Promoting Rigorous Citizen Science:

Coastal Observation and Seabird Survey Team (COASST) Evaluation Report on Citizen Impact

Appendix 4, Final Report for NSF 1114734

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Introduction

The Coastal Observation and Seabird Survey Team (COASST) is a well-established rigorous citizen science program that has been centered on a single data type collected regionally – that of beached birds. Begun in 1999 with a small program of 12 participants on the south coast of Washington, COASST has steadily grown to almost 850 active participants currently collecting data on more than 450 beaches, including sites in Oregon (added in 2001), California (2006) and Alaska (2006). It is one of the largest PPSR (Public Participation in Science and Research) programs on the West Coast. As of May 2013, over 2,100 individuals (n = 2112) have been trained by COASST (by experts: classroom, on-the-beach; by participants) and have collected at least one month of data Some of the original COASSTers (n = 12) have continued to take part in the program for close to 16 years.

To date, COASST participants have discovered 45,000 carcasses of 164 species. This numeric and geographic reach makes COASST the largest beached bird program in the world. As noted in project materials, COASST data have been published in the peer-reviewed scientific literature, on subjects as varied as historic use of seabird die-offs as a Native American food source, climate impacts on coastal ecosystems, and fishery bycatch.

COASST has regularly ensured and documented that the beached bird identification data collected by COASST volunteers meets a high degree of accuracy (86% accuracy to species level, averaged over all program participants), thereby producing high quality data useable by resource managers and scientists. COASST had not, however, undertaken any systematic evaluation that examined the program's impact on their adult volunteers.

In 2012, with funding from the National Science Foundation's *Advancing in Informal STEM Learning (AISL)* division, a one-year study was conducted to focus specifically on evaluating participant learning outcomes and impacts from the beached bird data module. *COASSTNET: Scaling Up COASSTal Citizen Science* (NSF-DRL – 2224734) is an initial exploration of the effectiveness of the COASST beached bird module to sustain outcomes at individual, research and community levels, with a specific focus on the degree to which participants understand various scales of data, from the individual bird identification through to the use of COASST data by the science and resource management communities. The study was conducted by Dr. Cynthia Char of Char Associates, an independent evaluation firm, working in close collaboration with Dr. Julia Parrish, COASST Executive Director; and COASST staff.

Description of COASST Training and Support: In COASST, participants are recruited and trained locally in a single 3-5 hour session focused on delivering STEM content and STEM skills. All training attendees are given a COASST protocol, a COASST field guide, and a COASST field kit (measuring, photographing, and tagging materials; data sheets; outreach materials). Trainings are divided into four parts:

• *Introduction* (lecture format) - answers "So What?"; focused on ecology, natural history, conservation and resource management, and oceanography

• *Bird Quiz* (call and response format)- highlights differences between live and beached bird identification; focused on morphometrics (the shape and size of body parts) and meristics (the number of body parts)

• *Beached Bird Identification* (hands-on pair:share format)- introduces simple skills (measurement and precision, morphometrics, meristics, graph reading, basic statistical concepts) and complex skills (use of a dichotomous key, relative weighting of evidence derived from simple skills) needed to participate in COASST

• *Survey Protocol* (call and response format) - introduces simple skills (sampling design, data entry) needed to participate in COASST.

After training, participants can sign a contract pledging to survey at least monthly (or seasonally in regions where extreme weather prevents winter surveys).

To increase participant learning and help sustain interest, COASST maintains regular contact with all participants via a range of in-person, electronic, and print methods. In addition to monthly data collection on their beach, COASST participation may also include:

- *direct interaction with COASST staff* (e.g., email, phone to/from COASST staff about their data; attending one or more refresher sessions conducted by COASST staff; attending one or more socials conducted by COASST staff; attending science lectures on COASST or related marine bird and coastal ecosystem topics presented by scientific experts)

- *web-based interaction* (e.g., data entry into the on-line web portal; receiving and reading COASST blog posts, facebook posts, or tweets; using the COASST website to review COASST data - their own, or others)

- *reading written material* received from COASST (e.g., COASST Annual Report; COASST holiday card and letter).

Any COASSTers who mis-identify a bird in their submitted beach surveys are individually contacted by project staff to review appropriate simple and complex skills. *COASST Reports*, *COASSTLine*, and the COASST webpage give COASSTers access to

local-to-regional data stories connecting data collected directly to its use in science and resource management; natural history, ecology, conservation, and oceanographic science; as well as encourages basic STEM skills including data analysis, simple statistics, and graph reading. These same data stories are the focus of evening talks presented by COASST staff and other science professionals to local audiences within the COASST geographic region (~15-20 talks annually). Short-term data "alerts" are sent to COASSTers via Facebook and email.

Current Study on Program's Impact on Participants

Evaluation Design: A one-year evaluation was conducted to assess two major aspects of the program, with each focused on a distinct COASST program component and volunteer population. First, we were interested in assessing the educational effectiveness of the initial ½-day training session at conveying scientific knowledge and skills to individuals new to COASST.

Second, we wished to assess the learning impact resulting from COASST volunteers' active involvement in conducting monthly bird surveys on their assigned beaches. More specifically, we examined whether volunteers actively involved in COASST for one or more years retained certain levels of scientific knowledge and skills, as well as understood the relationship between the data they personally collected and larger space-time scales of pattern in the data, and broader resource management and environmental issues. We also assessed individuals' levels of engagement, and whether volunteers' engagement extended to communicating their citizen science work to others in their communities.

Survey Instruments: Three different survey instruments were designed for the study: a pre-training survey, a post-training survey, and a survey given to all active participants who had been collecting data for a minimum of a year. (See Appendix 1-3 for copies of the surveys.) The three survey instruments were designed to look at:

1. The ***impact of training*** on learning outcomes, and specifically on the acquisition of a knowledge base and set of skills specific to COASST practice. Specifically, we used identical items in the pre- and post-training surveys.

2. The ***impact of the practice*** of COASST activities, and specifically monthly beach surveys, on the retention of, and/or deepening of, knowledge base and skill set. Specifically, we used identical questions in the post-training versus COASST participant surveys.

3. Evidence that participants ***engaged in the process of science***, as expressed in their abilities to use, or describe, ***a framework or model of scientific practice*** specific to COASST and/or used by COASST. Specifically, we used identical questions in the pre-training versus COASST participant surveys, or *only* asked COASST participants questions.

4. Evidence of ***engagement beyond COASST***, and specifically that participants communicated their knowledge, skills, and models of science to others. Specifically, we restricted these questions to only COASST participants.

COASST survey items assessed the extent to which participants gained improved skills and abilities to:

- identify and collect characteristics needed for species/object identification (e.g., foot type)
- collect accurate measurements (e.g., chord of bill length in millimeters)
- use the dichotomous key and collected data to correctly identify species/object through the process of deductive reasoning (evidence 1st, deduction 2nd)
- conduct standardized survey and search techniques (e.g., of a beach).

COASST survey items also assessed the extent to which participants acquired an increased awareness and understanding of:

- basic knowledge of the diversity, ecology, and conservation issues of coastal marine organisms and ecosystems (regionally-tuned)
- the relationship between data personally collected and larger space-time scales of pattern
- how their data is (can be) used in science and resource management
- the level of rigor their data must have to be used in science and resource management.

The table below illustrates the number of survey items per survey instrument that addressed various target areas.

Topic/Skill Area	**Pre-training Survey**	**Post-training Survey**	**COASSTER Survey**
Bird Identification	3 items	2 items	3 items
Measurement	1 item	2 items	--
Evidence Privileging	1 item	--	1 item
Survey/Search Techniques	--	3 items	3 items
Knowledge Scaling of Data	1 item	--	2 items
Knowledge/Concern regarding Marine Birds and Coastal Waters	2 items	--	2 items
Communication to Tertiary Audiences	1 item	--	3 items
Program Interest and Satisfaction	--	3 items	2 items
Background Information & Miscellaneous	1 item	1 item	2 items
Total Items	10 items	11 items	18 items

Question Type and Analyses: Surveys had four ***types of questions***, based on the way(s) in which the participants could answer them, and how those data were subsequently handled.

1. Bi- and multiple choice questions with exclusive answers (i.e. pick only one response option). In some cases, answers were scored as correct or incorrect, or used to place participants into a category of "feel they possess information" versus "do not feel they possess information" (e.g., by selecting an "I don't know" option.) In other cases, answers were simply used to place participants into exclusive categories (e.g., people who are aware vs. unaware of ways in which COASST data has been used for scientific, resource management or conservation purposes).

2. Multiple choice questions with inclusive answers (i.e., pick as many response options as you want). This question type was restricted to establishing seasonal patterns (i.e., choose which months are high versus low bird occurrence). Answers were graded on a ranked scale from most to least correct.

3. Short answer questions asking for a list of items (e.g., list up to five reasons that marine birds die). Answers were coded *a posteriori* into categories arising from the answers, and then occasionally coded into larger category sets based on similarity. In some cases, categories, or supercategories, were graded on a ranked scale from most to least correct.

4. Free write questions asking for a 1-3 sentence prose response (e.g., explain the main purpose of requiring monthly surveys). Answers were coded *a posteriori* into categories arising from the answers, and then occasionally coded into larger category sets (supercategories) based on similarity. In some cases, categories, or supercategories, were graded on a ranked scale from most to least correct.

Categorization: Coding was conducted by select COASST staff, using actual terms from all short answer and free write questions, where staff independently coded initial categories within a pilot set (N=50 minimum), and compared results to insure all potential categories were captured and inter-rater agreement was 95% or higher. In certain cases, *a posteriori* categories were collapsed into larger (super) categories (e.g., anthropogenic versus natural sources of mortality) by the Executive Director (Parrish).

Ranking: In cases where free write questions tested knowledge of a specific answer or scientific model, original or coded answers were graded along a continuum scale of 4-6 points, ranging from incorrect/nonsensical to highly accurate and/or detailed knowledge. For each question, all grading was conducted by a single COASST staff member, after consultation with the Executive Director on a training set (N=50 minimum) independently graded by Parrish and the staff member.

Statistics: For all comparison (pre, post, COASST) questions, χ^2 contingency tables, T-tests, or F-tests were used, as appropriate.

Sample and Methods: For the "new COASSTers" sample, individuals were drawn from 123 participants who attended one of 21 trainings conducted during the four-month period from February 5, 2012 to June 2, 2012 (range 1-15 participants per training,

mean = 7, see Table 1 in the Final Report). Trainings were located in 18 different communities across the four-state COASST area (Washington, Oregon, California and Alaska).

All participants attending the training were asked to fill out a pre-program survey at the beginning of the training. All but one participant agreed to fill out the survey. Participants completed one of two versions of a 5-page, 10-question survey. Within one week following the training, participants were sent a hard copy post-program survey (5-page, 11-question survey) to complete, and asked to mail it back to project staff. Of the 122 participants who filled out a pre-program survey during the training, 98 later submitted a completed post-program survey (80% return rate).

For the COASST volunteer sample, project staff contacted 412 volunteers who had participated in conducting COASST beach surveys for at least one calendar year (i.e., had begun collecting COASST beach data prior to March 2011), and who had submitted at least one beached bird survey in the last year.

These 412 COASSTers were sent a 9-page, 18-question survey to their residence during the 4-month time period from March – June 2012. Participants were asked to return their completed surveys via U.S. mail. By July 2012, the cut-off date for the present study, 308 individuals (75% return rate) had submitted a completed survey.

COASST Sample

New COASSTers	Pre-training survey (n = 122)	Post-training survey (n = 98)	Matched pre-post surveys (n = 98)
Regular COASSTers	"Regular" post-program survey (n = 308)		

I. Overview of Major Evaluation Findings and Program Design Recommendations

Learning Outcomes Arising from Training

The COASST training had significant positive impacts on participants' science knowledge and skills ***explicitly delivered in the training***. Two aspects of knowledge and skills are covered in the training: (1) sampling design, or the specifics of surveying the beach and searching for beachcast birds; and (2) bird identification, or the specifics of what pieces of evidence to record on a beachcast bird, and how to use those pieces to make an identification.

- In free write answers, post-training participants could correctly explain COASST survey practices, including width-specific beach survey techniques, why monthly surveys are necessary, and why carcasses are tagged.

- Relative to their pre-training performance, post-training participants could also correctly demonstrate how to make required morphological measurements of bird wings and bills.

In addition, the COASST training ***implicitly imparts several science practices***, which post-training participants could demonstrate use of.

- Post-training, participants could ***reason that there are more species than families***, without ever explicitly being taught the Linnean taxonomic classification system. What they did learn through COASST training was how to use the COASST Field Guide, which requires that they select a Foot Type Family first, and then select among one to many species nested within it.

- When asked how they would identify a bird, post-training participants significantly increased their tendency to cite the ***need to collect evidence*** (e.g., a photograph).

Learning Outcomes Arising from Program Participation

Beyond training, participation in the program includes both the actual, repeated practice of the beach surveying protocol, as well as many possible interactions with COASST and specifically with COASST staff and experts, via web-based interactions, in-person contact, and print materials.

Without regard to which of these elements may have influenced a shift in knowledge, skill, or understanding of the practice of science, participants who had been active members (defined as collecting a minimum of one beached bird survey in the most recent year) were at once more, and less, adept at demonstrating elements of the practice of science than the immediately post-trained population. This suggests that at least some of

the knowledge base and skill set learning trainees come away with is not reinforced by the practice of COASST.

COASST volunteers demonstrated an erosion of knowledge or understanding relative to the immediately post-trained population, in the following areas:

- ***Linnean Taxonomic Framework*** – Increased the tendency to choose "don't know" as an answer when asked about the relative number of families and species.

- Decreased their tendency to cite the ***need to collect evidence*** (e.g., a photograph) when identifying a bird.

- Decreased the accuracy of their understanding of ***how to sample beaches*** as a function of beach width.

COASST volunteers did better, or as well, as the pre and/or post-training population in the following areas:

- When asked how to identify a bird, increased their tendency to cite the ***use of tools*** (e.g., a field guide, camera, or measuring device).

- When given a choice of information types needed to make a deduction about bird identification, ***privileged in-hand evidence*** (morphological measurements) over less specific information.

- When asked to list what information they would use to differentiate among bird species, ***privileged in-hand evidence*** (foot shape, morphological measurements) used by COASST.

- Maintained a highly accurate understanding of ***why carcasses are marked***, and an accurate understanding of ***why surveys are conducted monthly***.

Science Synthesis Arising from Program Participation

Beyond learning particular pieces of information and/or skills (e.g., bird morphology and associated ways of measuring birds), and a framework within which to use them (e.g., collecting evidence such as measurements first to then use in a deductive process of species identification), the practice of COASST appears to allow participants to evolve mental models of their immediate environment and beyond.

Temporal models of beachcast bird occurrence. – Relative to the pre-trained population, COASST participants demonstrated a significant increase in knowledge of the annual cycle of occurrence of common species on their beach, including *whether* there was an annual pattern, and if so *what* it was. Moreover, individuals clearly integrated their monthly experiences over several years, without overly privileging the most recent year.

That is, COASST participants appeared to build up a mental model of each individual species, and then added to that model as they continued to collect data.

Reasons beachcast birds are found. – Relative to the pre-trained population, COASST participants demonstrated increased knowledge as to the mortality factors that contributed to why beachcast birds are found. In addition to demonstrating an increased breadth in the collective list of mortality agents, they displayed a decreased emphasis on anthropogenic sources (e.g., pollution, fishery entanglement), and an increased emphasis on natural events (e.g., post-breeding mortality – high late summer or early fall encounter rates for local breeders; winterkill – high winter encounter rates for migrant species) and ultimate causality (e.g., starvation) linked to the annual cycle of occurrence of common species on their beach. That is, they were able to understand, explain and presumably reinforce their temporal model.

Data patterns beyond the immediate participant environment. – Slightly over a third of COASST participants were able to describe one or more ways that COASST data had been used in a scientific or resource management context, even if they had not participated directly in the actual project. While this information obviously derived from the COASST program, rather than from the individual participant experience of data collection, it is telling that participants can remember, and articulate, over 50 particular data "stories." Most prominent among the data stories were ones related to the establishment of a baseline, or the year-over-year average annual pattern of occurrence of one or more species of beachcast birds. These stories are ones that COASST participants can all be directly involved in, at least in terms of collecting those data that create the baseline pattern (if not participating in the establishment of a shift in the pattern, and the reasons for it, as in an oil spill, an incidence of fishery-bycatch, or a harmful algal bloom die-off).

Communication about COASST

COASSTNET survey results suggest that COASSTers communicate about COASST with many different audiences, from family and friends, to scientists, and resource managers and other government personnel. During these exchanges, COASSTers share a personal finding on the beach, describe COASST "data stories," and recruit additional participants.

Discussion of Findings and Program Design Recommendations

Knowledge and Skill Acquisition – The evaluation findings suggest that post-training participants and COASST volunteers successfully acquired, and retained, knowledge and skills across a variety of areas, including measurement and bird identification methods, and reasons underlying the need for monthly surveys and tagging of bird carcasses. Thus, the one-day COASST training and follow-up contact and materials seems to be effective in these areas, with no modifications needed.

Science Practice and Implicit Learning – There were three areas in which COASST volunteers displayed decreased understanding, compared to post-training participants, pertaining to points that were only implicitly part of their surveying materials and practice. These included the Linnean Taxonomic Framework, the taking of photographs as evidence when identifying a bird, and the method they employed for surveying their assigned beach, based on beach width. Thus, the fieldguide materials and refresher trainings might need to be more explicit and increase the emphasis on tools and practice associated with how to survey beaches and why particular techniques are used.

Building Mental Models – Although participants who elected to answer questions about larger scale patterns in time (i.e., seasonal patterns in when certain bird species wash ashore) tended to be correct, less than half of respondents answered. This suggests that either the question was intimidating, and/or a significant portion of COASST participants do not build up a larger-scale understanding beyond the immediate experience of carcass identification or possibly what was found in the most recent survey. Thus, the program may wish to increase its volunteer outreach efforts and encourage more active learning, either in refresher sessions, annual reports, or in web-based activities, that allows more participants to use and test their knowledge about larger scale and seasonal patterns.

Understanding Scales of Use Beyond the Immediate – Although participants who elected to describe data use "stories" displayed extremely broad collective knowledge, most participants did not answer this question and those that did rarely displayed a high degree of understanding of the specifics of data analysis and use. Thus, the program may wish to increase data use outreach to all participants via multiple avenues (web, in-person, written materials) including a clearer description of the process of science and resource management: observation/data collection, collation, analysis, visualization, deduction/conclusion, decision/change, and adaptive management. The program might also wish to consider inventing more active learning approaches that allow participants to be more directly involved in stages beyond observation/data collection.

Outreach, Dissemination and Recruitment

Survey results suggest that participants regularly talk about their COASST work and findings with family and friends, fellow beachwalkers, co-workers and neighbors. Participants also mentioned discussing COASST with more professional audiences, including scientists, resource managers, politicians and reporters. Thus, deepening participants' understanding about the significance and utility of COASST data, through socials, refresher trainings, and print and electronic media, could further leverage the efforts of these committed individuals to disseminate COASST findings, data stories, and bolster volunteer recruitment.

II. Evaluation Findings, by Specific Outcome Areas

This section features more detailed accounts of evaluation findings, by specific survey items and outcomes areas. Six different areas of findings are presented: 1) program participation patterns of engagement and program satisfaction; 2) bird identification skills and knowledge; 3) survey/search techniques; 4) knowledge scaling; 5) knowledge and concerns about marine birds and coastal areas; and 6) communication.

1. Program Participation Patterns of Engagement, and Program Satisfaction.

Char Associates worked with COASST staff to develop a system to track and document a "COASST participation pipeline," to represent different juncture points at which a new participant could either opt out of future COASST activities or continue to actively engage in COASST. Of these 121 new training attendees who recently participated in COASST training during the 5-month period from February through June 2012, 93% (113) chose immediately to enroll as a COASST volunteer. Of these 113 enrolled COASSTers, 78% (88) went on to complete at least one beached bird survey of their assigned beach. And of those 88 individuals who conducted at least one beach survey, 90% (79) went on to complete at least two or more beach surveys in the past year. Thus, interest and retention in the program appears quite high for those who attend the initial training.

Moreover, an additional 64 volunteers who had already been involved in COASST prior to February 2012 elected to attend these trainings as "refreshers" – further evidence that the COASST volunteers remain interested in and engaged in the project, and that sessions continue to appear of interest to even experienced COASST volunteers.

Post-training survey respondents (n = 98) were highly satisfied with the quality of the training, with 75% rating it as excellent, and 24% rating it as good. Of the 98 respondents, only 56 offered suggestions for improving the training. Of those who responded with a suggestion, close to half (26) indicated a desire that there be more training in some form (more hands-on, more time spent on beach, longer training time).

2. Bird Identification Skills and Knowledge

There was a cluster of five different survey items that assessed the extent to which COASST training and practice enabled volunteers to acquire a variety of novel and measurable skills and areas of new understanding regarding bird identification. These items concerned specific morphometrics or body measurements (correct procedures for measuring bird wing chords and bills), understanding of basic taxonomy framework (that there are more species than families), and various approaches and use of evidence for bird identification.

Morphometric/Body Measurements

(Pre/Post) A central skill addressed during the initial COASST training is how to properly measure specific bird parts (wing, bill, leg) when collecting evidence for bird identifications. One pre and post-training survey item assessed whether participants could identify the correct method of accurately measuring bird parts, from a set of three photographs depicting different measurement methods (one correct, and two incorrect). Respondents could also select a "don't know" response option.

We hypothesized that those without specific training would not have such procedural knowledge for measuring birds, and that knowledge of such skills would increase after training. Therefore we expected that before training, respondents would have fewer correct responses and higher numbers selecting that they didn't know, whereas following training, there would be more respondents who were correct, and fewer who indicated that they didn't know.

To ensure that exposure to this question prior to the training did not affect participants' ability to answer correctly after the training, there were two versions of this item, concerning either the wing chord or bill. On the pre-test, participants received either the wing chord item OR the bill item, while on the post-test, all respondents received both wing chord and bill items. Subsequent analysis indicated that exposure to a particular version of this item (wing chord vs. bill) in the pre-test did not appear to affect participants' ability to answer correctly on the post-test.

As hypothesized, respondents following training had much higher levels of correct responses, and much lower levels of indicating "don't know".

Identification of wing chord measurement procedure	**Pre-test Responses (n=60) (%)**	**Post test Responses (n=98) (%)**
Correct	13%	84%
Incorrect	23%	14%
Don't know	63%	1%
Identification of bill measurement procedure	**Pre-test Responses (n=63) (%)**	**Post test Responses (n=98) (%)**
Correct	30%	94%
Incorrect	21%	5%
Don't know	49%	1%

Paired-samples t-tests (comparing those who received the identical question on both pre- and post-test) indicated that there was a significant difference between respondents' ability to correctly answer the question before and after the training, as shown in the table below.

Pre-post Paired Sample Comparisons to Knowledge Questions (don't know, blank, and incorrect responses have been combined into a single category)

Response Category	% Correct Response Pretest	% Correct Response Posttest	Difference (SD)	t	degrees of freedom	*p*
Which wing chord measurement is correct?	17%	89%	.72 (.544)	8.941	45	.000*

(n=46)						
Which bill measurement is correct? (n = 52)	31%	98%	.67 (.474)	10.247	51	.000*

*significant at or below .001

Families vs. Species

(Pre/Post/COASST) One survey item assessed whether or not participants knew the basic Linnean taxonomy framework that there were more species than families. While this point is *not* explicitly presented in the training, it is implicitly embedded in the way the COASST participants are taught to identify beached birds, and in the way the field guide is set up (i.e., identifying the "Foot-type Family" first, selecting a species within that family second.) It was hypothesized that pre-training respondents would be incorrect or chose "don't know" at higher levels, and that respondents post-training and the regular COASST volunteers would be correct at higher levels. COASST staff did not predict that there should be differences between post-training and COASSTers, as practice does not improve knowledge of this.

As hypothesized, higher levels of understanding were observed post-training. Pre-training, 59% of the trainees answered this question correctly. Post-training, an additional quarter of the respondents were able to respond correctly, at 86%.

A paired-samples t-test, that grouped unanswered and "don't know" responses together with incorrect responses, indicated a significant increase in participant understanding of this relationship.

Pre-post Paired Sample Comparisons to Family-Species Question (don't know, blank, and incorrect responses have been counted as incorrect)

Response Category	% Correct Response Pretest	% Correct Response Posttest	Difference (SD)	t	degrees of freedom	*p*
Are there more species or families? (n=98)	62%	86%	.23 (.513)	4.522	97	.000*

*significant at or below .001

COASSTers' responses, while 15 percentage points higher than the pre-trained respondents, were 9 points lower than that of post-respondents shortly after training. This slight fall off in ability suggests that some COASSTers, while they may be using the field guide, may be primarily following the field guide's dichotomous branching structure but not be consciously aware of the families/species structure embedded in the field guide, or that in regions with low bird occurrence (and thus few opportunities to identify birds using the field guide), that without reinforcement the knowledge erodes.

Non-paired frequency responses

Are there more species than families?	Pre-test Responses (N=123)	Post test Responses (N=98)	COASSTer Responses (N=308)
More Species -- correct	59%	86%	75%

More Families—incorrect	13%	8%	7%
Don't know	28%	6%	18%

Non-paired frequency responses for respondents who thought they knew the answer

Are there more species than families?	Pre-test Responses (N=89)	Post test Responses (N=98)	COASSTer Responses (N=308)
More Species -- correct	82%	91%	91%
More Families—incorrect	18%	9%	9%

A similar pattern was noted in the percentage of respondents who answered "don't know" across the groups. The percentage of participants responding "don't know" decreased by more than 20 percentage points after training, whereas the percentage of COASSTers responding "don't know" was about 12 percentage points higher than the Post trainees. When the non-responders were removed from the sample, the percentages of Post trainees and COASSTer able to give the correct response are virtually identical.

General Approach to Bird Species Identification

(Pre/Post/COASST) COASST training and practice are designed to impart knowledge about effective methods to identify beached bird species. COASST training, and the COASST approach favors the use of tools, and the collection of evidence, and - obviously - discounts any live bird characteristics.

Given that bird identifications are at the heart of the COASST project, one survey item gave respondents a general prompt to describe two ways they might identify a bird. Responses were combined and categorized as to whether or not they mentioned the following attributes and methods:

a) morphological characteristics (e.g., shape or color of bill, wing, tail, etc.);
b) live bird non-morphological characteristics (e.g., behavior, habitat, time of year);
c) tools (e.g., field guide, binoculars);
d) piece of evidence (e.g., measurement, photograph, bird-in-hand).

It was hypothesized that pre-training respondents would cite less evidence and tools and use more live bird characteristics, while post-training respondents and COASSTers would cite more evidence and tools, and more "dead bird" characteristics (like feet type).

Pre-post training paired sample comparisons indicated that respondents most commonly mentioned *morphological characteristics* as their primary focus for identification; however, respondents were also significantly less likely to mention *live bird characteristics* and significantly more likely to include reference to *evidence* in their explanations after the training. Thus, responses are trending both towards more COASST-specific strategies.

Pre-post Paired Sample Comparisons for Participant Responses on How to Identify Birds

Response Category(N=98)	Pre-Training	Post-Training	Difference (SE)	t	*p*

Morphological characteristics	91%	95%	.04 (.032)	1.269	.208
Live bird, non-morphological characteristics	42%	26%	-.16 (.046)	-3.617	.000*
Tool	14%	16%	.02 (.041)	.498	.620
Piece of evidence	3%	30%	.27 (.048)	5.640	.000*

Note: degrees of freedom=97
*significant at or below .001

COASSTers continued to cite *morphological characteristics* as the most common response (cited by 85%), as well as resumed a tendency to use live bird, *non-morphological characteristics* similar to pre-training levels. COASSTers, however, were more likely to mention using a *tool* in their response ($\chi 2$ (2, N =529) =13.257, $p < .005$; V=.158) This may be attributable to the fact that they are regularly using the tools (e.g., COASST Field Guide, measurement devices, etc.) as aids to identify birds during their surveying activity. However they were not as likely as Post-training responders to mention *evidence* (V=.124), but much more so than respondents before training (V=.204). ($\chi 2$ [1, N =431] =17.942, $p < .005$) Pre-COASSTer Evidence comparison ($\chi 2$ [1, N =406] =6.239, p=.012) Post-COASSTer Evidence comparison).
In general, it appears that COASST appears to alter the population of response categories, and that the shift favors tools, and evidence, and also suggests a tendency to think about beached birds in addition to live birds.

Frequency Responses on How to Identify Birds, for all Groups

Response Category	Pre-Training (N=123)	Post-Training (N=98)	COASSTers (N=308)	Total (N=529)
Morphological characteristics	89.4% (110) [108.1]	94.9% (93) [86.1]	85.1% (270) [262]	87.9% (465)
Live bird, non-morphological characteristics	39.8% (49) [41.4]	26.5% (26) [33]	33.4% 103 [103.6]	33.6% (178)
Tool	12.2% (15) [26.5]	16.3% 16 [21.1]	26.9% (83) [66.4]	21.5% (114)
Piece of evidence	2.4% (3) [20.2]	29.6% (29) [16.1]	17.9% (55) [50.7]	16.4% (87)

Observed counts are shown in parentheses; expected counts are shown in brackets

Using Measurement Evidence to Identify Bird Species
(Pre/COASST) By working with COASST, volunteers engage in the process of how to weigh evidence, such as that gleaned from actual measurements of bird parts of their beached carcasses versus field guide information on what time of the year various bird species are likely to become beached.

In this survey item, respondents are presented with a scenario describing a beached bird they have encountered while walking along a beach on the Washington outer coast in

January. In the scenario, they have already identified the bird to sub-family as a dark shearwater using COASST materials.

They are presented with bill, wing and foot measurement ranges for each these two species, along with measurements from the particular specimen they have encountered. They are also presented with a bar graph depicting the likelihood of encountering each species of shearwater on the Washington outer coast for each month of the year.

The question asks whether they can identify the beached bird as either a Sooty Shearwater or a Short-tailed Shearwater, or whether there is enough information to make an identification.

Answering correctly requires the respondent to privilege certain forms of evidence, and in particular recognizing that the graphs showing the *likelihood* of encounter don't override the measurement evidence they have actually collected. It was hypothesized that the COASSTers would be more adept at using evidence in this way, and that pre-training respondents would be more likely to indicate that they don't know, and less likely to correctly privilege the measurement evidence.

Response Category	% of Pre-training Respondents (N=123)	% of COASSTers (N=308)
Correct	46.3	66.2
Incorrect	26.8	24.4
Don't Know	26.8	9.4

As hypothesized, pre-training respondents were less likely to correctly privilege the measurement evidence and more likely to indicate that they didn't know, compared to COASSTers. Nearly two-thirds of the COASSTers were able to answer this question correctly, compared to slightly less than half the pre-training respondents ($\chi 2$ [1, N = 431] = 21.642, $p < .005$; V=.224). As the percentages of COASSTer and Pre-trainees answering the question incorrectly were similar, the difference came from the proportion of respondents electing to answer the question, rather than indicating that they didn't know.

Distinguishing Between Pairs of Birds

(Pre/Coast) COASST training introduces volunteers to distinguishing features and characteristics pertinent to species of beached birds, while practice in conducting surveys enables volunteers to sharpen this knowledge through continued use of these identification skills. Pre-training and COASST respondents were presented with an open-ended word problem in which they were asked to describe one way that they might reliably distinguish between two species of birds. Essential to this question was the notion that the respondent would come upon these birds as beached carcasses - that is, as if conducting a COASST beach survey - and that specific portions of the bird might be missing, forcing the respondent to think about the differentiation in the absence of complete evidence or information.

There were two versions of this problem, each featuring a different bird pair (Black Scoter and Tufted Puffin; or gulls and Northern Fulmars) and respondents received one version of the problem. It was hypothesized that pre-training, individuals would not know what key bird features to look for to identify these particular bird species, while COASSTers will have a better understanding of what bird features to look for, and might also refer to using a field guide in their process of bird identification.

Written responses were scored by project staff along a 4-point scale. *High* scores were assigned for responses that were correct and also easy to use as a distinguishing feature (e.g., using foot type). *Medium* scores were assigned to methods that were correct in some/all cases (e.g., could be used for some gulls, but not all gulls) and involved a more difficult a characteristic than high scores (e.g., foot color, a characteristic that is variable and can fade in death, versus foot shape, a character that is invariable across individuals within a species). Medium scores were also given to responses that referenced using the COASST field guide without explanation of the character(s) examined (e.g., "use COASST guide").

Low scores were assigned to methods that could not reliably be used to distinguish between the species, and/or could have been used in live birds although the question explicitly asked the respondent to provide ways to distinguish between beached birds. *Very low* scores were assigned to incorrect and/or immaterial answers (e.g., "habitat" or "ask a friend"). Respondents were also allowed to check "*Don't Know*" and this response was not scored. In cases of multiple answers (e.g., foot shape, wing shape, feather length) each individual answer was graded and the final grade was the average, occasionally creating fractions of an integer (e.g., 2.5).

Results indicate that significantly more COASSTers received a High score; the average score of respondents, however, was not significantly different across Pre and COASST groups. It appears that a non-trivial fraction (~ 25%) of the pre-trained population comes to the program with a fairly high level of knowledge as regards to bird identification, including beached birds. Nonetheless, the results suggest that participation in the COASST program approximately doubles this skilled and knowledgeable population.

Respondents who answered Gull/Fulmar item

Average Score of Response	% of Pre Respondents (n=60)	% of COASSTers (n=148)
High (2.5 - 3)	23.3%	56.1%
Medium (2)	--	3.4% (1.1-2.3)
Low (1)	5.0%	7.5 (0-1)
Very Low (-1)	1.7%	.7%
Blank/Don't know (n/a score)	70%	32.4%

Pre Trainees—Mean=2.44, Median=3; SD=1.149
COASST—Mean=2.68; Median= 3, SD=.762

Respondents who answered Scoter/Puffin item

Average Score of Response	% of Respondents (n= 21)	% of COASSTers (n=160)
High (2.5 - 3)	23.8%	45.6%
Medium (2)	--	16.9% (1.3-2.0)

Low (1)	19.0%	13.8 (0-1)
Very Low (-1)	4.8%	4.4%
Blank/Don't know (n/a score)	52.4%	19.4%

Pre Trainees-- Mean=1.80, Median=2, SD=1.389
COASSTers—Mean= 2.10, Median=3, SD=1.156

3. Survey/Search Techniques

COASST training and conduct of beach surveys adheres to a variety of different techniques for properly conducting monthly surveys. These include a system for tagging found beached carcasses for purposes of identification, conducting at least monthly surveys of one's given beach, and different techniques for conducting surveys depending on whether beaches are wide versus narrow. A set of three survey questions spanned this procedural knowledge and skill, where individuals are asked to reason out why a particular SKILL within survey design or search technique is performed. It was hypothesized that participants following the training would demonstrate a level of knowledge to indicate that training has imparted this knowledge, and that this level of knowledge would be sustained or possibly even increased by COASSTers, if practice conducting surveys reinforced or strengthened this knowledge.

Individual Marking of Each Carcass
(Post/COASST) One step of the COASST surveying protocol is that each beached bird found on a COASST survey is individually marked with a colored cable tie system, a procedure that is covered in the one-day training. In the COASST program, individual marking of each carcass is an essential feature of the dataset insuring that once found carcasses are not refound and counted as a fresh (untagged) bird. Secondary uses of individual marking include: feedback to participants should carcass identification of a particular carcass change from one survey to the next; as well as a range of scientific objectives: carcass persistence, and scavenging and decomposition rates. Following the training, respondents were asked on the post-test to describe one or two reasons for why COASST requires individual marking of each carcass. Regular COASSTERs were also asked this question on their survey. It was hypothesized the individuals following COASST training would understand the reasoning behind the cable method, and that this understanding would be maintained with COASSTers.

Respondents' reasons were scored using a 5-point grading system. A *Very High* response addressed ensuring that the surveyor didn't count a carcass more than once, if it is found again in a subsequent beach survey. A *High* response dealt with how the accessory data collected might be used (e.g., see how the carcass has been scavenged, or has decomposed, or persists). A *Medium* response was correct, but addressed only a portion of a High or Very High answer. A *Low* response was technically correct, but largely irrelevant. *Very Low* scores mirrored the question (i.e., "tag it to tag it"), or were technically incorrect or nonsensical. Responses were analyzed two different ways—identifying respondents' best score (maximum rating) and averaging the two responses (mean rating).

As hypothesized, almost all post-trainee responses received a "very high" or "high" grade for their maximum response, as well as for their mean response, suggesting that the training effectively imparted this concept to the participants.

Maximum Grade (best answer)

Response Category	% of POSTers receiving maximum grade (n=98)	% of COASSTers receiving maximum grade (n=308)
Very High (5)	69.4	75.6
High (4)	22.4	12.7
Medium (3)	5.1	5.8%
Low (2)	1.0	1.9
Very Low (1)	--	1.6
Unanswered (na)	2.0	2.3

POSTers --Mean=4.64; Median=5; SD=.634
COASSTers--Mean = 4.62; Median=5; SD=.822

Mean Grade (average answer)

Response Category	% of POSTers receiving mean grade (n=98)	% of COASSTers receiving mean grade (n=308)
Very High (5)	9.2	21.8
(4.5)	30.6	21.8
High (4)	35.7	32.1
(3.5)	13.3	8.8
Medium (3)	3.1	6.8
(2.5)	3.1	2.6
Low (2)	2.0	2.3
(1.5)	1.0	--
Very Low (1)	--	1.6
Unanswered (na)	2.0	2.3

POSTers--Mean=4.04; Median=4; SD=.678
COASSTers--Mean=4.08; Median=4; SD=.817

COASSTer responses indicate that COASSTers maintained this high level of understanding of the concept. Independent samples t-tests between the two groups did not reveal significant differences in either maximum [p=.893] or mean [p=.613] responses.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Why Tag MAX (14)	Equal variances assumed	1.061	.304	-.118	395	.906	-.011	.092	-.191	.169
	Equal variances not assumed			-.135	205.247	.893	-.011	.080	-.169	.147

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Why Tag MEAN (14)	Equal variances assumed	3.755	.053	.506	395	.613	.0466	.0921	-.1345	.2277
	Equal variances not assumed			.557	190.624	.578	.0466	.0837	-.1185	.2117

Requirement of Monthly Beach Surveys

(Post/COASST) The standard COASST procedure is that each COASST beach is surveyed at least once per month throughout the year, creating a consistent dataset across all survey sites as the basis from which all COASST analyses of pattern and the change(s) in it are conducted; this priority was discussed during the one-day training and examples of annual pattern or baseline, and departures from it, were presented. Following the training, respondents were asked on the post-test to briefly describe the main purpose of requiring monthly surveys. Regular COASSTERs were also asked this question on their survey.

Respondents' reasons were scored using a 6-point grading system. A *Very High* response captured a sense of creating a baseline that either included consistent change over time (i.e., seasonally, annually), and/or as the basis against which anomalous events (also known as wrecks) could be measured. Slightly less correct answers (*High*) included the word baseline but without any additional explanation, or a species-specific temporal pattern without identifying its use as a baseline. *Medium* responses addressed some aspect of temporal pattern (e.g., change over time), spatial pattern (e.g., regional comparison), and/or how data might be used (e.g., persistence, wrecks/anomaly) without any mention of baseline creation. *Low* responses were technically correct (e.g., "pattern") without any explanation detail indicating deeper knowledge, or addressed sampling regularity (e.g., amount of data, continuity/consistency, data reliability, standardize effort). *Very Low* responses were technically correct, but largely irrelevant (to find new carcasses before they wash away). *Extremely Low* responses were technically incorrect, vague, immaterial or nonsensical.

About one-third of the Post respondents (34%) following the training were able to produce high or very high levels of reasons, with responses involving creating a baseline, or ability to discern a pattern over time or for a specific species. About a fourth of Post-training respondents (24%) had correct but less elaborated explanations involving detecting changes over time (a common Medium response). These various levels of reasoning were largely sustained by the COASSTERs (30% High or Very High reasons; 26% Medium reasons.) Thus, the COASST training seemed to impart a high level of

understanding that was sustained past the immediate time following training, and COASSTers' hands-on experience in using the monthly survey method did not appear to lead them to having a deeper or more sophisticated grasp of the reasoning behind the method that they could articulate (independent samples comparison p=.875).

Response Category	% of POSTers (N=98)	% of COASSTers (N=308)
Very High (6)	18.4	19.8
High (5)	16.3	10.1
Medium (4)	23.5	26.0
Low (3)	29.6	31.8
Very Low (2)	2.0	4.9
Extremely Low (1)	7.1	4.2
Unanswered (n/a)	3.1	3.2

POST Mean=3.98; Median=4; SD=1.414
COASST Mean= 3.95; Median=4; SD=1.360

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Why Monthly GRADE (15)	Equal variances assumed	.158	.691	-.160	391	.873	-.026	.162	-.344	.292
	Equal variances not assumed			-.157	153.392	.875	-.026	.165	-.352	.300

Conducting Standardized Searches of a Beach

(Post/COASST) Another aspect of the COASST survey protocol is equal survey effort applied over the entire site (beach) regardless of beach width, i.e., wide versus narrow. The underlying concept is that all parts of the beach site are searched, and no part of the beach is searched more than once (for instance, on the walk out, and again on the way back). Most beaches are surveyed by pairs of surveyors. Individuals start the survey at a predetermined point, and walk along the length of the beach to a predetermined turn-around point. During the survey, individuals are spaced apart, each searching a different width of the beach. To maximize the width each surveyor can cover on a single pass, the search pattern is wavy, or sinusoidal, often referred to as a "zig-zag" pattern. For narrow beaches, a pair of surveyors can cover the entire width of the beach searching for bird carcasses "on the way out" to the turn-around point (covering the entire stretch, or length, of the site). For wide beaches, surveyor pairs need to survey both going out as well as when returning to their origination point, thereby covering the wide beach in two, non-overlapping passes. As appropriate, surveyors should take into account the rising or falling tide (e.g., surveying the low part of the beach first, if the tide was coming in, and the high part of the beach on the return leg.), although this element of beach search

pattern does not affect the most fundamental principles - all parts of the beach surveyed equally and no part of the beach surveyed more than once.

Following the training, respondents were asked on the post-test whether they would survey a wide or narrow beach differently. If they said "differently", respondents were asked to describe the survey differences, and provide a rationale for doing so. Regular COASSTERs were also asked this question on their survey.

Nearly all of the post training respondents answered, and answered correctly, that wide and narrow beaches should be surveyed differently. COASSTers, however, showed a statistically significant fall-off in getting the answer correct of about 14 percentage points ($t=-3.140$, $p<.005$), after excluding the "don't know" responses (~5%). While more COASSTers responded "don't know" to this question, the proportion was not significant ($\chi 2$ (2, N = 406) = 2.911, p=.088; V=.085).

Respondents Who:	% of POSTers (N=98)	% of COASSTERS (N=308)
Gave an Answer	99.0 (97)	95.1 (293)
Said "Don't know"	1.0 (1)	4.9 (15)

Of the respondents who gave an answer

Response Category	% of POSTers (N=97)	% of COASSTERS (N=293)
Correct--We would survey the beaches differently depending on width.	91.8 (89)	77.5 (227)
We would survey beaches the same regardless of the width.	8.2 (8)	22.5 (66)

Participants who said that they would survey the beaches differently were asked to explain how they would survey each beach, and why they would handle them differently. Responses were scored on a 4-point scale. Correct responses captured the central concept that one would use a "double pass" method for wide beaches and a "single pass" method for narrow beaches.

High responses also mentioned how one would factor in the tide and/or described the zig-zag survey pattern that all surveyors use. *Medium* responses captured the "double pass" and "single pass" difference, but described either response to tide or surveyor walking pattern (e.g., zig-zag) incorrectly. *Low* responses were the opposite, describing either the tide, or zig zag walking pattern, correctly; but failing to describe the double and single pass difference.. *Very Low* responses presented the double and single pass methods incorrectly, and may have also described response to the tide and/or the surveyor walking pattern incorrectly. Items that were left blank were coded as "UA" for unanswered.

All respondents who answered 10a item (correctly) that beaches should be surveyed differently:

Response Category	% of POSTers (n=89)	% of COASSTers (n=227)

High (4)	74.2 (66)	47.3 (96)
Medium (3)	1.1 (1)	4.4 (10)
Low (2)	4.5 (4)	6.6 (15)
Very Low (1)	16.5 (14)	24.7 (56)
Unanswered	4.5 (4)	22.0 (50)

Respondents who answered item 10a (correctly) and who provided a written answer to item 10b:

Response Category	% of POSTers (n=85)	% of COASSTers (n=177)
High (4)	77.6 (66)	42.3 (96)
Medium (3)	1.2 (1)	4.4 (10)
Low (2)	4.7 (4)	6.6 (15)
Very Low (1)	16.5 (14)	31.6 (56)

POSTers--Mean=3.40; Median=4; SD=1.157
COASSTers--Mean=2.83; Median=4; SD=1.368

Of the 89 Post trainees and 227 COASSTers who answered that they would handle narrow and wide beaches differently, 4.5% of the Post trainees and a full 22% of the COASSTers did not provide an explanation for their response, a highly statistically significant difference ($\chi 2$ (1, N = 316) = 13.870, p<.005; V=.210). Even when the non-respondents from both groups are excluded, an independent samples comparison of means shows that Post trainees had higher mean scores by more than half a point (.57) than COASSTers, a significant difference (t=3.343; p =.001). Immediately post-training, almost 80% of written explanations of survey pattern as a function of beach width included the central concept of uniform coverage - a single pass on a narrow beach and double pass on a wider one (i.e., high plus medium responses). However, for COASST participants, knowledge of this concept appears to have eroded, as only 47% of written explanations contained reference to a variable number of passes depending on beach width. Presumably more Post trainees were able to recall the correct beach surveying procedure from having just recently been presented this procedure at the training workshop, while COASSTers were more likely to have forgotten this fact, and only have repeated field experience with their one assigned beach.

Although ancillary to the central concept of even coverage across beaches of different widths, many respondents mentioned the preferred walking pattern of COASST surveys - the sinusoidal or "zig-zag" pattern. In fact, on many surveys, respondents had drawn this pattern. "Incorrect" descriptions of the walking pattern indicated the respondent would walk in a straight line down the beach. Of the respondents who received a grade for the walking pattern, COASSTers were significantly less likely than expected to have received a score of "correct" ($\chi 2$ [1, N = 143] = 28.943, p<.005; V=.450)—with a moderate effect size - further corroboration that understanding of the correct survey procedure eroded, and COASSTer ability to explain methods may be shaped by their particular beach experience rather than their remembrance of what they learned in the training, and/or their reference to the written protocol.

4. Knowledge Scaling

Beyond acquiring knowledge pertaining to bird identification and skills of proper surveying techniques, another desired area of learning was the extent to which participants gleaned scales of scientific patterns in the data, and realized the significance and relevance of the data. That is, beyond their immediate memory of their last bird found or last survey they personally conducted, COASSTers ideally would acquire an understanding of annual and seasonal patterns in the data, and moreover, ways in which COASST data connects with broader ecological and environmental issues in their communities.

Seabird Phenology/seasonal patterns

(Pre/COASST) This question was designed to elicit the degree to which program participants assimilate scales of scientific pattern, in this case, the annual pattern that one might encounter one of the two most prevalent species on COASST beaches. There were two versions of this problem: one featuring Northern Fulmars, and one featuring Common Murres. Respondents received one version of this problem, depending on which form of the pre-test or COASSTER survey they received.

First, respondents were asked whether there was a seasonal pattern of murre (or fulmar) beaching on their COASST beach, and allowed to answer "Yes," "No," or "Don't Know." If they responded "yes," they were asked to identify that pattern by checking which months of the year were “high” (versus "low") in beaching rate, without the ability to describe further degrees of difference (e.g., high, medium, low; ordinated numeric responses, etc.).

This survey item was unusual in that the correct answers were totally dependent on the participant’s specific COASST region (which could be one out of 13 different regions participating in COASST.) In other words, the seasonal timing of murre or fulmar occurrence on beaches in northern California (the southernmost COASST region) is different than on beaches along the northern outer coast of Washington, or within the Bering Sea in Alaska.

COASST staff pre-determined two levels of correct answer. First, an identification of those regions in which there is statistically recurrent annual pattern (allowing scoring of the answers to the first part of the question); and second, creation of a unique answer key for each of the COASST regions in which there was annual pattern (murres - 9 regions; fulmars - 8 regions).

Because respondents may privilege their past experience differently, COASST staff created two scoring systems: one method used the regional annual pattern in the most recent year (2011), whereas the second method used the long-term average (LTA) calculated over all yearly records of COASST data meeting minimum sampling standards. In both methods, "high" months were statistically defined as those above the 50% of maximum month level. Transitional months were defined as those when murre (or fulmar) beaching rates were 40-50% of the maximum month. All other months were defined as "low" months. Thus, for each month, a respondent could have:

1. labeled a "high" month as high, correctly
2. labeled a "transitional" month as high
3. labeled a "low" month as high, incorrectly

Responses were graded along a 4-point scale according to the degree of match between actual and answered high months. *Very High* scores were ones in which there were 2 or more correct "high" months (where "transitional" months were counted as half of a "high" month) *and* there were more correct than incorrect "high" months. *High* scores were ones in which there were 2 or more correct "high" months (where "transitional" months were counted as half of a "high" month). *Medium* scores had a single "high" or "transitional" month labeled by the respondent as high. *Low* scores had no overlap between actual and answered "high" (or "transitional") months. Grades were calculated for both the long-term average (LTA) and most recent year (2011) methods.

It was hypothesized that most people pre-training would not know about the seasonality of beached birds, but that COASSTers would demonstrate increased knowledge based on their greater experience of conducting monthly beach surveys in their region.

As might be expected, the pre-trained population had fairly limited awareness of annual pattern of beached bird deposition (when birds wash ashore). For the Murre problem, 22% of pre-trained respondents got this item correct, while only 5% got the fulmar problem correct. In contrast, about half of the COASSTers answered the question correctly (51% Murre problem; 45% fulmar problem). Understanding the annual patterns of these two species was still challenging for a number of COASSTErs, with somewhat less than half indicating that they didn't know (41% Murre problem; 48% fulmar problem.), but still at much lower rates than that of pre-training respondents (70% Murre; 86% fulmar). Further analysis showed that the differences in proportion of non-respondents between the pre-trained respondents and the COASSTers was statistically significant for both groups, with a stronger effect size found for the fulmar group ($\chi 2$ [1, N = 208] = 14.150, $p < .005$; V=.261 for the murres question, and $\chi 2$ [1, N = 223] = 27.151, $p < .005$; V=.349 for the fulmar question).

Is there a seasonal pattern to when murres wash ashore?

Response Category	% of Pre-Respondents (n=60)	% of COASSTers (n=148)
Correct choice	21.7%	50.7%
Incorrect choice	8.3%	8.1%
Don't Know	70%	41.2%

Is there a seasonal pattern to when Northern fulmars wash ashore?

Response Category	% of Pre Respondents (n=63)	% of COASSTers (n=160)
Correct choice	4.8	45.0
Incorrect choice	9.5	7.5
Don't Know	85.7	47.5

When examining the seasonal patterns described by respondents, COASSTers were dramatically better than the pre-trained population in accurately describing the annual

pattern of deposition of the two most common species on COASST beaches. When describing that pattern, COASSTers are significantly closer to the long-term average assessed over several years, than to the pattern expressed over the most recent year (i.e., 2011).

For respondents from COASST regions with a seasonal pattern in murre or fulmar deposition, who indicated the seasonal pattern by checking in one or more month as "high"

COASSTers:

Response Category	Long Term Average (n=101)	2011 (n=101)
Very High (3)	60.3 (61)	34.6 (35)
High (2)	19.8 (20)	12.9 (13)
Medium (1)	7.9 (8)	30.7 (31)
Low (-1)	11.9 (12)	25.7 (26)

Scores using LTA Method—Mean= 2.168; SD=1.32
Scores using 2011 Method—Mean= 1.307; SD=1.554

Pre-Training:

Response Category	Long Term Average (n=16)	2011 (n=16)
Very High (3)	25.0 (4)	6.25 (1)
High (2)	18.75 (3)	6.25 (1)
Medium (1)	6.25 (1)	31.25 (5)
Low (-1)	50.0 (8)	56.25 (9)

Scores using LTA Method—Mean= 0.687; SD=1.815
Scores using 2011 Method—Mean= 0.062; SD=1.340

Not surprisingly, the pre-trained population is not especially cognizant of the degree to which there is an annual pattern of beached bird deposition, even for bird species that are quite common throughout much of the COASST geographic range. On the other hand, COASSTers not only understand that such pattern exists, but many of them can specifically describe this pattern. Furthermore, they integrate their experience over several years. Because COASST does not give out species-level deposition information at the regional level, this understanding of pattern has to come from the participants themselves.

Awareness of the Use of COASST Data

The integration of COASST data into science and natural resource management is stated by staff as a fundamental part of the COASST program. In addition to having their own personally collected data, COASST participants may receive information on how COASST data are used from a variety of sources and on a variety of topics. No COASSTer will be the same in that multiple sources (e.g., COASST newsletters and annual reports; the local media; COASST speakers and staff) will intersect with each individual.

Whether COASST participants follow their individually collected data, or COASST data in general, into these use end points in science and natural resource management was assessed by a survey item asking whether COASSTers are aware of ways that COASST data is being used. If the respondent indicated that they were aware of COASST data

use, they were asked to describe up to three ways; that is, to write a particular "data story." Data stories were assessed by project staff for the level of accuracy, specificity, and process elements along a 5-point scale:

Very High = the story is true, contains elements of fact (e.g., correct location, species, time of year, mortality source), and "elements of process" defined by how COASST or other scientists discovered the relationship, what methods were used, and/or specifically how COASST data contributed to the story (e.g., "high mortality incident a couple of years back because of wave action plus algae cause, COASST could compare baseline, and historical numbers")

High = the story is true, and contains basic elements of fact (e.g., "an algal bloom off the Washington Coast a couple years ago")

Medium = the topic is correct, but vague (e.g., "algal blooms")

Low = the topic is correct, but the description is not (e.g., "die-off of Common Murres because of contaminated fish" - although Common Murres have undergone several die-offs, none have been because of contaminated fish)

Very Low = COASST data could conceivably be used in this way, but have not been to date (e.g., "disturbance from marine turbines")

Just under half of COASSTers (47%) reported that they are aware of ways that COASST data have been used. 13% of the COASSTers who answered that they were aware of ways that COASST was being used, however, did not go on to describe any of those stories.

Are you aware of any ways that COASST data have been used for scientific, resource management, or conservation purposes?

	COASST (n = 308)
Yes	47.4% (146)
No	49% (151)
Unanswered	3.6% (11)

Of those who answered "Yes"

	COASST (n = 146)
Elaborated on their response	87.0% (127)
Did not elaborate further	13.0% (19)

Of those who did respond with at least one "data story" description, about 43% received a High or Very High as their highest rating, indicating they were able to provide a correct story with at least a modest amount of detail. Slightly more than half (54%) received a Medium for their highest grade. The average responder offered two data stories, with about a third providing three stories. About one-third of the responders received a mean rating of 3 (Medium) or more for their overall descriptions.

16b. If you answered yes, please describe up to three ways that COASST data have been used

Maximum Response Category	N	% including non-responders	% of responders only
Story with "elements of process" (*Very high*)	18	12.3	14.2
Basic story (*High*)	36	24.7	28.3
Topic is correct, vague (*Medium)*	69	47.3	54.3
Topic is correct is correct, description is not (*Low*)	2	1.4	1.6
We could use COASST to do this but we haven't yet (*Very low*)	2	1.4	1.6
No Response	19	13.0	--
Total	146	100.0	100.0

Of those who elaborated:

	(n=127)
Received a *maximum* rating of Medium or higher	96.9% (123)
Received a *mean* rating of Medium or higher	33.1% (42)

Number of data stories reported by elaborators:

Number of Data Stories Provided	% of COASST Elaborators (n)
1	40.2% (51)
2	25.2% (32)
3	34.6% (44)

Mean=1.945; Median=2, SD=.8666

COASSTers gave examples of over 50 different types of story topics, many focusing on particular mortality events, such as the Tufted Puffin die-off during the winter of 2011-2012, and the death of Surf Scoters in 2009 from exposure and starvation following a bloom of harmful algae. Some story topics focused on particular projects where COASST has involved participants in added levels of data collection, such as avian influenza monitoring, and the collection of Western Grebe tissue for genetic analysis. Many story topics touched on basic scientific monitoring that COASST performs, such as documenting die-off events or wrecks, changes in bird populations, or patterns of mortality, monitoring endangered species, and creating a baseline of bird mortality. Several story topics were incorrect, in the sense that COASST has not yet engaged in the study or analysis, or allowed program data to be used for such an analysis by others (e.g., monitor birds before wave energy turbines are installed; assist in rescuing live birds; assess water quality).

Of the 251 data stories written, the top 5 types of story topics accounted for just under 50% of all stories. These included:

1. A harmful algal bloom along the Washington outer coast in the fall of 2009 that

caused the deaths of thousands of Surf Scoters, Common Murres, and other marine bird species via the production of a foam-like substance that coated the birds and wetted their feathers, causing hypothermia and starvation (16.3% of responses)
2. Creation of a baseline allowing documentation of die-off spikes or wrecks of marine birds (11.6% of responses)
3. Creation of a baseline allowing documentation of oiling impacts, and/or chronic oiling (11.2% of responses).
4. Non-specific creation of a baseline (4.4% of responses).
5. Non-specific documentation of the pattern of a specific bird species (4.4% of responses).

Although many different combinations of story sources were named, the vast majority (86.4%) listed COASST as the partial or sole source of their stories. Other sources included the news media (24.5%), government agencies (7.1%), and non-governmental organizations (3.1%).

5. Knowledge and Concerns about Marine Birds and Coastal Areas

Reasons for Marine Bird Mortality

COASST teaches (in trainings, presentations, annual reports, website) about the general patterns of marine bird mortality, and also about specific events that happen. Although individuals not in COASST might know these things, being a member of this "community of practice" gives COASSTers more access to this type of knowledge. Therefore it was hypothesized that when asked about the reasons for bird mortality, pre-training respondents would be more heavily anthropogenic (describing the influence of humans on nature) and less likely to cite the natural patterns that affect bird mortality (postbreeding mortality, winterkill, migration fatigue), compared with COASSTers. It was also hypothesized that COASSTers would emphasize major mortality events/sources that COASST has found, such as algal blooms.

(Pre/COASST) Because the COASST program communicates with program participants about the sources of marine bird mortality, this item assessed the degree to which COASST has influenced participants' awareness and understanding of bird mortality, relative to a COASST-naive pre-training population. This item asked respondents to list up to five reasons that marine birds die, and thus might wash up on beaches for COASST surveyors to find. Respondents were then asked to circle the two reasons they believed are responsible for the most marine bird mortality in an average year in the COASST region (northern California through Alaska). Based on actual responses, answers were categorized into one of 25 possible exclusive categories. Response categories focused on both specific mortality agents (e.g., oil or predation) as well as general mortality types (e.g., starvation or disease) regardless of agent.

Almost all respondents (97% pre-training; 98% COASSTers) listed one or more reasons they felt beached birds died. Asked to produce up to five reasons that marine birds die, pre-training respondents (n = 119) produced a total of 544 reasons (mean = 4.46 reasons), while COASSTers (n = 302) produced a total of 1347 reasons (mean = 4.57 reasons).

Among all 25 response categories, there was general agreement between pre-training and COASST responses. A rank categorization of all responses indicated that only 9 of the 25 categories had rankings more than 5 units apart, and none diverged by 10 or more units. The top 5 responses in the pre-training population (predation, starvation, pollution, oil, and storms/winterkill) accounted for just over 50% of total responses, and these same 5 accounted for 54.5% of COASSTer responses. The only notable difference was pollution, which was significantly more prevalent in pre-training responses.

In general, the pre-training population tended to list answers that were clearly of human origin (pollution, oil, plastics, fishery entanglement, marine debris/litter, humans, habitat loss, hunting, disturbance, pets, and invasive species - 40.3% of all pre-training responses vs. 35% of COASSTer responses) whereas the opposite was true of clearly natural sources of mortality (predation, storms/winterkill, other natural causes, post-breeding mortality, and migration fatigue - 29/1% of COASSTer responses vs. 23% of pre-training responses).

Bird Mortality Response Category	COASST rank	Pre-training rank
starvation	1	2
storms/winterkill	2	5
predation	3	1
oil	4	4
entanglement (fishery)	**5**	**10**
disease	6	6
old age	7	7
pollution	**8**	**3**
plastics	9	8
harmful algal blooms	**10**	**17**
trauma	11	9
post-breeding mortality	**12**	**18**
hunting	**13**	**19**
climate change	14	16
humans	15	12
low production	**16**	**21**
fisheries	17	14
habitat loss	**18**	**13**
migration fatigue	19	20
marine debris/litter	**20**	**11**
other natural	**21**	**15**
disturbance	22	22
pets	23	23
dead zones	24	
invasive species	25	24

rank differences of 5 or more are highlighted in **bold red** print.

When asked to highlight the top two mortality causes out of all answers given, about two-thirds of both pre-training and COASSTers responded to this prompt. The pre-training respondents (n = 82) listed 17 total categories, whereas COASSTers (n = 207) listed 23. Regardless of this apparent diversity, the top 5 COASST categories accounted for almost 70% of all responses, whereas the pre-training respondents demonstrated a broader spread - the top 5 categories accounted for slightly less than 59% of all responses. As expected, there was high concurrence between pre-training and COASST respondents. Rank ordering indicated that the top 3 responses: starvation, storms/winterkill, and predation were identical. As with the larger list, the pre-training respondents tended to identify mortality agents that were clearly of human origin (35.4% of responses vs. 15.7% of COASST responses) whereas COASSTers favored natural mortality agents (37.9% of responses vs. 25.3% of pre-training responses). Pre-trained respondents tended to overestimate the serious factors caused by humans alone, and were significantly more likely to mention marine debris/litter, oil, plastics, and pollution than COASSTers, who were more likely to mention post-breeding mortality and starvation than the pre-trainees.

COASST program literature (e.g., Annual Reports) and COASST presentations emphasize major sources of mortality as post-breeding mortality and winterkill of migrants; and the major type of mortality as starvation. For pre-training respondents these categories accounted for just over 30% of their "top two" reasons, whereas COASST respondents listed these categories just over 50% of the time.

Concerns About Human Activities in Local Coastal Area

(Pre/COASST) One survey item assessed the degree to which respondents were concerned about the impact of human activities in their local coastal area. If they did indicate they were concerned, they were asked to list up to three issues that concerned them. The third part of this question, asked only of COASST participants, asked respondents to indicate whether they thought COASST had addressed any of these issues.

Since the pre-training and COASSTer populations were presumed to be similar populations, it was hypothesized that there would be no difference in their concerns about human activities in the local coastal area.

The great majority of both Pre-trained (89%) and COASST respondents (82%) were concerned about the consequences of human activities on their beaches. Most (89% pre-training; n = 122; 82% COASSTers; n = 250) also offered up to three issues that concerned them.

When you think about your coastal area (the beaches in your vicinity), are there human activities or their consequences that you are concerned about?

Response Category	% of Pre-Trained Respondents (N=123)	% of COASSTers (N=308)

Yes, there are human activities or their consequences that I am concerned impact the coastal environment in my area.	88.6	81.8
No, my coastal area is healthy and therefore I am not concerned about the impacts of human activities.	8.9	16.2
Unanswered	2.4	1.9

If yes to above, please list up to three (3) issues that concern you

Respondents who:	Pre (N=122)	COASST (N=308)
Answered with at least one concern	88.6% (108)	81.8% (250)
Did not give any response	11.4% (14)	18.2% (58)

Pre-trainees' top three response categories were debris, pollution, and coastal development. Like the pre-trainees, COASSTers' top responses also included debris and coastal development, but cited disturbance/harassment as a top concern, rather than pollution. Overall, pre-trainees were significantly more likely to mention issues related to pollution, boats/ships and habitat loss than COASSTers, while COASSTers were more likely to mention debris.

Concerns	Pre-Trainees % of Respondents (n = 108)	COASSTers % of Respondents (n = 250)
debris	[#1] 50.9% (55)	[#1] 63.6%* (159)
pollution	[#2] 28.7%* (31)	10.4% (26)
coastal development	[#3] 24.1% (26)	[#2] 30.4% (76)
non-point source pollution	21.3% (23)	18.4% (46)
disturbance/harassment	20.4% (22)	[#3] 27.6% (69)
oil	18.5% (20)	13.2% (33)
boats/ships	14.8%* (16)	3.6% (9)
habitat loss	13.9%* (15)	1.6% (4)
fisheries	12.0% (13)	14.0% (35)
humans-animals	12.0% (13)	14.4% (36)

significant difference between groups at .05 level (appears in column with larger proportion)

COASSTers were also asked if they thought the program had addressed any of the issues that they indicated concerns about in the previous question. Eighty-nine COASSTers responded with some issue that they felt that COASST had addressed.

The most commonly cited issue was litter/marine debris, which was mentioned by 42 respondents, or 13.6% of all COASSTers, followed by oil and plastics, mentioned by 16 people each, or 5.2% of all COASSTers.

If you think the COASST program has addressed any of the issues above, please check the box beside the issue(s).

Response Category	N	% of Respondents (n=89)	% of Total COASSTers (N=308)
litter/marine debris	42	47.2%	13.6%

oil	16	18.0%	5.2%
plastics	16	18.0%	5.2%
beach driving	8	9.9%	2.6%
pollution	8	9.0%	2.6%

When conducting a quantitative analysis on the **kinds of responses** produced and seeing what types of concerns were most frequently mentioned (rather than focusing on the types of responses per respondent), COASSTers were most concerned about debris (including land-based litter, marine debris, plastics, and specifically debris resulting from the Japanese tsunami); this is also the category most often identified as one which COASST has, or could, address.

Although COASSTers clearly identified coastal development (including beach armoring, building, and erosion) as of concern, far fewer felt that COASST data could tackle this concern. This pattern also held with non-point source pollution.

By contrast, although relatively few responses were the concern "oil," a fair number of the respondents felt that COASST data could address this issue. This pattern also held with fisheries.

Concern Supercategory	**Personal Coastal Concern** Raw % (raw count)	**COASST Data Can Address** Raw % (raw count)
Debris	30.8% (178)	44.0% (62)
Coastal Development	16.1% (93)	4.3% (6)
Disturbance/harassment	13.3% (77)	12.1% (17)
Non-point source pollution	8.3% (48)	3.5% (5)
Fisheries	6.2% (36)	9.9% (14)
Humans-animals	6.2% (36)	2.1% (3)
Oil	5.7% (33)	11.3% (16)
Pollution	4.7% (27)	6.4% (9)
Humans	3.5% (20)	1.4% (2)
Climate change	2.1% (12)	2.8% (4)
Boats/ships	1.6% (9)	2.1% (3)

As reported by COASST staff, the COAST program actually did address issues of oil in the past. Debris will be addressed in a future module that is currently planned for COASST, to address a new data type that would map directly onto things that COASSTers and non-COASSTers (pre-trainees) felt strongly about.

6. Communication

One of the desired outcomes of COASST is that COASST volunteers demonstrate a level of engagement with COASST that extends into sharing knowledge and interest with others within the community. Through greater knowledge and engagement fostered through COASST, COASSTers ideally would: understand they are an essential part of

coastal science and resource management; develop/express a passion for coastal resource conservation.; develop/express a passion for science; and recruit others to citizen science.

A series of communication questions were asked on the survey to obtain an idea of how many other people are reached via COASST participants, what kinds of people they are, and what kinds of messages COASSTers are providing them with. Do COASSTers only talk about what they find on their beach, or do they also communicate about larger patterns through their "data stories"?

Since the pre-training and COASSTer populations were presumed to be similar populations, it was hypothesized that there would be no difference in their level of "chattiness" and talking with others. In general, the population of citizens from which COASST participation is drawn tends to be out-going, with 60-75% of all respondents claiming that they communicate with others "often" or "a lot."

How often do you communicate with others?

Response Category	% of Pre-trainee Respondents (N=123)	% of COASSTers (N=308)
Rarely	.8%	3.9%
Infrequently	22.0%	30.2%
Often	56.9%	50.6%
A lot	20.3%	13.0%

A sizeable proportion of COASSTers report communicating about COASST at least once to a range of professional audiences; communication with more informal audiences was much more frequent. Just under half of COASSTers (47.4%) report communicating about COASST to scientists other than COASST staff, while over a third (37.7%) spoke about COASST with resource managers and other governmental personnel.

Since you joined COASST, have you ever communicated about COASST to the following audiences?

Professional Audience Group	Have communicated "Once" or "More Than Once" % (n)
Scientists other than COASST staff	47.4% (146)
Resource Managers and other Gov't personnel	37.7% (116)
Politicians and/or their staff (includes tribes)	20.8% (64)
Reporters and news professionals	16.9% (52)

In the past year, how often have you found yourself communicating about COASST to the following audiences?

Audience Group	Have Communicated "Sometimes" or "Often" % (n)
Friends/Family	94.8% (269)
Beachwalkers	75.0% (231)
Co-workers	69.8% (215)
Neighbors	67.5% (208)

Other Envir Grps	57.8% (178)
Other non-partner COASSTers	52.0% (160)
On-line	26.6% (82)
Other	5.5% (17)

Moreover, many COASSTERs report communicating about COASST to a range of more informal audiences either "sometimes" or "often", including friends and family (95%), fellow beach walkers (75%), co-workers (70%), neighbors (68%), members of other environmental groups (58%), and other COASSTERs (52%). Communicating about the program on-line (e.g., facebook, blog, tweet) was not a nearly as common for COASSTers—with only 27% of respondents reporting they did this either sometimes or often. This might be related to the age of the typical COASSTers, of whom a sizeable proportion are retirees, according to COASST project records.

Regarding the types of communication regarding COASST done at least four times a year (quarterly), the most frequent topics of conversation were explaining what the COASST program is about, including what you do on your survey (70%), and sharing a finding from your own beach, from your surveys (58%). About a third (30%) reported sharing a finding from the COASST program that you read about, or heard about from COASST, while almost a fourth (23%) reported that they talked to someone about joining, or recruiting someone to join COASST.

Category	**At Least 4 Times per Year**
Explaining what the COASST program is about, including what you do on your surveys	70.1% (216)
Sharing a finding from your own beach, from your own surveys	58.5% (180)
Sharing a finding from the COASST program that you read about, or heard about from COASST	30.1% (93)
Talking to someone about joining, or recruiting someone to join COASST	22.7% (70)

In order to develop an estimation of the breadth of outreach done by COASSTers in the sample, we calculated respondents' estimations of the number of times they engaged in a particular type of communication per year as follows: "annually"= 1 'event'; "quarterly"=4 'events'; "monthly"=12 'events'; and "weekly"=52 'events'. If one assumes that each communication event was a one-on-one interaction with a different acquaintance, this yields an estimation of 4,493 people who heard something about the program directly from a COASST participant in the previous year.

Since you joined COASST, how often have you engaged in the following types of communication (rough estimate)?

Category	Blank	Never % (n)	Annually (Once/yr) % (n)	Quarterly (4 times/yr) % (n)	Monthly (12 times/yr) % (n)	Weekly (52 times/yr) % (n)
Talking to someone about	6%	23.7%	52.9%	19.5%	3.2%	--

joining, or recruiting someone to join COASST	(2)	(73)	(163)	(60)	(10)	
Explaining what the COASST program is about, including what you do on your surveys	1.3% (4)	3.9% (12)	24.7% (76)	48.7% (150)	20.1% (62)	1.3% (4)
Sharing a finding from your own beach, from your own surveys	1.0% (3)	13.3% (41)	27.3% (84)	32.5% (100)	23.7% (73)	2.3% (7)
Sharing a finding from the COASST program that you read about, or heard about from COASST	1.6% (5)	29.9% (92)	38.3% (118)	26.6% (82)	3.2% (10)	.3% (1)

The two most common type of events reported by COASSTers was sharing their own findings from their COASST activities (1,628 instances), followed by providing general information about the program. Given that COASSTers were giving only rough estimates of their communication activities, and also given that a number of these communications were likely made to repeat listeners, we also developed two more conservative projections—the first revising the calculation downward to 75% of the original calculation for an estimate of 3,370 people hearing about COASST. A more conservative revision to 60% gives an estimate of 2,696 non-involved people hearing about COASST.

Type of "Event" Category	Estimated number of Events by Frequency Category				Total Self-Reported Estimated Number of Events by Scenario		
	Annually (1x/yr)	Quarterly (4 x/yr)	Monthly (12 x/yr)	Weekly (52 x/yr)	Total Estimated Events	Total Estimated Events with 75% handicap	Total Estimated Events with 60% handicap
Recruitment	163	240	120	--	523	392	314
General COASST Informational	76	600	744	208	1628	1221	977
Sharing individual findings	84	400	876	364	1724	1293	1034
Sharing COASST findings	118	328	120	52	618	464	371
Total Events					4493	3370	2696

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