Title: Evaluation of a bottom-moored echosounder array to provide a survey-comparable index of abundance

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Project duration and annual budget total(s): 1 Year, $ 203,400

Abstract/Summary: A retrospective analysis suggested that as few as three bottom-moored echosounders can provide an index of abundance comparable to that produced by an annual acoustic-trawl (AT) survey conducted for stock assessment purposes. The primary uncertainty in the moored sounder approach is knowledge of the spatial-equivalent or spatial-representativeness of the mooring data, which is needed to design a mooring array (i.e., appropriate number and placement of moorings) capable of providing information suitable for stock assessments. Thus, the primary objective of the proposed work is to: 1) develop and deploy three echosounder moorings within the Shelikof Strait, Alaska AT survey area, and 2) establish the spatial relationship, and associated uncertainty, between the mooring measurements and acoustic-trawl survey data by comparing the time-averaged mooring observations with periodic small-scale acoustic survey information. We anticipate that an echosounder array approach will provide a cost effective method to measure the abundance of aggregated fishes to help offset ship-based acoustic survey needs throughout the Agency.

Scope, objectives, and scientific merit of the work: Standardized acoustic-trawl (AT) surveys provide critical input to stock assessment modeling efforts and other management needs throughout NOAA. AFSC researchers, for example, provide AT survey estimates of the pre-spawning pollock biomass as well as indices of age-1 year class strength for use in the Gulf of Alaska (GOA) pollock stock assessment model (Dorn et al. 2012). There is a recognized need within the Agency for the "development and use of sampling platforms to augment the FSVs to further improve the efficiency…of standardized surveys" (ASTWG Theme 5). The goal of our proposed work is to evaluate the use of an array of bottom-moored echosounders to provide similar stock assessment information to that produced by an annual AT survey (conducted with an FSV), and thus reduce the frequency that the AT survey would need to be conducted. We anticipate that the moored echosounder approach could make the FSV available for other research and survey priorities**.** The abundance of many fishes from other regions can be efficiently measured when aggregated in localized areas (e.g., Atlantic herring, Jech and Stroman, 2012; reef fishes, Taylor et al. 2006, De Mitcheson, 2008; orange roughy, Doonan et

al., 2003; Arctic cod, Benoit et al., 2008; Atlantic cod, Lawson and Rose, 2000). Thus, the proposed approach will have widespread application.

Technological developments have reduced the cost and increased the endurance of autonomous echosounders, and they have proven to be effective tools for studies of behavior (e.g., Kaartvedt et al., 2009, Kaltenberg et al. 2010). The technology can potentially be used to generate low-cost abundance indices of fish from areas where they aggregate for spawning or other purposes (e.g., feeding). However, methods are needed to evaluate the number and the geographical placement of the moored echosounders required to provide a useful abundance index estimate over the area of interest (e.g., traditional AT survey area).

The major outstanding question regarding the utility of moored echosounders for abundance estimation concerns the degree that temporally averaged measurements from stationary instruments represent the density of fishes over a wider area. Specifically, stationary echosounders provide high temporal resolution at a single point in space compared to ship-based surveys, and the time-averaged measurements of fish movements past a stationary sensor represent the abundance over a broader area than the relatively small sampling volume of a stationary instrument (e.g., Brierley et al., 2006). Knowledge of this spatial-extent or spatial-representativeness of the mooring data is critical for the design of a mooring array (i.e., appropriate number and placement of moorings). Thus, the primary objective of the proposed work is to establish the relationship (and associated uncertainty) between temporal averaging of the stationary measurements and the areal size of the local fish density estimates that the averaging represents. The GOA Shelikof Strait pre-spawning walleye pollock AT survey will be the test bed for the proposed work. The survey's extensive data time series facilitates a retrospective analysis to initiate a mooring array design. Additionally, the importance of the survey to the GOA pollock stock assessment makes this survey ideally suited for the study as described in the next section.

The proposed work addresses ASTWG Theme 5 as it will establish the feasibility of producing abundance estimates that will augment those from ship-based surveys. For example, it may be possible to conduct the Shelikof AT survey biennially or less frequently if the bottom-moored system can supply abundance index information suitable for the stock assessment needs. The ship time saved can be redirected to other important research or survey activities, which need vessel time or are currently being conducted with chartered vessels. Although the proposed work focuses on pollock, the results are of national importance, as many of the NMFS Science Centers use AT surveys to conduct assessments of fishes that aggregate.

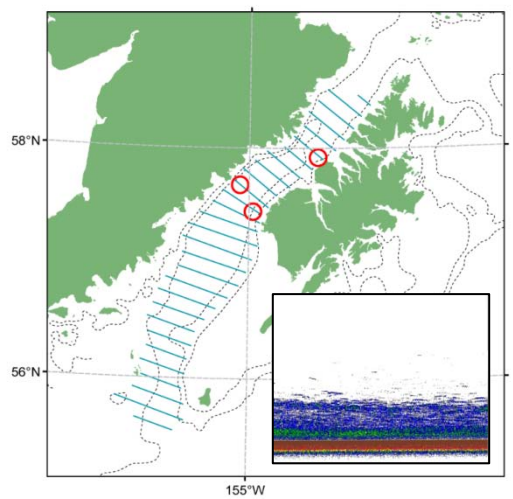

Fig. 1. Study area showing acoustic survey trackline and location of 3 proposed mooring sites at ~275 m bottom depths. The insert shows a typical pollock backscatter pattern observed in Shelikof Strait pre-spawning surveys.

Technical approach, expected results and probability of success: We propose to deploy 3 trawl-resistant bottom moorings with upward-directed echosounders to generate a pollock index of abundance in Shelikof Strait during the spring spawning season (Fig. 1). The mooring

locations were determined based on an analytical method we developed to optimize placements of moored echosounders by retrospective analysis of the AT survey data. This analysis consisted of gridding the survey area into 7×7 km blocks, and computing the mean backscatter within the block for surveys spanning 2003 to 2012 (data were readily available for this period). Backscatter values were normalized by dividing by the total backscatter within each survey year to prevent high abundance years from disproportionately influencing the spatial analysis. Blocks with consistently high abundance in the time series were identified by ranking them based on the among-survey mean divided by the among-survey standard deviation for each block. A time series based on AT survey data since 2003 from only the top 3 ranked blocks (locations in Fig. 1) was remarkably similar to the total AT survey estimates of pre-spawning pollock in Shelikof Strait (Fig. 2). About 94% of the variance in the AT survey time series would be captured by moorings in these 3 locations, assuming that the proposed mooring time-averaged data (e.g. over days to weeks) contained equivalent information as the length of AT track line contained with each block (~ 20 km; Fig. 2). Even if the equivalent content of the mooring were only 1 km of AT survey data (i.e., the closest 1 km to the mooring site is averaged rather than the 20 km in Fig. 2), ~ 50% of the variance is still explained.

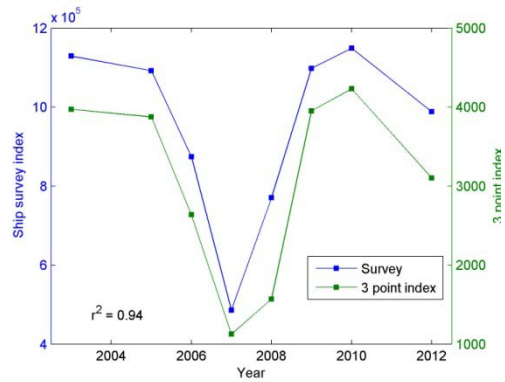

Fig. 2. Abundance indices from acoustic survey and three optimally chosen 7×7 km locations within the survey area, shown with circles in Fig. 1. Each location represents ~ 20 km of acoustic survey trackline.

The proposed work will essentially answer whether an actual mooring measurement is comparable to 1 km, 20 km, or some other amount of AT survey trackline. To determine the spatial sampling dimension of a moored echosounder in this environment, small-scale acoustic surveys will be repeated in the area of each mooring during the February-April spawning season.

Instrumentation: We have examined existing echosounder designs, and find that there are no commercially available autonomous instruments suitable for collecting the high-quality data needed for generating estimates of fish biomass. The primary requirements for such an instrument include prolonged autonomous deployment, long-term stability, well-established time varied-gain, and low pressure sensitivity of the transducer. Additionally, a relatively low frequency is required to collect data with an acceptable signal to noise ratio over the required range (250 m) and minimize the contribution from zooplankton. Although there is an autonomous echosounder on the market, current users raised concern about the performance characteristics of the instrument. Thus, we think that a new design specifically developed for autonomous fish abundance estimates is required for quantitative work. We have consulted with Simrad, the manufacturer whose scientific echosounders are used in most NMFS acoustic stock assessment work, and have developed plans for a low-power, high-quality, autonomous 70 kHz echosounder equipped with a transducer that is not highly pressure sensitive at the same cost to the project as the alternative instrument. The data from the new instrument will have the same format as that from Simrad's existing products, so no changes would be needed to standard analysis software. The frequency selection was driven by transducer requirements, including our need for a pressure-stabilized transducer. A modification of the existing Simrad composite 70

kHz transducer design was determined to be the best choice for the work. The instrument will be built to our specifications, but will serve as the prototype for a commercial product which is intended to be a split-beam, and ultimately multiple-frequency. However, the instruments developed for our proposed study will likely be single-beam as this will reduce costs and development times, and is sufficient for our initial needs. Instrument components (e.g., batteries, data storage, and control electronics) will be housed in a 1m long, 17 cm diameter pressure case with an external transducer.

In Shelikof Strait, and other areas where fish stock assessments surveys are conducted, there is an active fishery. To minimize the probability of adverse impacts from the trawl fleet, the autonomous echosounder will be placed into a Mooring Systems, Inc. (Catumet MA) trawl-resistant bottom mooring equipped with an Edgetech acoustic release, floatation, and a transducer dual-axis gimbal (Fig. 3). These low-profile moorings will be lowered to the seafloor and released to ensure that they are deployed in the right orientation at a known location. To further minimize mooring damage or disturbance by commercial fishing operations, we will distribute a NOAA News Release to the commercial fishing industry through the Alaska NMFS Regional Office describing the project and mooring locations as well as provide this information during our AT survey briefings with industry representatives and the public.

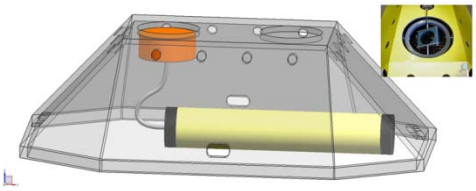

Figure 3. Trawl resistant mooring with installed echosounder. The transducer will be mounted in a gimbal similar to that shown (inset).

The echosounders will be field tested prior to use in Shelikof Strait, and will be calibrated at the deployment depth of 275 m before and after instrument recovery to account for pressure-induced effects on the transducers (Dalen et al., 2003). To calibrate the single-beam instruments, the echosounders will be removed from the mooring and will be mounted in tandem with an existing self-contained lowered 38 kHz EK60 echosounder developed by SWFSC/AFSC and lowered to depth with a 38.1 mm tungsten carbide standard sphere. The split-beam positions from the EK60 will be used to establish the sphere location, from which the sphere relative to the 70 kHz transducer will be computed (Demer et al., 1999), allowing for application of standard split-beam calibration procedures (e.g. Foote, 1987). In the event that split-beam instruments are delivered to us, a similar procedure will be implemented without the EK60. We will also attempt to deploy a sphere equipped with a float above the mooring (by releasing a spooled line with a dissolving magnesium link after mooring deployment), and analyzing the sphere backscatter over an extended period, which has proven very successful for moored echosounders (J. Horne, Univ. WA, Pers. Comm.).

Field deployments and expected results: The three moorings will be deployed in February 2014 using the NOAA ship *Oscar Dyson* and recovered with a chartered fishing vessel 2.5 months later in mid April. Four small-scale (~8 h) acoustic-trawl surveys will be conducted in the vicinity of each mooring (*Dyson* Feb, Mar, Mar; *Charter* Apr). The Dyson has a 70 kHz echosounder. For the charter vessel, the acoustic observations will be made at 38 kHz, and converted to the equivalent at 70 kHz using the frequency response of pollock which is 0.3 (95% CI 0-0.5) dB higher at 38 kHz than at 70 kHz (De Robertis et al., 2010).

From the backscatter measurements, we will compute the standardized mean error of mooring-based predictions of AT survey backscatter ($MPE_{S,T}$) as a function of how large an area of the AT survey is aggregated (S, i.e., km^2 surveyed), and duration (length of time) the mooring data are averaged (±T around ship survey), $MPE_{S,T} = \left|\left(\frac{AT_S - Mooring_T}{AT_S}\right)\right|$. The estimates of the prediction error as a function of spatial and temporal averaging, will allow us to incorporate the errors into our analysis (e.g., Fig. 2) by recomputing the retrospective analysis with bootstrap error estimates parameterized based on the mean prediction error from the surveys. We anticipate maximum agreement between the AT and mooring survey at 10s of km^2 with moderate temporal averaging of the mooring data (i.e., days to weeks, Fig. 4).

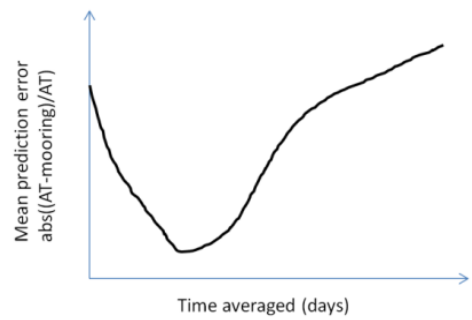

Figure 4. Hypothetical relationship expected between mooring and acoustic survey measurements when the mooring is averaged over intermediate time scales (i.e., averaging over time is equivalent averaging over space to some degree due to fish movement over the stationary moored echosounder).

We will determine the optimal averaging window (i.e., the minimum in Fig. 4) and use this information with realistic MPE estimates to refine the array design of moored echosounders to generate a pollock abundance index. Kaltenberg et al., 2010 report (but do not demonstrate) in their study on sardines and anchovies that there is a high correlation among moorings arranged at the corners of a 4 km^2 square and conclude, "that one mooring provides daily abundance data representative of sampling over at least 1 nmi^2." Given that the pelagic species schools in their study were relatively patchy (Kaltenberg and Benoit-Bird, 2010), one would expect that point measurements will be even more spatially representative for pre-spawning pollock in Shelikof Strait, which have a much more even distribution (e.g., Fig 1, De Robertis et al., 2010).

In addition to the spatial comparisons, we will conduct an analysis on the increase and decline of pollock abundance at the index sites over the spawning season in Shelikof Strait. This will help us understand how the timing in the formation, duration, and dispersal of pollock spawning aggregations impacts biomass estimates. This will also provide baseline information useful for designing additional experiments similar to those conducted on other species to evaluate impacts of spawning behavior on survey estimates of abundance (Robichaud and Rose 2002). Survey timing has been demonstrated to be the major source of uncertainty in some surveys of spawning fish (e.g. O'Driscoll, 2004), and optimizing survey timing may be difficult because spawning timing can be variable (e.g., Lawson and Rose, 2000). Repeated survey passes in Shelikof Strait, for example, have revealed that the pollock abundance and distribution can change substantially over ~2 weeks during the spawning period (Nelson and Nunnallee, 1984). Analysis of the time series from the autonomous echosounders will allow us to describe the temporal variability at the index sites, which can then be used to evaluate the effects of survey timing in the context of an overall survey error budget (O'Driscoll, 2004). This type of direct measurement to describe spawning aggregation timing represents an advance over current practice for the Shelikof Strait survey where the proportion of spawning females is currently used as an indicator for appropriate survey timing. However, the indicator may be misleading. For example, the proportion of Atlantic cod in spawning condition is not necessarily related to the abundance at spawning sites (Lawson and Rose 2000).

Anticipated probability of success: Shelikof Strait is well-suited for autonomous acoustic measurements as the backscatter is relatively homogenous, and backscatter at ≤ 70 kHz (but not at 120 or 200 kHz due to the contribution from macrozooplankton) is dominated by walleye pollock, so species identification is not a major concern. Our retrospective analysis suggests that only a few moorings will be needed to generate a pollock abundance index comparable to that generated by the acoustic-trawl survey for the GOA pollock stock assessment in this environment (Fig. 2). The results from our proposed work to evaluate the spatial extent of the mooring measurements will provide a definitive answer for the location and number of the moorings that are needed. If we find that additional mooring deployments and small-scale vessel surveys are required to accurately estimate MPE, we anticipate continuation of this project through collaboration with the Kodiak fishing industry (e.g., Cooperative Research Grant) in subsequent years to help defray some costs.

The technical challenges of our proposed work are minimal. Simrad has a proven track record of producing high quality acoustic systems, which are widely used by fisheries acousticians internationally and within NOAA. Simrad representatives have informed us that our proposed study has provided the needed impetus for them to act on developing a high-quality self-contained echosounder and that any over-budget costs will be absorbed by them and not NOAA. Trawl-resistant bottom moorings (e.g., Mooring Systems, Inc.) are commonly used for ADCP deployments, and we have been assured by MSI engineers that their use with echosounders should be straightforward. Expected products from the proposed work to facilitate the pathway for implementation to other Centers/regions where moored echosounders can potentially be used in place of ship-based surveys, will include a paper describing the methodology for mooring site selection, and the estimation of uncertainty in an abundance index as a function of number of moorings.

Outcomes: This project has the potential to develop an innovative and efficient method to use autonomous echosounders to augment traditional ship-based acoustic surveys to assess aggregations of fish or other organisms in a wide variety of situations. Our particular application focuses on walleye pollock that periodically concentrate in a restricted part of their habitat for spawning purposes. Given that many other species aggregate in predictable and restricted parts of their habitat (Lawson and Rose 2000, Josse et al., 2000, Doonan et al., 2003, Taylor, 2006, Benoit et al., 2008, De Mitcheson et al., 2008, Ressler et al., 2009, Jech 2012), other situations likely exist where an autonomous echosounder approach could be used to augment ship-based assessment surveys. In essence, the proposed work will establish a quantitative method to 1) determine the spatial sampling dimension of a moored echosounder, and 2) provide an estimate of uncertainty in the abundance index as a function of number of moorings. Although the work will be conducted in Alaska, the approach is general enough to have national relevance as there are numerous stocks that are amenable to acoustic assessment methods, and thus the application of the proposed study results will be valuable. Notable project products are listed below.

- Development of new instrumentation for autonomous monitoring of fish abundance. This instrument will become commercially available after this study.

- Methodology to establish the potential suitability of a moored approach based on retrospective analysis of surveys (i.e., mooring area(s) selection, and development of uncertainty estimate based on historical survey data).

- Potentially lower-cost autonomous measurement of fish abundance. The majority of studies with moored echosounders to date have been behavioral studies, and the proposed application constitutes the first attempt to use the approach specifically to support a stock assessment.

- Quantification of uncertainty in spawning surveys introduced by survey timing, which can be a major source of uncertainty but is often poorly known.

- More efficient use of Fishery Survey Vessels (FSV). Implementation of moored echosounder approach to augment Shelikof Strait acoustic survey will mean FSV time could be reallocated from Shelikof survey to other important research or survey priorities.

Transition to operations: This project has a clear path to operations on both a regional and national basis. In terms of walleye pollock in Alaska, the PIs are responsible for conducting both the GOA acoustic surveys to assess pre-spawning pollock as well as the GOA pollock stock assessment (see attached CVs) so an understanding of the proposed study results and their implementation into the assessment will be straightforward. The project is designed to produce both an index of abundance comparable to the AT survey estimate and a quantitative evaluation of the uncertainty in that estimate, which are directly useable in the present assessment model for Gulf of Alaska pollock. The echosounder developed under the auspices of this proposal will become commercially available. Analysis of data from these autonomous instruments is expected to be very similar to FSV Simrad echosounders, which will leverage existing NMFS staff knowledge. Assuming the proposed project is successful, there will likely be applications for this approach outside Alaska, and we will help to transition the field and analytical methods to other NOAA Fisheries Science Centers. We will provide written documentation of mooring configurations and deployments, and will extend invitations to interested parties to participate on subsequent cruises using the proposed approach.

Replies to Reviewers' Comments:

Pros: If successful, the full survey of pollock will be unnecessary!

The moorings may ultimately provide sufficient information about the abundance and behavior of pollock in Shelikof Strait to allow more efficient vessel use by reducing the survey spatial extent or frequency that the survey needs to be conducted. At the conclusion of this project, we will evaluate whether changes to the pollock survey are warranted. As suggested in the next comment, it would be prudent to not assume *a priori* that pre-spawning conditions in Shelikof now and in the recent past will exist unchanged forever. Thus, it will be important to periodically conduct the traditional ship-based AT survey of Shelikof Strait to confirm that the moored sounders are providing an index that is comparable to that from an acoustic-trawl survey. This is the same strategy that is employed when using opportunistically collected acoustic data from commercial vessels to generate an index of pollock abundance for the eastern Bering Sea during alternate years when a traditional MACE acoustic-trawl survey is not conducted (Honkalehto et al. 2011).

Cons: Explain why the entire survey area must be sampled each year if the three small areas are sufficient to describe the abundance of pollock. The explanatory power of the three index areas depends upon the spatial and temporal stationary of the pollock distribution and seasonal migration. Provide evidence that the process is sufficiently stationary so that the three stations will continue to be informative.

The fact that a small subset of the survey area was highly correlated with the entire survey data set was a very recent and exciting discovery, which prompted submission of this proposal. We view this observation as a positive finding and hope to capitalize on it to make more efficient use of vessel time for AFSC, and ideally for other Centers as well. Analysis of the readily available data (since 2003) suggests that 60 km of acoustic trackline produces an index that is highly correlated with the entire survey over the past decade when the pollock stock exhibited a substantial change in abundance (Fig. 2). We applied a relatively simple and intuitive criterion to identify these areas (i.e. select blocks that maximize the mean/stdev of abundance across the time series). We would likely have generated a stronger relationship by searching for stations with the highest correlation, but felt that this would have little out-of-sample validity. A combination of moored echosounder measurements along with periodic surveys and comparisons with the stock assessment model predictions will confirm that the moorings are providing an informative index of stock abundance.

Add more detail in the proposal regarding modification of the 70 kHz system to fit into the bottom-mooring pressure housing.

As described in this proposal, this will be a new acoustic system specifically built for this project.

Describe the details of the calibration method.

The two calibration approaches are described in the text and would include a standard sphere calibration at the deployment depths as well as a moored sphere suspended above each upward pointed echosounder during the actual deployments.

This proof of concept study may be conducted using only one mooring. Consider proving the concept with fewer landers and less money. Consider a two-year proposal, ramping up to three moorings if the first mooring is successful; thus making the proposal more competitive.

The results of our retrospective analysis identified three areas within the Shelikof survey area where data are needed to provide the strong correlation we observed. There are several reasons for placing moorings in each of these areas during year one of the proposed study. First, there is no reason to assume that conditions at all sites are similar. For example, it may be that a single mooring will provide sufficient sampling coverage at two sites but not the third site. With three available moorings we would not have to assume that one site (w/ mooring) is representative of the other sites (w/o moorings). We would also not be forced to relocate a single mooring among the three sites during a single spawning season, or take multiple years to characterize the three sites. Incidentally, if our proposed study results suggest that a single mooring provides inadequate coverage in one of our 3 areas as described in the scenario above, we would have the option (with 3 available moorings) in subsequent years to use up to three instruments at the site to evaluate whether we can obtain the needed level of coverage with the additional moorings. Secondly, if we are able to deploy all three instruments during year one of the study, we are one

step closer to providing an autonomous sounder-based index of abundance for Shelikof and thus closer to a decision to reallocate vessel time for more efficient use. Finally, our proposed project requires the development of new instrumentation as no suitable device currently exists. When we initially approached Simrad to build an instrument to fulfill our needs, we were informed that the difference in cost of 1 versus 3 units was relatively trivial compared to the development (i.e., R&D) cost. Given the potential advantages that the use of three units would be to the project during year one, and the relatively modest savings that would result from purchasing a single unit, we have maintained our request for three units.

Project Milestones/Schedule

Task	2013	2014
Trawl-Resistant Bottom Mooring (TRBM) field tests (Washington)	Sept	
TRBM and autonomous echosounder field tests (Washington)	Dec	Jan
Deploy moorings, small-scale *Oscar Dyson* surveys (n =3/mooring)		Feb-Mar
Recover moorings, small-scale *charter vessel* survey (n=1/mooring)		Apr
Data analysis, production of final report		Dec

Budget and Justification:

Item	unit price	units	Cost
Trawl-resistant bottom-mooring	4540	3	13620
shipping to Seattle	300	3	900
Edgetech Port LF-SD acoustic release	7300	3	21900
Simrad autonomous echosounder system	40000	3	120000
Shipping (to/from Kodiak, Alaska field location)	--	--	4000
4-day charter vessel	9500	4	38000
Travel for PIs to charter vessel	2500	2	5000
Total			**$203,420**

We request a total of **$203,400** for three trawl-resistant bottom moorings with acoustic releases and custom-built echosounders. Funds for a 4-day charter (April survey, mooring recovery) are required as the *Oscar Dyson* will be in the Bering Sea and unavailable in April 2014. We will request support for the charter vessel funds in FY14 via a Cooperative Research proposal (Dec 2013 decision) with industry as part of the National Cooperative Research Program. If that is successful, the amount requested from ASTWG will be reduced to $165,400.

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Taylor, J. C., Eggleston, D. B., and Rand, P. S. 2006. Nassau grouper (*Epinephelus striatus*) spawning aggregations: hydroacoustic surveys and geostatistical analysis. In Emerging technologies for reef fisheries research and management, J. C. Taylor (ed.), p. 18-25

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Education
Ph.D. (Oceanography) 1992, University of Hawaii, Honolulu
M.S. (Fisheries) 1985 Oregon State University, Corvallis
B.S. (Fisheries) 1978 University of Washington, Seattle

Professional Experience

2004-present	Program Manager, Midwater Assessment and Conservation Engineering (MACE) Program (Fisheries Acoustics), NOAA, Alaska Fisheries Science Center, Seattle.
1992-2004	Fishery Biologist, Midwater Assessment and Conservation Engineering, NOAA, Alaska Fisheries Science Center, Seattle.
1986-1992	Oceanographer & Graduate Research Assistant, NOAA, Pacific Islands Fisheries Science Center, Honolulu Laboratory, Honolulu (Ph.D. and other work).
1981-1985	Research & Teaching Assistants, Department of Fisheries and Wildlife, Oregon State University (M.S. and other work).
1980-1981	Research Assistant; National Institute of Water and Atmospheric Research - Fisheries, Wellington, New Zealand.
1977-1979	Fisheries Biologist/Research Assistant; Fisheries Research Institute, University of Washington, Seattle.

Scientific Committee Memberships
NOAA Advanced Sampling Technology Working Group
ICES Fisheries Acoustics Science and Technology Working Group
Dissertation committees of two students (Univ. Washington)

Recent Publications

Weber, T.C., C. Rooper, J. Butler, D. Jones, and **C.D. Wilson**. *accepted.* Seabed classification for trawlability using the Simrad ME70 multibeam echosounder on Snakehead Bank in the Gulf of Alaska. Fish Bull NOAA.

De Robertis, A., **Wilson, C. D**., Furnish, S. R., and Dahl, P. H. 2012. Underwater radiated noise measurements of a noise-reduced fisheries research vessel. ICES J Mar Sci:

Hollowed, A.B., S. Barbeaux, E. Farley, E.D. Cokelet, S. Kotwicki, P.H. Ressler, C. Spital, and **C.D. Wilson**, 2012. Effects of climate variations on pelagic ocean habitats and their role in structuring forage fish distributions in the Bering Sea. *Deep-Sea Research II* 65-70: 230-250.

Sigler, M., K. Kuletz, P.H. Ressler**,** N. Friday, **C.D. Wilson**, and A. Zerbini, 2012. Apex predators and hot spot persistence in the southeast Bering Sea. *Deep-Sea Research II* 65-70: 292–303.

Woillez, M., P.H. Ressler, **C.D. Wilson**, and J.K. Horne, 2012. Multifrequency species classification of acoustic-trawl survey data using semi-supervised learning with class discovery. *JASA Express Letters* 131(2), DOI: 10.1121/1.3678685.

Jones, D., **Wilson, C. D**., De Robertis, A., Weber, T. C., and Butler, J. L. 2012. Evaluation of Rockfish Abundance in Untrawlable Habitat: Combining Acoustics with Alternate Sampling Tools. Fisheries Bulletin, 110: 332-343.

Walline, P.D., **Wilson, C.D**., Hollowed, A.B., Stienessen, S.C. 2012. Short-term effects of commercial fising on the distribution and abundance of walleye pollock. Canadian J. Fish Aquatic Sci 69: 354-368.

Honkalehto, T.H., Ressler, P.H., Towler, R.H., and **Wilson, C.D.** 2011. Using acoustic data from fishing vessels to estimate walleye pollock abundance in the eastern Bering Sea. Canadian Journal of Fisheries and Aquatic Sciences 68:1231-1242.

Williams, K., Punt, A.E., **Wilson, C.D.**, Horne, J.K. 2011. Length-selective retention of walleye pollock, Theragra chalcogramma, by midwater trawls. ICES J Mar. Sci.

De Robertis, A. and **Wilson, C.D**. 2011. Silent ships do not always encounter more fish (revisited): comparison of acoustic backscatter from walleye pollock recorded by a noise-reduced and a conventional research vessel in the eastern Bering Sea ICES J. Mar Sci.

De Robertis A, **Wilson C. D.**, Williamson N. J., Guttormsen M. A., Stienessen S. (2010) Silent ships sometimes do encounter more fish. Part I: Vessel comparisons during winter pollock surveys. ICES J Mar Sci. 67: 985-995.

De Robertis A., **Wilson C. D.**, (2010) Silent ships sometimes do encounter more fish. Part II: Concurrent echosounder observations from a free-drifting buoy and vessels. ICES J of Mar Sci. 67:996-1003.

Mann, D.A., **Wilson, C.D**., Song, J. and Popper, A.N. 2009. Hearing sensitivity in the walleye pollock, *Theragra chalcogramma.* Trans. Am. Fish. Soc. 138:1000-1008.

Guttormsen, M. A. and **Wilson, C. D**. 2009. *In situ* target-strength measurements of capelin (Mallotus villosus) in the North Pacific Ocean. ICES J. Mar. Sci. 66: 258-263.

Recent Collaborators

Dorn, M.W., NOAA Fisheries, Alaska Fisheries Science Ctr, REFM Div., Seattle WA
Godo, O.R., Institute of Marine Research, Bergen, Norway
Hollowed, A.B., NOAA Fisheries, Alaska Fisheries Science Ctr, REFM Div., Seattle WA
Ianelli, J., NOAA Fisheries, Alaska Fisheries Science Ctr, REFM Div., Seattle WA
Rooper, C.N., NOAA Fisheries, Alaska Fisheries Science Ctr, Seattle WA
Somerton, D.A., NOAA Fisheries, Alaska Fisheries Science Ctr, RACE Division, Seattle WA
Stabeno, P.J., OAR, Pacific Marine Environmental Lab., Seattle, WA
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Weber, T.C. Center for Coastal & Ocean Mapping, Durham NY

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Education and experience:

2003-Present: Research Fishery Biologist, Alaska Fisheries Science Center. Conduct research to improve acoustic-trawl surveys.

2001-2003: National Research Council Postdoctoral Fellow, Northwest Fisheries Science Center. Project title: Feeding ecology of juvenile salmonids in turbid environments. Adviser: Richard D. Brodeur

1995-2001: Ph.D. Biological Oceanography, Scripps Institution of Oceanography. Dissertation: Small-scale spatial distribution and swimming behavior of euphausiids in relation to visual predation risk. Adviser: Mark D. Ohman.

1995: BS Biology, University of California Los Angeles.

Collaborators in the past 24 months:

Chris Wilson (AFSC), Bree Witteeven (Univ of Alaska), Stan Kotwicki (AFSC), Patrick Ressler NOAA/AFSC, Tom Weber (UNH), Larry Mayer (UNH), Nils Olav Handegard (IMR), Edward Cokelet (NOAA/PMEL), Peter Dahl, (UW), Kevin Boswell (FIU), Paul Wade (AFSC)

Five publications relevant to this proposal:

De Robertis, A., Wilson, C. D., Furnish, S. R., and Dahl, P. H. in press. Underwater radiated noise measurements of a noise-reduced fisheries research vessel. ICES Journal of Marine Science.

De Robertis, A., and Cokelet, E. D. 2012. Distribution of Fish and Macrozooplankton in Ice-covered and Open-water Areas of the Eastern Bering Sea. Deep Sea Research: 217-229.

De Robertis, A., and Higginbottom, I. 2007. A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise ICES Journal of Marine Science, 64: 1282-1291.

De Robertis, A., McKelvey, D., and Ressler, P. H. 2010. Development and application of empirical multi-frequency methods for backscatter classification. Canadian Journal of Fisheries and Aquatic Sciences, 67: 1459–1474.

De Robertis, A., Wilson, C. D., Williamson, N. J., Guttormsen, M. A., and Stienessen, S. 2010. Silent ships sometimes do encounter more fish. Part I: Vessel comparisons during winter pollock surveys. ICES Journal of Marine Science: 985-995.

Five other publications:

De Robertis, A., and Handegard, N. O. in press. Fish avoidance of research vessel and the efficacy of noise reduced vessels: A review. ICES Journal of Marine Science.

Weber, T. C., De Robertis, A., Greenaway, S., Smith, S., Mayer, L., and Rice, G. 2011. Estimating oil concentration and flow rate with calibrated vessel-mounted acoustic echo sounders. Proceedings of the National Academy of Sciences. doi/10.1073/pnas.1108771108

De Robertis, A., and Williams, K. 2008. Weight-length relationships in fisheries studies: the standard allometric model should be applied with caution. Transactions of the American Fisheries Society, 137: 707-719.

De Robertis, A., Ryer, C. H., Veloza, A., and Brodeur, R. D. 2003. Differential effects of turbidity on prey consumption of piscivorous and planktivorous fish. Canadian Journal of Fisheries and Aquatic Sciences, 60: 1517-1526.

De Robertis, A. 2002. Size-dependent visual predation risk and the timing of vertical migration: An optimization model. Limnology and Oceanography, 47: 925-933.

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Education:

M.S. Auburn University, 2002, Fisheries And Aquaculture
B.S. Samford University, 1995, Biology

Positions:

Fishery Biologist, NMFS, NOAA, AFSC, Midwater Assessment and Conservation Engineering, 2003-present
Fisheries Observer, Alaskan Observes, Inc. 1997-2000

Research Interests:

Influence of fish behavior on survey design and uncertainty, advanced sampling technology and underwater instruments fish observation and enumeration, fisheries management, population modeling

Computer Skills:

Proficient programming skills in Matlab, Python, VB. Database design, image processing, 3-D visualization

Awards:

Bronze medal, NOAA, 2007 – for development of open design high precision fish measurement device
H.S. Swingle Award for Outstanding Master's Student, Auburn University, 4/02
Presidential Fellowship, Auburn University, 9/00 – 5/02
Russel – Barber Award for Excellence in Marine Studies, Samford University, 6/93

Publications:

Williams, K.; Punt, A.E.; Wilson, C.D.; Horne, J.K. 2011. Length-selective retention of walleye pollock, Theragra chalcogramma, by midwater trawls. ICES J Mar. Sci. 68:119-129.

Williams, K., Rooper, C. N., Towler, R. 2010. Use of stereo camera systems for assessment of rockfish abundance in untrawlable areas and for recording pollock behavior during midwater trawls. Fish Bull 108(3): 352-362.

De Robertis, A; Williams, K. 2008. Weight-length relationships in fisheries studies: The standard allometric model should be applied with caution. *TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY* 137 (3): 707-719.

Handegard, NO; Williams, K. 2008. Automated tracking of fish in trawls using the DIDSON (Dual frequency IDentification SONar). *ICES JOURNAL OF MARINE SCIENCE* 65 (4): 636-644.

Williams, K. 2007. Evaluation of the Macroscopic Staging Method for Determining Maturity of Female Walleye Pollock *Theragra chalcogramma* in Shelikof Strait, Alaska. *ALASKA FISHERY RESEARCH BULLETIN* 12 (2): 252-263.

Williams, K; Papanikos, N; Phelps, RP; Shardo, JD. 2004. Development, growth, and yolk utilization of hatchery-reared red snapper *Lutjanus campechanus* larvae. *MARINE ECOLOGY-PROGRESS SERIES* 275: 231-239.

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Education

B.S. University of Washington, Fisheries, 1979.
M.S. University of Washington, Biomathematics, 1989.
Ph.D., University of Washington, Fisheries, 1998, Committee chair: Gordie Swartzman

Professional Experience

Fisheries Research Biologist, Alaska Fisheries Science Center, National Marine Fisheries Service, 1988-present.

Lead assessment author for the Gulf of Alaska pollock assessment.

Five Recent Publications

Spencer, P.D., and M.W. Dorn. In Press. Incorporation of weight-specific relative fecundity and maternal effects in larval survival into stock assessments. Fish. Res. http://dx.doi.org/10.1016/j.fishres.2012.05.003

Berkson, J, L. Barbieri, S Cadrin, S. Cass-Calay, P. Crone, M. Dorn, C. Friess, D. Kobayashi, T. J. Miller, W. S. Patrick, S. Pautzke, S. Ralston, M. Trianni, Calculating acceptable biological catch for stocks that have reliable catch data only. 2011. NOAA Technical Memorandum NMFS-SEFSC-616. 44 p.

Forrest, R.E., M. K. McAllister, M. W. Dorn, S. D.Martell and R. D. Stanley. 2010. Hierarchical Bayesian estimation of recruitment parameters and reference points for Pacific rockfishes (Sebastes spp.) under alternative assumptions about the stock recruit function. Canadian Journal of Fisheries and Aquatic Sciences. 67: 1611–1634.

A'mar, Z.T., A.E. Punt, and M.W. Dorn. 2009. The impact of regime shifts on the performance of management strategies for the Gulf of Alaska walleye pollock fishery. Canadian Journal of Fisheries and Aquatic Sciences 66:2222-2242.

A'mar, Z.T., A.E. Punt, and M.W. Dorn. 2009. Incorporating ecosystem forcing through predation into a management strategy evaluation for the Gulf of Alaska walleye pollock (Theragra chalcogramma) fishery. Fisheries Research.

Five Other Significant Publications

Haltuch, M.A., A.E. Punt, and M.W. Dorn. 2009. Evaluating the estimation of fishery management reference points in a variable environment. Fisheries Research 100:42-56.

A'mar, Z.T., A.E. Punt, and M.W. Dorn. 2009. The evaluation of two management strategies for the Gulf of Alaska walleye pollock fishery under climate change. ICES Journal of Marine Science, 66: 1614–1632.

Shen, H. M.W. Dorn, V. Wespestad, and T.J. Quinn. 2009. Schooling pattern of eastern Bering Sea walleye pollock and its effect on fishing behaviour. ICES Journal of Marine Science, 66:1284-1288.

Punt, A.E, M.W. Dorn, and M.A. Haltuch. 2008. Evaluation of threshold management strategies

for grounfish off the U.S. west coast. In Advances in the analysis and application of harvest policies in the management of fisheries. Fisheries Research, Special Issue, 94(3)251-266.

Dorn, M.W. 2002. Advice on West Coast rockfish harvest rates from Bayesian meta-analysis of stock-recruit relationships. N. Am. J. Fish. Management 21:280-300.

Appointments and Committee Memberships

Scientific and Statistical Committee, Pacific Fisheries Management Council (2001-), Vice Chair, 2008-2009, Chair 2010-2012.

Affiliate Associate Professor, School of Aquatic and Fisheries Sciences, University of Washington.

Member of study group formed during the 2009 National SSC workshop to evaluate data-poor methods used to set acceptable biological catches.

Member of National Standard 2 Working Group convened by National Marine Fisheries Service to develop guidance on the role of the SSC and the use of best available science.

Guest editor of Fisheries Research special issue: Advances in the analysis and application of harvest policies in the management of fisheries.

Collaborators in the past 48 months

André Punt (UW), John Horne UW), Jim Ianelli (AFSC), Paul Spencer (AFSC), Teresa A'mar (AFSC), Vidar Wespestad (Resource Analysts International), Suzanne Romain (Romain Consulting), Robyn Forrest (Fisheries and Oceans Canada), Murdoch McAllister (UBC Fisheries Centre), Steven Martell (UBC Fisheries Centre), Richard Stanley (Fisheries and Oceans Canada), Jim Berkson (SEFSC), Luiz Barbieri (Florida FWC), Steve Cadrin (UMass), Shannon Cass-Calay (SEFSC), Paul Crone (SWFSC), Claudia Friess (Ocean Conservancy), Donald Kobayashi (PIFSC), Thomas J. Miller (U Maryland), Wesley Patrick NMFS OSF), Sarah Pautzke (WPFMC), Steve Ralston (Retired SWFSC), Michael Trianni (CNMI DFW), Haixue Shen (ADF&G), Terrance Quinn (UAF), Stéphane Gauthier (Fisheries and Oceans Canada), Luiz Mello (Fisheries and Oceans Canada), Gary Melvin, (Fisheries and Oceans Canada), Vladlena Gertseva (NWFWSC), Cynthia Jones (Old Dominion University), Mathew Cieri (Maine Department of Marine Resources).