/meeting venues & logistics	Meeting room, parking, equipment renting, etc.	$5000.00	06/01/2012
Workshop travel expense	Neighbor-island partners & fishing community representatives attending the workshop	$10000.00	09/01/2012
Data compilation	Organize and compile needed data files & documents for review	$2000.00	03/01/2012
MRIP contractor support	Labor (90 hrs each) and travel (airfare and hotel) for three consultants	$52000.00	06/01/2012
Pilot field study (roving survey)	Field contractor labor & mileage reimbursement	$4000.00	09/01/2012
TOTAL COST		$73000.00	

8. Risk

8.1. Project Risk

Risk Description	Risk Impact	Risk Probability	Risk Mitigation Approach
The face-to-face working meeting and a workshop with partners and fishing communities may not be held during the months planned due to unpredictable schedule conflicts.	May delay the completion time of the project	Medium	Report drafting/finalizing process could be expedited to make up for possible delays.

9. Supporting Documents
"Final Report", page 1

Consultant's Report: Preliminary Review of Hawai'i Marine Recreational Fishing Survey

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1 Introduction

Our review of the Hawai'i Marine Recreational Fishing Survey (HMRFS) included a one-day field trip (July 16, 2012) by Lesser and Breidt to recreational fishing sites on the island of Oahu, where we observed a field intercept, followed by a three-day meeting (July 17–19) in Honolulu. In this document, we will provide our reaction to the design and estimation procedures for Hawai'i, as we understand following this visit and subsequent discussion of this report.

We begin by briefly summarizing our overall reaction to HMRFS. First, as in other states, Hawai'i faces the challenge of getting representative samples of anglers. The nature of the island geography is unique. The approach to fisheries management was surprising to us: the state of Hawai'i seems to ask little of anglers and to provide little in return. For example, no licenses

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are required for recreational fishing, even for out-of-state anglers. At $50, a Commercial Marine License (CML) is extraordinarily cheap. The state of Hawaii does not seem to be actively managing any species: many of the published regulations specify open season and no bag limits. Boat ramps are in disrepair and there are essentially no man-made structures designed for fishing. Given this hands-off environment, it is perhaps not surprising that there was a general pessimism about asking anything of anyone in managing the fishery.

In addition to the fact that the HMRFS data were not being used for management by the state, they were not being used by the Council, due to perceived variability issues. We were left wondering how the data are currently used. This indicates that NOAA management should participate in discussion with Hawai'i to determine their data needs and goals for this study. Having a clear purpose could be helpful in outreach activities that could engage anglers to improve cooperation rates, leading to improved data and estimates.

In the remainder of this report, we outline our recommendations for possible extensions or improvements to HMRFS, as well as a few suggestions for further study.

2   Preliminary Findings and Recommendations

2.1   Re-estimation

Historical data from HMRFS have been collected via a stratified, clustered, unequal probability design, but the estimation procedures used for these data have not reflected these design features. This mismatch between design and estimation leads to potential for bias. A written report reviewed by us indicated that not all of the metadata necessary for constructing appropriate weights were available, but our understanding from the meeting is that these data may be available, albeit not electronically. In any event, some effort to conduct the reestimation procedure should be undertaken. The weights can be modeled, if necessary, by making assumptions about the stability of pressures over time. Any such modeling assumptions must be clearly stated as part of any reestimation data products.

Though this was not discussed at the meeting, it is worth noting that for the future, HMRFS should collect sufficient design information to allow for

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proper weighting of the data. An external review of current protocols would be useful to ensure that such design information is being collected.

2.2 Training

The first day of the meeting included attendance by the field staff from all the islands. Discussions with these staff indicated some inconsistencies in their understanding of field methods. Examples included differences in the way they understood their enforcement mission, if any (*report or do not report gross violations?*), and differences in the way they understood the definition of man-made versus beach-bank mode (*which mode is fishing from an old house foundation?*) This measurement error is particularly troublesome because it leads to systematic, correlated errors across all assignments handled by that staff member. In the case of Hawaii, this could mean that a substantial fraction (or even all) the intercept data could suffer from correlated measurement error.

The best way to ensure consistency across field staff is through training exercises at regular intervals. Protocols should be reviewed at these training meetings to assure that the field interviews remain consistent among the interviewers.

2.3 Nonresponse in the shore angler intercept survey

Nonresponse errors occur because complete data are not obtained for all sampled elements. Nonresponse may lead to serious bias if the nonresponding part of the sample differs systematically from the responding part.

In the intercept survey, anglers may be missed, or may be intercepted but refuse to cooperate. These refusals may be due to a language barrier or a general aversion to surveys, or might be due to catch characteristics: e.g., wanting to focus on fishing because of having zero catch, or wanting to focus on fishing because of having lots of catch. Discussions with the interviewing staff yielded additional examples of how refusal rates could depend on weather, gear types, illegal or not-clearly-legal activities, etc. For example, throw nets have more regulations than other gear types. Anglers using throw nets might prefer to stow their gear and leave if they have any doubts about their compliance.

This last example explains why enforcement should be clearly separated from data collection, as noted in §2.2. We were glad to see that surveyors are

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making great efforts to build rapport with anglers. Incentives like hats and t-shirts can be very effective. It might be worth including interpreters on occasion, if consistent refusals are being obtained due to language barriers. Another possibility is to consider collecting additional data that could help explain refusals, for later use in weighting and imputation. Such data would need to be observable without the cooperation of the angler, such as gear type, any catch observed, etc.

2.4   Boat intercept survey

The boat intercept survey was not discussed to any great extent, but one point that did arise was the visibility of the boat's registration tags. If the interviewer could record the tag information, this could be linked to the CML list through matching of the addresses on each list. Such a match would allow cross-checking of the catch (or non-catch) of CML-holding private boat owners against CML monthly reports.

2.5   Extreme events

Hawai'i provided a number of examples of unusual or extreme catch events. For example, Hawai'ian anglers may use gear types that are relatively unusual elsewhere, such as throw nets or spears. The catch in a net haul would be extreme if combined with rod-and-reel catch. The kinds of species caught by spearfishing might be quite unusual. "Trashbag fishing", in which a baited line is carried far offshore by a trashbag used as a kite, can lead to other extreme events, such as the (anecdotal) marlin caught from shore.

There is a literature in survey statistics on how to handle extreme or outlying values: see, for example the papers by Chambers (1986), Smith (1987), Hulliger (1995) and the review by Beaumont and Rivest (2009). We will not attempt to summarize this literature here, but will briefly sketch a standard approach.

First, the data must be carefully edited by staff with local knowledge, so that such unusual or extreme events do not badly distort catch estimates. For the most part, it seems that such editing procedures are already in place.

Next, in the event that a data value is found to be valid, but is known to be very unusual, a standard approach is to leave the observation in the data set but reduce its sampling weight. The sampling weight represents

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the number of elements in the population represented by this sampled element. A data value known to be *unique* would receive the greatest possible reduction in sampling weight, all the way down to a weight of one. Elements with a weight of one are said to be "self-representing" since they represent themselves and no other population elements. Weights larger than one and less than the original sampling weight could be entertained for data values known to be unusual but not unique. The literature referenced above gives formal statistical techniques for determining such weights.

2.6   Charter boats

Our understanding of charter boats in Hawai'i is as follows. A charter boat must have a CML. Some charter boats keep essentially all of the catch for sale to a dealer. As a CML holder, the charter boat captain fills out a CML daily log and reports monthly. These reports can be checked against dealer listings of sales. This system, therefore, has both a well-defined method of assessing catch and effort and an external method for validating catch and effort.

However, not all charter boats complete log reports. Therefore, there are compliance issues to address for the charter boats, particularly the need for improvement in reporting for the recreational fishery. If the data quality and compliance issues can be addressed for the charter boats through other mechanisms, possibly including focus groups to determine methods that may improve cooperation, then no additional sampling of charter boats is recommended. During the focus group discussion, Hawai'i can not only determine why the logs are not completed, but also find out ways to convince the boat owners/captains that recording recreational fish catch is important to the State and to them. Hawai'i can also ask the focus group participants how to efficiently get this message out to all the charter boat owners/captains.

2.7   Effort estimation options

A number of options for effort estimation were discussed at the meeting. These included off-site options, such as the current Coastal Household Telephone Survey (CHTS), a proposed coastal household mail survey, and the use of a list frame for boats. Another option was a proposed shoreline on-site method, consisting of "instantaneous" counts on a prescribed route with

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stops. This would serve as a complement to the existing intercepts. Other options might include some combination of off-site and on-site methods.

Before discussing these options further, it is worth reviewing potential errors in surveys. Surveys are subject to sampling error, which is due to the fact that the selected sample is not the entire population. Sampling error is easily quantified using the sample itself and standard statistical techniques.

Surveys are also subject to non-sampling errors, including coverage error, nonresponse error, and measurement error. Coverage error occurs when the sampling frame does not match the population of interest. Overcoverage occurs when the frame contains elements not in the universe, such as non-fishing households in the random digit dialing frame used for the telephone survey. Overcoverage results in wasted sampling effort. Undercoverage occurs because the frame misses some elements of the population. For example, private access sites and remote or dangerous access sites are not covered by the intercept survey. Similarly, night fishing is not covered. Households without landlines, and households not in coastal counties are not covered by the telephone survey. Undercoverage may result in serious bias if the uncovered part of the population differs systematically from the covered part of the population.

Nonresponse errors occur because complete data are not obtained for all sampled elements. As noted in §2.3, nonresponse may lead to serious bias if the nonresponding part of the sample differs systematically from the responding part.

Finally, measurement errors can occur whenever data are collected by any means. For surveys with human respondents, measurement errors occur due to complex interactions among the interviewer, the respondent, the instrument (including the length, wording, and ordering of the questionnaire), and the mode of interaction (mail, telephone, face-to-face). Analogous errors occur for other kinds of data collection.

2.7.1 Errors in the current CHTS

The CHTS suffers from known undercoverage due to households with no landlines, and due to out-of-state non-coastal households (all households in Hawai'i are coastal). There is an attempt to correct for this undercoverage by estimating adjustment factors from the intercept data. There is overcoverage due to the large fraction of non-fishing households. There is a high and increasing rate of unit nonresponse, in which no data elements are collected.

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		Mode–Time			
Method	**Access**	Boat-Day	Shore-Day	Boat-Night	Shore-Night
CHTS	Public	Yes	Yes	Yes	Yes
	Private	Yes	Yes	Yes	Yes
Coastal household	Public	Yes	Yes	Yes	Yes
mail survey	Private	Yes	Yes	Yes	Yes
Shoreline	Public	No	Yes	No	Maybe?
on-site counts	Private	No	No—unless visible from public	No	Probably not
Boat survey	Public	Yes	No	Yes	No
	Private	Yes	No	Yes	No
Boat survey	Public	Yes	Yes	Yes	Maybe?
+ Shoreline	Private	Yes	No—unless visible	Yes	Probably
on-site counts			from public		not

Table 1: Summary of coverage properties for various effort estimation methods across Access–Mode–Time cells.

There is also item nonresponse due to the fact that a cooperative angler may begin profiling trips but then not finish profiling all trips. There are also measurement errors due to the two-month recall period. On the other hand, the CHTS does not suffer from undercoverage due to private access or night fishing, as indicated in Table 1, nor does it suffer from undercoverage due to remote sites, dangerous sites, or inaccessible military sites.

2.7.2 Errors in a coastal household mail survey

Mail surveys have the potential to reduce some of the undercoverage errors associated with the telephone survey. The address-based sample file using the US Postal Service's Computerized Delivery Sequence File (CDS) contains over 135 million residential addresses and provides nearly 100% coverage of all households in the US; see, for example,

`http://www.m-s-g.com/web/genesys/Address-based-samples.aspx`

The proposed coastal household mail survey would eliminate undercoverage due to households without landlines, particularly households with only cell phones. Pilot versions of the mail survey have included non-coastal counties in (non-Hawaiian) coastal states, but it is not clear if a fully-implemented

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version would cover all counties. If so, undercoverage due to no out-of-state non-coastal households would be eliminated. If not, it would still be necessary to estimate adjustment factors from the intercept data. Like the CHTS, the mail survey would not suffer from undercoverage due to private access or night fishing, as indicated in Table 1, nor would it suffer from undercoverage due to remote sites, dangerous sites, or inaccessible military sites. Overcoverage due to a large fraction of non-fishing households would continue to be a problem, though presumably less expensive. Pilot testing has provided some evidence that non-response is reduced compared to the telephone survey. The item nonresponse in which anglers begin but do not finish profiling all trips is a continuing problem, as are the measurement errors due to recall issues over the two-month wave.

2.7.3 Errors in a shoreline on-site count

The proposed shoreline on-site method, consisting of "instantaneous" counts of shore anglers on a prescribed route with stops, would reduce or eliminate some errors but lead to a new set of nonsampling errors. First, overcoverage due to non-fishing households would be eliminated. Undercoverage due to households without landlines or households in non-coastal counties would be irrelevant, but new undercoverage problems would arise. Some remote, dangerous, private and military sites might be covered, if they could be safely viewed from public access, but many such sites would be undercovered. Night fishing would also be likely to be undercovered, due to danger, visibility problems, or both. Non-response would no longer be an issue, since field staff would not need angler cooperation. New measurement issues would arise, related to the ability of field staff to view shore anglers, correctly identify them, and to determine the type of gear they are using.

Naturally, boat angling would not be captured in the shoreline on-site counts, as indicated by Table 1.

2.7.4 Errors in a boat survey (non-charter boats)

The proposed boat survey would use the availability of a good list frame of registered boats. Much of the overcoverage would be eliminated, though of course some boats are not used for fishing. Other overcoverage could come from out-of-date registrations, e.g, when the registered boat is no longer in service. Undercoverage would occur because not all boats are registered, ei-

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ther because they are illegally unregistered, or because they are not required to be registered (small or unmotorized boats). Further undercoverage may occur due to registered boats with inaccurate addresses, but this is expected to be a small problem since a correct address is needed in order for the boat owner to receive the boat's registration tags. A survey based on the boat list frame would not suffer from undercoverage due to remote, dangerous, military or private sites, and the undercoverage due to cell-phone-only households or non-coastal households would be irrelevant. Based on our experience with other surveys with a targeted list frame, we would expect the response rate to be higher than with CHTS or other options with non-targeted frames. Item nonresponse in which anglers begin but do not finish profiling all trips would again be a problem, as would the measurement errors due to recall issues over the wave.

The boat survey would benefit from matching the boat registrations with CML holders. Our understanding is that about 2,000 of the 16,000 to 20,000 registered boats have a CML. In principle, the boat registry and CML list can be matched fairly accurately using the addresses on each list. This would allow the survey designers to categorize boats according to CML status and regularity of the required CML reporting. CML-charter boats could be left alone to minimize their burden. This might also hold for the CML holders who report regularly, as they are required to do.

CML holders who do not report regularly are subject to fines. However, anglers can avoid getting a fine by turning in a 3×5 DidNotFish card regardless of the number of fishing events. An investigation to determine the frequency of such underreporting should be undertaken. Focus groups should include non-charter boat owners with and without a CML. This discussion should engage the anglers to discuss what might be helpful to try to improve cooperation and also determine why anglers provide inaccurate reports. Information from the focus group and from the boat survey of non-charter boats would allow, to a large extent, disentangling of commercial catch from recreational catch.

Of course, such a boat survey would not capture shore angling, as indicated by Table 1. Given the complementary nature of the shoreline on-site counts and the boat survey, it would be natural to try to combine the two, as described in the next section.

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2.7.5 Errors in a combined shoreline on-site count and boat survey

As indicated by the bottom block in Table 1, a combined shoreline on-site count and boat survey would come close to the coverage of the CHTS, though shore fishing from private access and night fishing from shore would continue to be undercovered. These gaps could be addressed, for example, by a telephone or mail survey, perhaps conducted with lower temporal frequency than the shoreline on-site counts.

We do not currently have sufficient information to compare the total error of such an approach to the total error of the current CHTS approach or a mail-based version of the CHTS. Our reaction was, however, that both the boat survey and the shoreline on-site effort count held some promise of yielding efficiencies. In our estimation, it seems that the current system overburdens regular anglers. Sites are revisited frequently, sometimes twice per week.

We recommend considering the redeployment of some sampling activity to effort counts instead of intercept and interviews. If effort information could be obtained via on-site methods, it would reduce recall errors and non-response errors relative to any off-site approach. Based on our driving tour of Oahu, we had the impression that the island scales are small enough to make substantial effort coverage feasible. We also met with the interviewers; this is a small and dedicated staff with considerable expertise. This combination suggested to us that it would be possible to get very accurate participation counts using on-site methods. Designing the assignments for effort counting can be done using field staff expertise to ensure that assignments are operationally feasible. For example, the length of coastline covered and number of sites observed can be allowed to vary by island, wave, time of day, etc., to reflect anticipated angling activity as well as traffic or other travel time considerations. If complete coverage of the shore fishing sites is not feasible, a random sample of site-days can be designed that allows for efficient and statistically valid estimation of effort.

It is worth pointing out that any hybrid of on-site and off-site effort collection would face the technical challenge of combining per-hour data from the on-site counts with per-trip data from the off-site counts. These and other questions, such as variance estimation, would require further investigation. A pilot study may be helpful to understand and evaluate the shoreline on-site effort estimates and to compare them with the CHTS effort estimates.

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2.8 Auxiliary data

There may be opportunities to include auxiliary information into the estimation procedures, to gain precision at almost no additional cost. In Hawai'i, wind and wave action are the most likely covariates to consider as potential predictors of effort and catch. According to HDAR staff, the islands have distinct windward and leeward sides and strong wave activity, particularly at certain times of the year. Both wind and wave action are likely to affect both effort and catch.

Note that even if regression relationships are imperfect, auxiliary data may be very useful in producing more efficient estimators using "model-assisted estimation." Like direct survey estimates, model-assisted estimators are design-unbiased or nearly so, and allow for consistent variance estimation and proper confidence interval construction (even if the regression model is imperfect). If the regression model has reasonable explanatory power, the model-assisted estimator has smaller variance and narrower confidence intervals than the direct estimator that ignores auxiliary data.

To make things concrete, fix attention on one particular island and consider collecting data using the current design, but additionally recording (on the basis of wind and wave conditions) whether the sampled site-day is a "good" or "bad" fishing day at the site. Denote the total number of good sampled site-days on the island as d_{good} and the total number of bad sampled site-days as d_{bad}. Further, let D_{good} denote the total number of good site-days (sampled or unsampled) and D_{bad} the total number of bad site-days, obtained by looking at daily wind and wave records for each site. (If fishing was impossible on some site-days due to weather, then $D_{\text{good}} + D_{\text{bad}} < D =$ total number of site-days.) Finally, let $\widehat{C}_{\text{good}}$ denote the estimated total catch on good site-days on the island, and $\widehat{C}_{\text{bad}}$ denote the estimated total catch on bad site-days on the island. Then the post-stratified estimator of total catch is

$$\widehat{C} = D_{\text{good}} \frac{\widehat{C}_{\text{good}}}{d_{\text{good}}} + D_{\text{bad}} \frac{\widehat{C}_{\text{bad}}}{d_{\text{bad}}}.$$

This estimator is essentially unbiased whether or not catch on good site-days differs from catch on bad site-days. If the catch does differ, then the post-stratified estimator will have smaller variance than the estimator that ignores good versus bad.

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2.9 Domain and small domain estimation

We first define three distinct terms that are often confused: "domain", "stratum", and "post-stratum". A "domain" is any subpopulation of interest for producing estimates, such as gear type (e.g., throw net, spearfish, rod-and-reel, other) or island. A "stratum" is a subpopulation that is identifiable prior to sampling. Strata are sampled independently, with a sample size that is allocated in advance. Islands within Hawai'i are strata in both the intercept and effort surveys. Sample sizes for strata can be treated as known (modulo nonresponse issues).

A stratum is often a domain of interest for producing estimates, but does not have to be a domain. A domain might be a stratum, but often is not. A domain that is not a stratum has a random sample size, which might be small or even zero. For example, the number of site-days on which spearfishers are intercepted during a wave might be extremely small.

A "post-stratum" is a subpopulation used in the production of estimates. Unlike a stratum, a post-stratum does not have a pre-allocated sample size. It is typically not identifiable *a priori*, so the sample size in a post-stratum is an unpredictable random quantity. A post-stratum does, however, have a known population size, obtained outside the survey. An example of a post-stratum would be "good fishing site-days" as defined in §2.8, for which the total number of good site-days is determined from external weather records.

A post-stratum is often a domain of interest for producing estimates, but does not have to be a domain. A domain might be a post-stratum, but often is not, because no external information about the size of the domain is available. Post-stratification estimation is relatively straightforward, if suitable post-strata with known population counts can be identified; see §2.8.

Another relevant term is a "small domain" or "small area". Small domain estimation arises when the sample size for a particular domain estimate is too small to yield the desired precision. In this case, it is necessary to draw on data from outside the domain of interest, often referred to as "borrowing strength." Often, data are drawn from domains that are "nearby" spatially or temporally, and hence expected to be similar to the domain of interest. Such procedures rely, either implicitly or explicitly, on modeling assumptions. These procedures may be severely biased if the modeling assumptions are incorrect.

As the workshop participants pointed out, Hawai'i is geographically isolated and unable to borrow strength from any nearby states. Islands within

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Hawai'i can borrow strength from each other, and can borrow strength from past time points. Similarly, estimates for a gear-type domain could borrow strength across time. Any estimates produced from small domain estimation procedures should include discussion of the assumptions underlying the procedure, and the potential biases in the procedure if the assumptions prove false. We emphasize that small domain estimation is not an "off-the-shelf" technology, but requires considerable effort to develop and test models for borrowing strength. Because of the incorporation of modeling into the estimation, all subsequent estimates of uncertainty need to be modified, and estimates are not directly comparable to the corresponding design-based estimates in large domains, which have adequate sample sizes. These topics are beyond the scope of this report.

3   Conclusion

We will not attempt to summarize the above report point-by-point. Instead, we highlight some of our key findings and recommendations for the Hawai'i recreational survey:

- Historical data and metadata from HMRFS should be reviewed to determine if estimates can be revised to reduce the mismatch between the survey design and the estimation procedure. This may require modeling assumptions in the event that not all metadata needed for constructing weights are available.

- The current HMRFS should be reviewed to ensure that sufficient design information is being collected to construct appropriate weights.

- Regularly scheduled meetings among interviewers to discuss interviewer protocols and any new angling concerns that are introduced should continue to be conducted. This will assure consistency among interviewers.

- The literature on dealing with extreme events in complex surveys should be reviewed for its applicability to HMRFS. Introductory references have been provided in this report.

- Methods to improve data quality and compliance issues for recreational fishing done from charter boats should be investigated. This investigation may include a focus group to determine methods that may im-

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prove cooperation from charter captains. No additional sampling of CML-charters is recommended.

- The sample based on the boat registry looks very promising for the private boats, and should be developed further. In particular, the boat registry should be matched against the list of CML holders by using addresses. This matching will allow stratification of the boat registry into CML and non-CML, possibly subdividing CML according to regularity of reporting. Stratified sampling using this categorized registry could improve the efficiency of the boat survey.

- Methods to improve data quality and compliance for anglers with a CML should be investigated. This investigation may include a focus group to determine methods that may improve cooperation from anglers and ways to dissuade responders from using the "DidNotFish" card if fishing was done.

- A pilot study to obtain on-site effort estimates for shore fishing, using instantaneous counts and other information, should be conducted. These counts would have to be supplemented by off-site methods in order to capture areas that are not accessible such as private beach or docks, points not visible from the road, etc. A hybrid methodology that combined on-site and off-site methods might result in efficiency gains. Estimates from the pilot study should be compared with the CHTS effort estimates. Methods for combining on-site and off-site effort data should be investigated. Smallwood et al. (2012) discusses some of the statistical issues associated with an instantaneous count to obtain shoreline effort.

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A Review of the Current Sampling and Estimation Methods of the Hawaii Marine Recreational Fishing Survey (HMRFS)

FY12 MRIP Project Report (Executive Summary)

April 2013

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"Final Report", page 2

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Executive Summary

The main objectives of the project were to identify issues with current Hawaii Marine Recreational Fishing Survey (HMRFS) and to evaluate alternative data collection designs. HMRFS follows the standard dual-frame design that was re-initiated (in Hawaii) with the Marine Recreational Fisheries Statistics Survey (MRFSS) in 2001. The on-site intercept surveys (for catch rate) in Hawaii are conducted by HMRFS field surveyors and managed by the State of Hawaii's Division of Aquatic Resources (HDAR). The coastal household telephone survey (CHTS, for fishing effort) in Hawaii is currently conducted by a local contractor and managed by a mainland company that also runs the CHTS for the Atlantic and Gulf States. The review of MRFSS by the National Research Council (NRC) provided recommendations for improving intercept surveys and telephone surveys (NRC 2006). The alternative method for catch rate estimation developed by MRIP (Breidt et al., 2011) was one of the major responses to the NRC's recommendations. The new MRIP estimation procedures were mainly based on data from Atlantic and Gulf States. A review of HMRFS intercept survey data indicated that the available historical data files were not adequate for the new estimation procedures (Ma et al., 2011). Since early 2011, HMRFS sampling protocols and programs have been more similar to the Atlantic and Gulf States. Although the new estimation methods are currently applicable to HMRFS data, the new estimation procedures may need to be modified to re-estimate catch from HMRFS prior to 2011.

In response to the recommendations by the National Research Council panel (NRC, 2006) to improve the fishing effort survey, the National Saltwater Angler Registry (NSAR) was created to provide a more efficient sampling frame. Most states/territories have applied for exemptions based upon pre-existing state angler registries, newly-created license programs, or other alternative databases. However, the State of Hawaii does not require saltwater fishing licensing/registration for most recreational fishermen (though there is a Federal permit requirement for non-commercial bottom fishing). Consequently, Hawaii is now the only state where recreational fishermen are required to register with NSAR. There are no anadromous fish in Hawaii, and shoreline anglers and boat fishermen only fishing within 3 miles from the shore are exempted from NSAR. Therefore, Hawaii's NSAR database is an incomplete sampling frame for boat fishing effort surveys and the registry does not contain anglers who are involved in shoreline fishing only.

A major component of this project, a workshop, was held in Honolulu on July 16-19, 2012. Attendees included MRIP statistical consultants, NMFS staff (from Office of Science and Technology (OST), Pacific Islands Fisheries Science Center (PIFSC), and Pacific Islands Regional Office (PIRO)), HMRFS staff (project manager and all field staff), and a Council staff member. On the day (July 16) before the meeting, the HMRFS project manager and a PIFSC statistician gave the MRIP statistical consultants a field tour around the island of Oahu to demonstrate various survey sites and highlight the complexities associated with them. During the following three days (July 17-19), presentations followed by discussions were conducted. An OST staff began the presentations with a review of the implementation of HMRFS in 2001 and the subsequent development of the project in 2002-2004. The HMRFS project manager gave an overview of current HMRFS protocols, reviewed problems with the current shoreline survey methodology, and discussed the unique characteristics of fishing activities in Hawaii. The OST

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Fisheries Statistics Division Chief gave two presentations: a) implementation of the new MRIP estimation methods (i.e., incorporating sampling weights/inclusion probabilities into catch estimation) and b) review of the new access point survey sampling design recently tested in North Carolina. MRIP efforts in developing license-frame surveys (to replace CHTS) were also presented by another OST staff member. The Council staff discussed the Hawaii-specific data needs for the Western Pacific Regional Fishery Management Council. The PIFSC statistician presented some results from HMRFS data analyses (2003-2010) on fishing methodology and fishermen categorization and outlined potential overlaps between HMRFS catch estimates and the catch totals from the Hawaii commercial fishing reports. PIRO staff presented a modified approach for collecting fishing effort information from the private boat mode using a vessel registry as the sampling frame. The PIFSC Fisheries Monitoring Brach Chief reviewed how creel surveys are currently conducted in Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands (CNMI) via the Western Pacific Fisheries Information Network (WPacFIN).

The MRIP statistical consultants had a question-and-answer session with HMRFS field surveyors and the project team member and presented their initial reactions on the last day of the meeting. A draft consultant report was provided to the project team members in late September. The report was revised and finalized based on the comments from project members (Breidt et al. 2012, Appendix 2). The major recommendations include:

1) Historical data and metadata from HMRFS should be reviewed to determine if estimates can be revised to reduce the mismatch between the survey design and the estimation procedure. Current HMRFS should be reviewed to ensure that sufficient design information is being collected to construct appropriate weights for estimations.
2) Survey design improvements should focus on the private boat and shore fishing modes. The sample based on the boat registry looks very promising for the private boats, and should be developed further. Methods to improve data quality and compliance issues for fishing done from charter boats should be investigated even though no additional sampling of charter boats is recommended.
3) A pilot study to obtain on-site effort estimates for shore fishing, using instantaneous counts and other information should be conducted. These counts would have to be supplemented by off-site methods in order to capture areas that are not accessible. Methods for combining on-site and off-site effort data should be investigated.

A FY13 project plan has been submitted to MRIP to design an appropriate survey for the shore fishing effort survey in Hawaii. The same consultants are expected to help with the design. For another Hawaii MIRP FY12 project, the vessel registry maintained by the State of Hawaii's Division of Boating and Ocean Recreation (DBOR) is being used as a sampling frame for a pilot survey (mail survey). The MRFSS catch estimates (2004-2011) in Atlantic and Gulf State have been revised based on the new estimation methods reflecting the sampling design (a stratified, clustered, and unequal probability design). The issue of lacking some of the metadata necessary for constructing appropriate weights (for new estimation) in HMRFS may also exist in the Atlantic and Gulf surveys before 2004. The re-estimation for HMRFS catch can be synchronized with the re-estimation for MRFSS prior to 2004.

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Breidt, F. J., Lesser, V., and J. D. Opsomer. 2012. Consultant's report: Preliminary review of Hawaii Marine Recreational Fishing Survey (see Appendix 2).

Ma, H., D. Hamm, L. Johansen, T. Sminkey, and T. Ogawa. 2011. Hawaii pilot study to improve intercept survey (MRIP project report).

NRC (National Research Council). 2006. Review of recreational fisheries survey methods. The National Academies Press, Washington, D.C.

Appendix 1: Outline of MRIP Working Group Meeting

July 17-19, 2002 (start at 9:00 AM on July 17, and at 8:30 AM on July 18-19)

NMFS Observers Conference Room (11th floor, 1601 Kapiolani Blvd, Honolulu, HI 96814)

Participants

Dave Van Voorhees (Office of Science and Technology (OST), NMFS)

Dave Hamm (Pacific Islands Fisheries Science Center (PIFSC), NMFS)

Tom Sminkey (OST)

Rob Andrews (OST)

John Foster (OST)

Tom Ogawa (Hawaii Division of Aquatic Resources)

Steve Kaneko (Hawaii Division of Aquatic Resources)

Chris Hawkins (Pacific Islands Regional Office)

Walter Ikehara (Pacific Islands Regional Office)

Joshua DeMello (Western Pacific Regional Fishery Management Council)

Jay Breidt (Colorado State University)

Virginia Lesser (Oregon State University)

Wade Van Buskirk (Electronic Consulting Services, Inc.)

Hongguang Ma (PIFSC)

Justin Hospital (PIFSC)

Michael Quach (PIFSC)

Marti McCracken (PIFSC)

All (12) HMRFS surveyors (Hawaii Division of Aquatic Resources)

Presentations (presenters)

1. Hawaii Marine Recreational Fishery Survey – Then and now (Tom Sminkey, July 17)
2. Review of the Hawaii Marine Recreational Fishing Survey (Tom Ogawa, July 17)

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3. New sampling and estimation methods for the U.S. access-point intercept survey (Dave Van Voorhees, July 17)
4. New access point survey sampling design (Dave Van Voorhees, July 17)
5. Hawaii data needs for the Western Pacific Regional Fishery Management Council (Josh DeMello, July 17)
6. Estimating Hawaii's boat-based catch and effort: A proposed approach and an initial survey (Walter Ikehara, July 17)
7. Initial DBOR mail survey (Chris Hawkins, July 17)
8. Developing license-frame surveys (Rob Andrews, July 18)
9. Hawaii specific information in HMRFS onsite and telephone survey data (Hongguang Ma and David Hamm, July 18)
10. Creel surveys in WPacFIN (David Hamm, July 18)

List of documents provided

1. Hawaii Division of Aquatic Resources and National Marine Fisheries Service. 2001. Hawaii Marine Recreational Fishery Survey Procedures Manual.
2. HMRFS onsite intercept survey questionnaire (2012).
3. Coastal Household Telephone Survey CATI Instrument.
4. Allen, S.D. and N. Bartlett. 2008. Hawaii Marine Recreational Fisheries Survey: How analysis of raw data can benefit regional fisheries management and how catch estimates are developed. Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96822-2396. Pacific Islands Fisheries Science Center Administrative Report H-08-04, 33 p.
5. Ma, H., D. Hamm, L. Johansen, T. Sminkey, and T. Ogawa. 2011. Hawaii pilot study to improve intercept survey (MRIP project report).
6. Ma, H., D. Hamm, and S. Allen 2011. Hawaii for-hire pilot study to incorporate validation procedures in the commercial marine license reporting program (MRIP project report).
7. Ma, H. 2012. Catch and effort estimates for 2003-2010 from the Hawaii Marine Recreational Fishing Survey. PIFSC (Pacific Islands Fisheries Science Center) Internal Report IR-12-010.
8. Oram, R. et al. 2011. American Samoa, Guam, and CNMI shore-based survey documentation.
9. Oram, R. et al. 2011. American Samoa, Guam, and CNMI boat-based survey documentation.
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Appendix 2: Consultant report

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Consultant's Report: Preliminary Review of Hawai'i Marine Recreational Fishing Survey

F. Jay Breidt[*]
Colorado State University
Virginia Lesser[†]
Oregon State University
Jean D. Opsomer[‡]
Colorado State University

November 28, 2012

1 Introduction

Our review of the Hawai'i Marine Recreational Fishing Survey (HMRFS) included a one-day field trip (July 16, 2012) by Lesser and Breidt to recreational fishing sites on the island of Oahu, where we observed a field intercept, followed by a three-day meeting (July 17–19) in Honolulu. In this document, we will provide our reaction to the design and estimation procedures for Hawai'i, as we understand following this visit and subsequent discussion of this report.

We begin by briefly summarizing our overall reaction to HMRFS. First, as in other states, Hawai'i faces the challenge of getting representative samples of anglers. The nature of the island geography is unique. The approach to fisheries management was surprising to us: the state of Hawai'i seems to ask little of anglers and to provide little in return. For example, no licenses

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are required for recreational fishing, even for out-of-state anglers. At $50, a Commercial Marine License (CML) is extraordinarily cheap. The state of Hawaii does not seem to be actively managing any species: many of the published regulations specify open season and no bag limits. Boat ramps are in disrepair and there are essentially no man-made structures designed for fishing. Given this hands-off environment, it is perhaps not surprising that there was a general pessimism about asking anything of anyone in managing the fishery.

In addition to the fact that the HMRFS data were not being used for management by the state, they were not being used by the Council, due to perceived variability issues. We were left wondering how the data are currently used. This indicates that NOAA management should participate in discussion with Hawai'i to determine their data needs and goals for this study. Having a clear purpose could be helpful in outreach activities that could engage anglers to improve cooperation rates, leading to improved data and estimates.

In the remainder of this report, we outline our recommendations for possible extensions or improvements to HMRFS, as well as a few suggestions for further study.

2 Preliminary Findings and Recommendations

2.1 Re-estimation

Historical data from HMRFS have been collected via a stratified, clustered, unequal probability design, but the estimation procedures used for these data have not reflected these design features. This mismatch between design and estimation leads to potential for bias. A written report reviewed by us indicated that not all of the metadata necessary for constructing appropriate weights were available, but our understanding from the meeting is that these data may be available, albeit not electronically. In any event, some effort to conduct the reestimation procedure should be undertaken. The weights can be modeled, if necessary, by making assumptions about the stability of pressures over time. Any such modeling assumptions must be clearly stated as part of any reestimation data products.

Though this was not discussed at the meeting, it is worth noting that for the future, HMRFS should collect sufficient design information to allow for

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proper weighting of the data. An external review of current protocols would be useful to ensure that such design information is being collected.

2.2 Training

The first day of the meeting included attendance by the field staff from all the islands. Discussions with these staff indicated some inconsistencies in their understanding of field methods. Examples included differences in the way they understood their enforcement mission, if any (*report or do not report gross violations?*), and differences in the way they understood the definition of man-made versus beach-bank mode (*which mode is fishing from an old house foundation?*) This measurement error is particularly troublesome because it leads to systematic, correlated errors across all assignments handled by that staff member. In the case of Hawaii, this could mean that a substantial fraction (or even all) the intercept data could suffer from correlated measurement error.

The best way to ensure consistency across field staff is through training exercises at regular intervals. Protocols should be reviewed at these training meetings to assure that the field interviews remain consistent among the interviewers.

2.3 Nonresponse in the shore angler intercept survey

Nonresponse errors occur because complete data are not obtained for all sampled elements. Nonresponse may lead to serious bias if the nonresponding part of the sample differs systematically from the responding part.

In the intercept survey, anglers may be missed, or may be intercepted but refuse to cooperate. These refusals may be due to a language barrier or a general aversion to surveys, or might be due to catch characteristics: e.g., wanting to focus on fishing because of having zero catch, or wanting to focus on fishing because of having lots of catch. Discussions with the interviewing staff yielded additional examples of how refusal rates could depend on weather, gear types, illegal or not-clearly-legal activities, etc. For example, throw nets have more regulations than other gear types. Anglers using throw nets might prefer to stow their gear and leave if they have any doubts about their compliance.

This last example explains why enforcement should be clearly separated from data collection, as noted in §2.2. We were glad to see that surveyors are

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making great efforts to build rapport with anglers. Incentives like hats and t-shirts can be very effective. It might be worth including interpreters on occasion, if consistent refusals are being obtained due to language barriers. Another possibility is to consider collecting additional data that could help explain refusals, for later use in weighting and imputation. Such data would need to be observable without the cooperation of the angler, such as gear type, any catch observed, etc.

2.4   Boat intercept survey

The boat intercept survey was not discussed to any great extent, but one point that did arise was the visibility of the boat's registration tags. If the interviewer could record the tag information, this could be linked to the CML list through matching of the addresses on each list. Such a match would allow cross-checking of the catch (or non-catch) of CML-holding private boat owners against CML monthly reports.

2.5   Extreme events

Hawai'i provided a number of examples of unusual or extreme catch events. For example, Hawai'ian anglers may use gear types that are relatively unusual elsewhere, such as throw nets or spears. The catch in a net haul would be extreme if combined with rod-and-reel catch. The kinds of species caught by spearfishing might be quite unusual. "Trashbag fishing", in which a baited line is carried far offshore by a trashbag used as a kite, can lead to other extreme events, such as the (anecdotal) marlin caught from shore.

There is a literature in survey statistics on how to handle extreme or outlying values: see, for example the papers by Chambers (1986), Smith (1987), Hulliger (1995) and the review by Beaumont and Rivest (2009). We will not attempt to summarize this literature here, but will briefly sketch a standard approach.

First, the data must be carefully edited by staff with local knowledge, so that such unusual or extreme events do not badly distort catch estimates. For the most part, it seems that such editing procedures are already in place.

Next, in the event that a data value is found to be valid, but is known to be very unusual, a standard approach is to leave the observation in the data set but reduce its sampling weight. The sampling weight represents

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the number of elements in the population represented by this sampled element. A data value known to be *unique* would receive the greatest possible reduction in sampling weight, all the way down to a weight of one. Elements with a weight of one are said to be "self-representing" since they represent themselves and no other population elements. Weights larger than one and less than the original sampling weight could be entertained for data values known to be unusual but not unique. The literature referenced above gives formal statistical techniques for determining such weights.

2.6 Charter boats

Our understanding of charter boats in Hawai'i is as follows. A charter boat must have a CML. Some charter boats keep essentially all of the catch for sale to a dealer. As a CML holder, the charter boat captain fills out a CML daily log and reports monthly. These reports can be checked against dealer listings of sales. This system, therefore, has both a well-defined method of assessing catch and effort and an external method for validating catch and effort.

However, not all charter boats complete log reports. Therefore, there are compliance issues to address for the charter boats, particularly the need for improvement in reporting for the recreational fishery. If the data quality and compliance issues can be addressed for the charter boats through other mechanisms, possibly including focus groups to determine methods that may improve cooperation, then no additional sampling of charter boats is recommended. During the focus group discussion, Hawai'i can not only determine why the logs are not completed, but also find out ways to convince the boat owners/captains that recording recreational fish catch is important to the State and to them. Hawai'i can also ask the focus group participants how to efficiently get this message out to all the charter boat owners/captains.

2.7 Effort estimation options

A number of options for effort estimation were discussed at the meeting. These included off-site options, such as the current Coastal Household Telephone Survey (CHTS), a proposed coastal household mail survey, and the use of a list frame for boats. Another option was a proposed shoreline on-site method, consisting of "instantaneous" counts on a prescribed route with

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stops. This would serve as a complement to the existing intercepts. Other options might include some combination of off-site and on-site methods.

Before discussing these options further, it is worth reviewing potential errors in surveys. Surveys are subject to sampling error, which is due to the fact that the selected sample is not the entire population. Sampling error is easily quantified using the sample itself and standard statistical techniques.

Surveys are also subject to non-sampling errors, including coverage error, nonresponse error, and measurement error. Coverage error occurs when the sampling frame does not match the population of interest. Overcoverage occurs when the frame contains elements not in the universe, such as non-fishing households in the random digit dialing frame used for the telephone survey. Overcoverage results in wasted sampling effort. Undercoverage occurs because the frame misses some elements of the population. For example, private access sites and remote or dangerous access sites are not covered by the intercept survey. Similarly, night fishing is not covered. Households without landlines, and households not in coastal counties are not covered by the telephone survey. Undercoverage may result in serious bias if the uncovered part of the population differs systematically from the covered part of the population.

Nonresponse errors occur because complete data are not obtained for all sampled elements. As noted in §2.3, nonresponse may lead to serious bias if the nonresponding part of the sample differs systematically from the responding part.

Finally, measurement errors can occur whenever data are collected by any means. For surveys with human respondents, measurement errors occur due to complex interactions among the interviewer, the respondent, the instrument (including the length, wording, and ordering of the questionnaire), and the mode of interaction (mail, telephone, face-to-face). Analogous errors occur for other kinds of data collection.

2.7.1   Errors in the current CHTS

The CHTS suffers from known undercoverage due to households with no landlines, and due to out-of-state non-coastal households (all households in Hawai'i are coastal). There is an attempt to correct for this undercoverage by estimating adjustment factors from the intercept data. There is overcoverage due to the large fraction of non-fishing households. There is a high and increasing rate of unit nonresponse, in which no data elements are collected.

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		Mode–Time			
Method	**Access**	Boat-Day	Shore-Day	Boat-Night	Shore-Night
CHTS	Public	Yes	Yes	Yes	Yes
	Private	Yes	Yes	Yes	Yes
Coastal household	Public	Yes	Yes	Yes	Yes
mail survey	Private	Yes	Yes	Yes	Yes
Shoreline	Public	No	Yes	No	Maybe?
on-site counts	Private	No	No—unless visible from public	No	Probably not
Boat survey	Public	Yes	No	Yes	No
	Private	Yes	No	Yes	No
Boat survey + Shoreline on-site counts	Public	Yes	Yes	Yes	Maybe?
	Private	Yes	No—unless visible from public	Yes	Probably not

Table 1: Summary of coverage properties for various effort estimation methods across Access–Mode–Time cells.

There is also item nonresponse due to the fact that a cooperative angler may begin profiling trips but then not finish profiling all trips. There are also measurement errors due to the two-month recall period. On the other hand, the CHTS does not suffer from undercoverage due to private access or night fishing, as indicated in Table 1, nor does it suffer from undercoverage due to remote sites, dangerous sites, or inaccessible military sites.

2.7.2 Errors in a coastal household mail survey

Mail surveys have the potential to reduce some of the undercoverage errors associated with the telephone survey. The address-based sample file using the US Postal Service's Computerized Delivery Sequence File (CDS) contains over 135 million residential addresses and provides nearly 100% coverage of all households in the US; see, for example,

http://www.m-s-g.com/web/genesys/Address-based-samples.aspx

The proposed coastal household mail survey would eliminate undercoverage due to households without landlines, particularly households with only cell phones. Pilot versions of the mail survey have included non-coastal counties in (non-Hawaiian) coastal states, but it is not clear if a fully-implemented

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version would cover all counties. If so, undercoverage due to no out-of-state non-coastal households would be eliminated. If not, it would still be necessary to estimate adjustment factors from the intercept data. Like the CHTS, the mail survey would not suffer from undercoverage due to private access or night fishing, as indicated in Table 1, nor would it suffer from undercoverage due to remote sites, dangerous sites, or inaccessible military sites. Overcoverage due to a large fraction of non-fishing households would continue to be a problem, though presumably less expensive. Pilot testing has provided some evidence that non-response is reduced compared to the telephone survey. The item nonresponse in which anglers begin but do not finish profiling all trips is a continuing problem, as are the measurement errors due to recall issues over the two-month wave.

2.7.3 Errors in a shoreline on-site count

The proposed shoreline on-site method, consisting of "instantaneous" counts of shore anglers on a prescribed route with stops, would reduce or eliminate some errors but lead to a new set of nonsampling errors. First, overcoverage due to non-fishing households would be eliminated. Undercoverage due to households without landlines or households in non-coastal counties would be irrelevant, but new undercoverage problems would arise. Some remote, dangerous, private and military sites might be covered, if they could be safely viewed from public access, but many such sites would be undercovered. Night fishing would also be likely to be undercovered, due to danger, visibility problems, or both. Non-response would no longer be an issue, since field staff would not need angler cooperation. New measurement issues would arise, related to the ability of field staff to view shore anglers, correctly identify them, and to determine the type of gear they are using.

Naturally, boat angling would not be captured in the shoreline on-site counts, as indicated by Table 1.

2.7.4 Errors in a boat survey (non-charter boats)

The proposed boat survey would use the availability of a good list frame of registered boats. Much of the overcoverage would be eliminated, though of course some boats are not used for fishing. Other overcoverage could come from out-of-date registrations, e.g, when the registered boat is no longer in service. Undercoverage would occur because not all boats are registered, ei-

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ther because they are illegally unregistered, or because they are not required to be registered (small or unmotorized boats). Further undercoverage may occur due to registered boats with inaccurate addresses, but this is expected to be a small problem since a correct address is needed in order for the boat owner to receive the boat's registration tags. A survey based on the boat list frame would not suffer from undercoverage due to remote, dangerous, military or private sites, and the undercoverage due to cell-phone-only households or non-coastal households would be irrelevant. Based on our experience with other surveys with a targeted list frame, we would expect the response rate to be higher than with CHTS or other options with non-targeted frames. Item nonresponse in which anglers begin but do not finish profiling all trips would again be a problem, as would the measurement errors due to recall issues over the wave.

The boat survey would benefit from matching the boat registrations with CML holders. Our understanding is that about 2,000 of the 16,000 to 20,000 registered boats have a CML. In principle, the boat registry and CML list can be matched fairly accurately using the addresses on each list. This would allow the survey designers to categorize boats according to CML status and regularity of the required CML reporting. CML-charter boats could be left alone to minimize their burden. This might also hold for the CML holders who report regularly, as they are required to do.

CML holders who do not report regularly are subject to fines. However, anglers can avoid getting a fine by turning in a 3×5 DidNotFish card regardless of the number of fishing events. An investigation to determine the frequency of such underreporting should be undertaken. Focus groups should include non-charter boat owners with and without a CML. This discussion should engage the anglers to discuss what might be helpful to try to improve cooperation and also determine why anglers provide inaccurate reports. Information from the focus group and from the boat survey of non-charter boats would allow, to a large extent, disentangling of commercial catch from recreational catch.

Of course, such a boat survey would not capture shore angling, as indicated by Table 1. Given the complementary nature of the shoreline on-site counts and the boat survey, it would be natural to try to combine the two, as described in the next section.

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2.7.5 Errors in a combined shoreline on-site count and boat survey

As indicated by the bottom block in Table 1, a combined shoreline on-site count and boat survey would come close to the coverage of the CHTS, though shore fishing from private access and night fishing from shore would continue to be undercovered. These gaps could be addressed, for example, by a telephone or mail survey, perhaps conducted with lower temporal frequency than the shoreline on-site counts.

We do not currently have sufficient information to compare the total error of such an approach to the total error of the current CHTS approach or a mail-based version of the CHTS. Our reaction was, however, that both the boat survey and the shoreline on-site effort count held some promise of yielding efficiencies. In our estimation, it seems that the current system overburdens regular anglers. Sites are revisited frequently, sometimes twice per week.

We recommend considering the redeployment of some sampling activity to effort counts instead of intercept and interviews. If effort information could be obtained via on-site methods, it would reduce recall errors and non-response errors relative to any off-site approach. Based on our driving tour of Oahu, we had the impression that the island scales are small enough to make substantial effort coverage feasible. We also met with the interviewers; this is a small and dedicated staff with considerable expertise. This combination suggested to us that it would be possible to get very accurate participation counts using on-site methods. Designing the assignments for effort counting can be done using field staff expertise to ensure that assignments are operationally feasible. For example, the length of coastline covered and number of sites observed can be allowed to vary by island, wave, time of day, etc., to reflect anticipated angling activity as well as traffic or other travel time considerations. If complete coverage of the shore fishing sites is not feasible, a random sample of site-days can be designed that allows for efficient and statistically valid estimation of effort.

It is worth pointing out that any hybrid of on-site and off-site effort collection would face the technical challenge of combining per-hour data from the on-site counts with per-trip data from the off-site counts. These and other questions, such as variance estimation, would require further investigation. A pilot study may be helpful to understand and evaluate the shoreline on-site effort estimates and to compare them with the CHTS effort estimates.

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2.8 Auxiliary data

There may be opportunities to include auxiliary information into the estimation procedures, to gain precision at almost no additional cost. In Hawai'i, wind and wave action are the most likely covariates to consider as potential predictors of effort and catch. According to HDAR staff, the islands have distinct windward and leeward sides and strong wave activity, particularly at certain times of the year. Both wind and wave action are likely to affect both effort and catch.

Note that even if regression relationships are imperfect, auxiliary data may be very useful in producing more efficient estimators using "model-assisted estimation." Like direct survey estimates, model-assisted estimators are design-unbiased or nearly so, and allow for consistent variance estimation and proper confidence interval construction (even if the regression model is imperfect). If the regression model has reasonable explanatory power, the model-assisted estimator has smaller variance and narrower confidence intervals than the direct estimator that ignores auxiliary data.

To make things concrete, fix attention on one particular island and consider collecting data using the current design, but additionally recording (on the basis of wind and wave conditions) whether the sampled site-day is a "good" or "bad" fishing day at the site. Denote the total number of good sampled site-days on the island as d_{good} and the total number of bad sampled site-days as d_{bad}. Further, let D_{good} denote the total number of good site-days (sampled or unsampled) and D_{bad} the total number of bad site-days, obtained by looking at daily wind and wave records for each site. (If fishing was impossible on some site-days due to weather, then $D_{\text{good}} + D_{\text{bad}} < D =$ total number of site-days.) Finally, let $\widehat{C}_{\text{good}}$ denote the estimated total catch on good site-days on the island, and $\widehat{C}_{\text{bad}}$ denote the estimated total catch on bad site-days on the island. Then the post-stratified estimator of total catch is

$$\widehat{C} = D_{\text{good}} \frac{\widehat{C}_{\text{good}}}{d_{\text{good}}} + D_{\text{bad}} \frac{\widehat{C}_{\text{bad}}}{d_{\text{bad}}}.$$

This estimator is essentially unbiased whether or not catch on good site-days differs from catch on bad site-days. If the catch does differ, then the post-stratified estimator will have smaller variance than the estimator that ignores good versus bad.

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2.9 Domain and small domain estimation

We first define three distinct terms that are often confused: "domain", "stratum", and "post-stratum". A "domain" is any subpopulation of interest for producing estimates, such as gear type (e.g., throw net, spearfish, rod-and-reel, other) or island. A "stratum" is a subpopulation that is identifiable prior to sampling. Strata are sampled independently, with a sample size that is allocated in advance. Islands within Hawaiʻi are strata in both the intercept and effort surveys. Sample sizes for strata can be treated as known (modulo nonresponse issues).

A stratum is often a domain of interest for producing estimates, but does not have to be a domain. A domain might be a stratum, but often is not. A domain that is not a stratum has a random sample size, which might be small or even zero. For example, the number of site-days on which spearfishers are intercepted during a wave might be extremely small.

A "post-stratum" is a subpopulation used in the production of estimates. Unlike a stratum, a post-stratum does not have a pre-allocated sample size. It is typically not identifiable *a priori*, so the sample size in a post-stratum is an unpredictable random quantity. A post-stratum does, however, have a known population size, obtained outside the survey. An example of a post-stratum would be "good fishing site-days" as defined in §2.8, for which the total number of good site-days is determined from external weather records.

A post-stratum is often a domain of interest for producing estimates, but does not have to be a domain. A domain might be a post-stratum, but often is not, because no external information about the size of the domain is available. Post-stratification estimation is relatively straightforward, if suitable post-strata with known population counts can be identified; see §2.8.

Another relevant term is a "small domain" or "small area". Small domain estimation arises when the sample size for a particular domain estimate is too small to yield the desired precision. In this case, it is necessary to draw on data from outside the domain of interest, often referred to as "borrowing strength." Often, data are drawn from domains that are "nearby" spatially or temporally, and hence expected to be similar to the domain of interest. Such procedures rely, either implicitly or explicitly, on modeling assumptions. These procedures may be severely biased if the modeling assumptions are incorrect.

As the workshop participants pointed out, Hawaiʻi is geographically isolated and unable to borrow strength from any nearby states. Islands within

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Hawai'i can borrow strength from each other, and can borrow strength from past time points. Similarly, estimates for a gear-type domain could borrow strength across time. Any estimates produced from small domain estimation procedures should include discussion of the assumptions underlying the procedure, and the potential biases in the procedure if the assumptions prove false. We emphasize that small domain estimation is not an "off-the-shelf" technology, but requires considerable effort to develop and test models for borrowing strength. Because of the incorporation of modeling into the estimation, all subsequent estimates of uncertainty need to be modified, and estimates are not directly comparable to the corresponding design-based estimates in large domains, which have adequate sample sizes. These topics are beyond the scope of this report.

3 Conclusion

We will not attempt to summarize the above report point-by-point. Instead, we highlight some of our key findings and recommendations for the Hawai'i recreational survey:

- Historical data and metadata from HMRFS should be reviewed to determine if estimates can be revised to reduce the mismatch between the survey design and the estimation procedure. This may require modeling assumptions in the event that not all metadata needed for constructing weights are available.

- The current HMRFS should be reviewed to ensure that sufficient design information is being collected to construct appropriate weights.

- Regularly scheduled meetings among interviewers to discuss interviewer protocols and any new angling concerns that are introduced should continue to be conducted. This will assure consistency among interviewers.

- The literature on dealing with extreme events in complex surveys should be reviewed for its applicability to HMRFS. Introductory references have been provided in this report.

- Methods to improve data quality and compliance issues for recreational fishing done from charter boats should be investigated. This investigation may include a focus group to determine methods that may im-

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prove cooperation from charter captains. No additional sampling of CML-charters is recommended.

- The sample based on the boat registry looks very promising for the private boats, and should be developed further. In particular, the boat registry should be matched against the list of CML holders by using addresses. This matching will allow stratification of the boat registry into CML and non-CML, possibly subdividing CML according to regularity of reporting. Stratified sampling using this categorized registry could improve the efficiency of the boat survey.

- Methods to improve data quality and compliance for anglers with a CML should be investigated. This investigation may include a focus group to determine methods that may improve cooperation from anglers and ways to dissuade responders from using the "DidNotFish" card if fishing was done.

- A pilot study to obtain on-site effort estimates for shore fishing, using instantaneous counts and other information, should be conducted. These counts would have to be supplemented by off-site methods in order to capture areas that are not accessible such as private beach or docks, points not visible from the road, etc. A hybrid methodology that combined on-site and off-site methods might result in efficiency gains. Estimates from the pilot study should be compared with the CHTS effort estimates. Methods for combining on-site and off-site effort data should be investigated. Smallwood et al. (2012) discusses some of the statistical issues associated with an instantaneous count to obtain shoreline effort.

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Appendix 3: Response to Comments on Consultant's Report on Hawaii Marine Recreational Fishing Survey Review

DCH1: In what way? Do mainland surveys employ many surveyors for similar amounts of coverage?

We do not know about the number of surveyors used per area on the mainland. Our comment was made with respect to the uniqueness of an island. The size of the island population is small so many of the surveyors may see anglers multiple times.

B2: Their comments in the Intro about management needs for rec. data are also interesting and suggest that we need management to weigh-in on what they need from HMRFSS before we redesign it. Seems like management is focused more on what they want rather than what they actually need or how they will use the data" so, I think its the parts about data not being used, no creel limits or seasons, so it's just hard to understand what data are needed now, versus the "if we had this and that data, we could do this and that additional analyses" - the chicken and egg argument, but also the actual management used in HI doesn't seem to require hard data, or at least not the type that typically needs landings info, so maybe some brief statement about impending ACL needs

We agree and include a comment on management getting involved on clearly stating their goals for the study.

DCH3: Overly negative IMHO…. There are rules for some species for size limits and bag limits

We have toned down the wording in the report.

H4: Not complete rather than not available

We have made the statement more precise in the report.

H5: I think current HMRFS is collecting sufficient design information, following similar protocols as other Atlantic and Gulf states

Since we did not discuss this topic at the meeting, it is not possible for us to comment on whether sufficient design information is being collected. We have noted that an external review of current protocols would be useful.

H6: *I am not sure how the surveyors difference in their recommendations for recording bottomfish catch through CML or federal reporting would lead to measurement error in their surveys for HMRFS. CML reporting (for CML holders) and federal reporting (for non-commercial bottom fishing registered with NOAA, <100 registered now and only few reporting) are separate from HMRFS. Regardless of the surveyors' opinions, they would not record the bottom fishing catch differently in HMRFS*

The comment was meant to illustrate inconsistency of understanding among field staff, but since there are other examples relevant to HMRFS measurement error, we have deleted the discussion of bottomfish.

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H7 HMRFS does have regular trainings/meetings; and DCH8 Although they do have meetings, I'm not sure how 'regular' they are or how effective they are in 'standardizing' fielding protocols and discussing areas of 'consistency'.:

This correction was made in the report.

DCH9: If they could provide there best reference for handling these situations, that would be great.

We have added some references to the literature, including a recent review article by Beaumont and Rivest (2009).

DCH10 What might other 'reasonable approaches' be? E.G. stratifying differently, spatially or by gear type? and H11 The weights (1<weight<sampling weight) for unusual data values would be based on expert opinion? It seems such weights are not easy to be assigned objectively.

We have added a number of references to the text. There are formal statistical approaches to handling this weight adjustment. Such methods rely on modeling assumptions, implicitly or explicitly. The methods are "objective" to the extent that the models are objective.

DCH12 *A bit over stated…. There are many exceptions to this 'standard' and many of the fish caught on charter boats do NOT end up going to dealers*; and *DCH13 Dr. Ma's recent surveys have documented many issues with compliance and data quality……. However I agree with the conclusion that sampling of this sector is not appropriate for HMRFS, but emphasize need for significant improvement in reporting from this very important 'recreational' fishery sector.*

We have edited this section to reflect the comments.

B14: *can the authors give some thoughts on how to correct the errors such as under-coverage, over-coverage, measurement errors (in most cases, recall errors), and unit and/or item nonresponses*

We address some examples in other subsections of 2.7.

H15: Typo-would be undercoverage

We agree and have made the correction.

DCH16 Are on-base military housing units an issue? Are addresses available for these?:

We are uncertain about the specifics for military housing. We have added a note and a reference about the coverage of address-based sampling using the US Postal Service's Computerized Delivery Sequence File (CDS), which contains over 135 million residential addresses and provides nearly 100% coverage of all households in the US.

H17: *The undercoverage due to non-coastal households is not applicable in Hawaii (all counties are coastal). The undercoverage for out-of-state households will always exist in Hawaii for mail/phone surveys because there are no non-commercial fishing licenses /permits to capture out-of-state fishermen or households.*

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There is some confusion here, with us or with the reviewer. We think that effort estimation for Hawaii is based on the CHTS, for which undercoverage of non-coastal households is relevant to Hawaii for out-of-state angling effort. If future effort estimation were based on a mail survey replacing the CHTS, then non-coastal non-Hawaii households may or may not be an issue, depending on how the mail survey is conducted. On the other hand, if effort estimation is based on a survey conducted by Hawaii within Hawaii only, then this requires further discussion.

DCH18: I would highly recommend against profiling trips for anything even close to a 2-month period. If this sample scheme is adopted or tested, I would hope a short recall time would be implemented and perhaps more short-term surveys sent out for responses.

The two-month recall is not a recommendation of our report, but standard practice in the surveys conducted by NOAA. Since the discussion here is for a proposed boat survey, which may use some other length of wave, we have replaced "two-month wave" by "wave."   We acknowledge that recalling for two months may lead to recall bias. This concern was raised to NOAA. It would be informative for NOAA to conduct studies to determine the optimum recall period that could obtain data cost efficiently without concerns for recall bias.

DCH19: This might be a little misleading in that fishers can avoid getting a fine by simply turning in a DidNotFish 3x5 card regardless of how many times they actually went fishing. There is believed to be a considerable amount of 'recreational/subsistence' fishing done by CML holders but not reported on their 'commercial' forms submitted to HDAR. This is a challenging aspect of this 'disentangling'.

Text was reworded to acknowledge the concern to disentangle the fish catch.

H20 Would like to have more details here – the effort counts would be a roving survey trying to cover the whole island (for each assignment), or to cover a section of the island for each run, or just to cover fishing sites near the assigned intercept site; and H21 We only covered half of Oahu during the tour (from Hawaii Kai to Haleiwa). The other half is harder to drive/cover especially during rush hours.

We have edited the text to reflect the fact that there is considerable flexibility in designing assignments for on-site participation counts.

DCH22: Could this be done at any level other than at the island (or county) level for effort estimation given the current CHTS methods?

Depending on the intensity of the sampling for on-site effort counts, it could be possible to make effort estimates at sub-island levels. This is not possible with the current CHTS because effort is only measured at the county level. Even with this difference in spatial resolution, on-site effort counts could be combined with CHTS effort estimates, though this would require some modeling assumptions.

H24: Dgood and Dbad are island days or site days? It is not easy to assign good/bad for an island for a specific day based on wind and wave records. That day can be good for one side of the island but bad for the other side of the island. Whether a day is good or bad for fishing will depend on which sides (and sites) of the island; and H26: See comments on §2.8

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The text has been edited to reflect that these counts are for site-days, so there can definitely be differences across sites (e.g., windward versus leeward) on the island.

DCH25 It would be helpful to give more examples of a 'post-stratum domain' and 'small domain' (if I have the terms correct) gear type is a 'small domain', right? Are there specific tests that can be run on existing data to figure out the "borrowing strength" of various options? When 'borrowing' occurs, how are the descriptive statistics calculated for confidence limits etc.?; DCH27 Are there specific tests that can be run on existing data to figure out the "borrowing strength" of various options?; and DCH28 When 'borrowing' occurs, how are the descriptive statistics calculated for confidence limits etc.?

We have tried to clarify the differences among domain, stratum, post-stratum, and small domain. Some gear types (like spearfishing) may be small domains, while others (like rod and reel) may not. The quick answer to the remaining questions above is no, there are no such tests. The text has also been edited to emphasize that small domain estimation is not an off-the-shelf technology that is readily adopted; it requires considerable investment to build and test models and develop appropriate estimators of uncertainty. This is beyond the scope of this report.

B29 a clear recommendation or statement of 'next steps' would be helpful, i.e., develop specific designs of the recommended general survey programs, followed by proposing pilot studies to test specific designs, rather than quickly proposing pilot study (s) to test general ideas., B30 summarize all the recommendations at the end (bullets) to make it easier to pick out from the narrative,

We have addressed this collection of comments by revising the Conclusion section as a bulleted list.

H32 As mentioned in the first comment in §2.7.5, we would like know more details about the design of onsite instantaneous counts. The design would depend on what the supplemental off-site survey can offer. It is not clear if the current off-site effort survey (CHTS) can provide information about the ratio of fishing efforts from sites covered by an onsite effort survey to the fishing effort from all fishing sites. If these are out of the scope of the current project, will the consultants be willing to be involved in future projects on designing alternative effort surveys?, B33 An onsite instantaneous counts (for fishing effort) supplemented by off-site methods were suggested for shore-fishing. If the specifics of such methods can be provided , such methods could be tested in FY13 MRIP projects. Otherwise, the FY13 projects could be on the designing of such methods (in that case, we would need to ask for additional FY13 funding for the consultants' support). To me (my personal opinion and I am not an expert on roving survey), the effort counts could be conducted in several ways. For a small island or lake with easy access to fishing sites (ideal situation), you can cover "all" sites (in the area you want to have estimates) in each assignment. The starting time and starting point (in space) can be randomly selected and a circuit is completed during each assignment. On the other end of the spectrum, only efforts at/near the intercept sites are counted (such as NC pilot?). The roving surveys in WpacFIN fall somewhere in between. Some sections (covering significant proportions of the islands) were covered during each assignment. The proportions of the covered sections (out of the total) are estimated based on other information/data/surveys. I am not sure which method would be the best for HMRFS. It will depend on the budget, the flexibility of surveyors'

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working hours, and the supplemental offsite survey (for effort). A group discussion may be beneficial because one person (or one side) may not have all the information/knowledge.

The reviewers make a number of good points in these comments. We are not in a position to make specific recommendations on the design of an on-site effort survey, beyond those already discussed in the report. Additional recommendations would require further study of the problems unique to Hawai`i and of the existing literature on instantaneous counts. A recent paper by Smallwood et al. (2012) discusses some of the statistical issues associated with an instantaneous count to obtain shoreline effort.   This reference has been added to the report.

DCH31 I'd prefer to see a strong statement about improving the compliance and accuracy of the charter data submitted to HDAR, and IF that can be done, then leave that sector out of further surveys.

We agree and have made this a specific recommendation in the Conclusion.

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