Logic models of NOAA education programs

and implications for restructuring

Bill Clune, May, 2009

Executive Summary

This paper was commissioned by a Committee to Review the NOAA Education Program convened by the Board on Science Education of the National Research Council and addresses the following research question:

> Based on an analysis of logic models, how well do multiple, often small educational programs spread across different agencies of NOAA serve the larger educational goals of the agency as formulated in the national education strategic plan?

The paper formulates a common logic model applied across programs, discusses policy issues, inefficiencies, redundancies, and implementation challenges in each link (or component) of the generic logic model as applied to NOAA programs, and considers options for management. All of NOAA's instructional programs have all of the components of the logic model in some form -- they have educational goals, management, an audience, instructional activities, a delivery method, and intended learning outcomes. Analysis of implementation issues in this paper was done for each element of the model, using examples from particular programs or all programs. In a sense, the logic model was used as a framework considering all programs as strategies for implementing a common mission then asking how the programs might be managed more efficiently and effectively. The gaps of interest to the committee might be in particular programs or in the portfolio of programs or in the management (or lack thereof) of the

portfolio. Implementation questions were asked about whether individual programs used the most effective strategies, whether some programs seemed more effective than others (e.g., the instructional materials and professional development of a specific branch), and how different programs doing the same thing might be consolidated, share best practice, or be centrally managed.

In reviewing the programs, the main question about management was where coordination of different programs is presently located in the agency and where it might be located assuming an intensified restructuring effort. Questions about audience concerned the three audiences of mass education, K-12 instruction and professional development, and higher education. A question about the K-12 audience was how much of the desired instructional content and pedagogy actually appears in state and district standards, textbooks, curriculum guides, standardized assessments, teacher professional development, and the enacted curriculum, for example, in large urban districts, and, in light of those targets, how might multiple NOAA programs aimed at K-12 education be configured more effectively. Questions about instructional materials included possible duplication of meta-cognitive content (e.g., principles of conservation) across programs focusing on different natural resources (e.g., coral reefs, estuaries, fisheries), as well as the desirability of agency-wide standards of content and pedagogy that might be used for quality control of instructional materials dispersed in different branches and programs. Questions about delivery methods and sites asked whether methods such as online education reflect research on best practice and whether exemplary practice within NOAA has been identified and disseminated. Questions about learning outcomes were oriented

around the components of environmental literacy (natural resources, negative human behavior, stewardship), the link between knowledge and action, non-cognitive learning outcomes such as engagement and trust, and the operational definition of minimum and higher levels of literacy, including the depth of knowledge. Clarification of the intended outcomes might lead to improved appraisal of the content of both informal and formal educational programs.

Options for management, varying roughly from least to most in the extent of restructuring required of existing programs, include:

- *Reviews and dissemination of basic and applied research.* Many questions raised in this paper could be illuminated through research: the extent of environmental literacy in various demographic groups, standards of effectiveness of online education, the extent that NOAA content appears in K-12 standards and curricula
- *Reviews of program redundancy and effectiveness.* NOAA educational programs could be reviewed for duplication and evaluated against standards of program effectiveness.
- *Identification of best practice within existing programs.* Programs could be reviewed for the purpose of identifying best practice within the agency with dissemination of results or management efforts directed at replication.
- *New initiatives aiming for increased effectiveness in selected areas.* Assuming availability of new resources, new initiatives could be launched in areas with the

highest priority for an increase in overall effectiveness, for example, a concerted effort to see more NOAA materials in the K-12 curriculum.

- *Consolidation, termination, and expansion of existing programs.* Basic research, reviews of redundancy and effectiveness, and identification of best practice could be used to phase out certain programs, consolidate others, and expand those that are deemed to be most effective.

Management will require close and detailed attention as part of any restructuring. The organizational agent of change should be carefully located and have sufficient authority and resources to make a difference. One possibility is reallocating the budget for external research grants in the Office of Education (approximately 2.5 million dollars per year) to an internal review process, managed by NOAA staff but likely including external consultants.

An internal review process might start with an agency-wide needs assessment built around the gaps identified in this paper and the corrective actions suggested above. Restructuring will require vision, resources, cultivation of buy-in, and overcoming obstacles. A change strategy should be formulated. Logic models used for formative assessment at the beginning of programs have the advantage of a clean slate free of prior commitments. In contrast, formative evaluation of mature and institutionalized programs must identify what can and cannot be changed and identify realistic options.

This paper was commissioned by a Committee to Review the NOAA Education Program convened by the Board on Science Education of the National Research Council. The Committee charged that the paper should address the following issues and questions:

- Using logic model analysis, identify the prevailing implementation strategies for NOAA's current education programs. From this perspective the committee would be most interested in understanding whether there are distinct classes of logic models that describe NOAA's programs.
- What critical gaps do these logic models highlight in NOAA's capacity to translate policies and strategic goals into outcomes and impacts from the education programs?
- How well do current evaluations assess the key relationships and processes identified in the logic models describing education programs?
- Based on the analysis of existing programs, develop a logic model that can be used to assess the effectiveness of NOAA's education programs in future evaluations. As a part of this analysis the committee would be interested in recommendations concerning the organizational design and relationships amongst NOAA's existing education programs.

In discussions between the author, program officer (Michael Feder), and members of the committee, the third bullet on evaluation was excluded from the scope of this paper

because it is the topic of another paper, and the major research question was formulated in this way:

> Based on an analysis of logic models, how well do multiple, often small educational programs spread across different agencies of NOAA serve the larger educational goals of the agency as formulated in the national education strategic plan.

It was agreed that, in addressing this research question, the paper should, first, formulate logic models for categories (or genres) of existing programs (identifying goals, activities, intended outputs, intended outcomes); second, on the basis of the models analyze how well the programs individually and collectively advance the general goals; third, discuss strategies for advancing goals that seem to be missing; and, fourth, reach overall conclusions.

The paper will be organized as follows: first, a discussion of a common logic model applicable across NOAA educational programs; second, a discussion, as to each link (or component) of the model, of issues for implementation; and, last, a discussion of the responses that central management might consider in light of the issues raised.

A common logic model for NOAA's instructional programs

A logic model is a description of the sequence of activities carried out by a program and how these activities are linked to the results the program is expected to achieve (W.K. Kellogg Foundation, 2004). Logic models often are subdivided into goals, activities, and outcomes (or more expansively, goals, inputs, resources, activities, outputs, outcomes, and impacts). The generic or common logic model in this paper was developed from the description of and links to NOAA's education programs furnished by the NRC program officer, Michael Feder, attached here as Appendix A, documents describing various programs also furnished by Mr. Feder, and outward exploration on the web from those documents and links. Because it was not based on a rigorous review of program goals and implementation (including interviews with and documents provided by program staff), the broad overview of programs offered here is far from being authoritative or complete and is intended rather as a means of framing issues for further inquiry and planning.

NOAA instructional programs can be fit into or classified according to the logic model depicted in Table 1 below.

Table 1

Common Logic Model for NOAA Instructional Programs

Logic Model elements[1]	**Corresponding NOAA components**
INPUTS	**Educational goals in a research agency**
	provide guidance for:
	Educational management
	That creates and administers:
ACTIVITIES	**Instructional activities**
	directed at:
	An audience (or audience clusters)
	consisting of:
	Educational content
	instructional materials
	pedagogy
	delivered at/ through:
	A geographical site, website, partnership
	aimed at producing:
OUTCOMES	**Learning outcomes**
	knowledge about:
	(1) Natural resources

[1] from the many similar templates, see this parallel depiction of a NOAA-like program from EPA: http://yosemite.epa.gov/R10/ECOCOMM.NSF/webpage/measuring+environmental+results

	Reefs, estuaries, fisheries, etc.
	(2) Negative human behaviors
	Pollution, overuse, climate change, etc
	(3) Stewardship
	Ameliorative decisions, policies
	Conservation
Medium and long term outcomes and impacts	**Behavioral outcomes**, including positive:
	Decisions
	policies
	operations
	politics
	that lead to:
Impacts	**Societal outcomes**, including:
	conservation
	restoration
	sustainable use and development

All of NOAA's instructional programs have all of the components of the logic model in some form -- they have common educational goals, management, an audience, instructional activities, a delivery method, and intended outcomes. Analysis of implementation issues in this paper was done for each element of the model, using examples from particular programs or all programs. In a sense, the logic model was used

as a framework considering all programs as strategies for implementing a common mission then asking how the programs might be managed more efficiently and effectively. The gaps of interest to the committee might be in particular programs or in the portfolio of programs or in the management (or lack thereof) of the portfolio. Implementation questions were asked about individual programs (e.g., whether they have used the most effective strategies), whether some programs are more effective than others (e.g., the instructional materials and professional development of a specific branch), and how different programs doing the same thing might be consolidated, share best practice, or be centrally managed.

Although not its purpose here, the logic model is adaptable for use in evaluations of individual programs. The goals of individual programs would be narrower and more specific than the goals for all programs, but the same research questions could be asked about each of the other components of the common logic model, for example, what are the learning objectives, what is the intended audience, are the activities well designed to reach that audience (e.g., to have an influence on K-12 instruction and professional development), do content and pedagogy meet appropriate standards of alignment and quality, does the medium of instruction (e.g., online, museum) measure up to best practice, how effective is management in the tasks of design, administration, and continuous improvement, and to what extent have the outcomes (learning, behavioral, societal) actually been achieved.

Use of logic models to find gaps in program design is usually associated with formative evaluation in the planning phase of new projects.

> In program design and planning, a logic model serves as a planning tool to develop program strategy and … help craft structure and organization … based on shared understanding of what is to take place. During the planning phase, developing a logic model requires stakeholders to examine best practice research and practitioner experience in light of the strategies and activities selected to achieve results. (Kellogg Foundation, 2004, p. 5).

Formative evaluation of established programs inevitably raises questions about the feasibility of change. Many options available in the planning phase are foreclosed by program development. Established organizations and programs are hard to change. And yet, as explained later in the paper, facially feasible tools varying in the amount of change required can be suggested for restructuring of NOAA's educational programs. For both new and established programs, formative evaluation (evaluation for change rather than evaluation of change), functions best as a means of stimulating ideas and conversation among the evaluator, clients, and constituents. As an exercise in formative evaluation, this paper should not be thought of as a definitive analysis but rather as a starting place for conversation about issues and options.

Components of the logic model in NOAA's instructional programs

This part of the paper address one component of the logic model at a time, giving examples of NOAA programs and discussing implementation issues germane to that component. The next part considers possible responses by management to the issues raised.

Inputs: Educational goals of a research agency

All of NOAA's educational programs operate under and seem to be well aligned with common goals set by the agency. The goals were usefully articulated in an evaluation project of the education team of the National Marine Sanctuary Program (NMSP) designed to assess education program outcomes and impacts across all sites and activities and to link outcome measures to program efforts, in these words:

> The National Oceanic and Atmospheric Administration (NOAA) is the parent organization for the NMSP and provides additional guidance on educational efforts within sanctuaries. In the annual update of NOAA's Strategic Plan, the NOAA Annual Guidance Memorandum for FY 2008 – 2012, environmental literacy goals are also specified: "Environmental literacy is integral to NOAA's mission: All of NOAA's long-term goals ultimately depend on the public's capacity to understand and react to Earth system science and ecosystem conditions. A better informed public will provide improved environmental stewardship and will acquire, use, and respond to NOAA's information services and forecasts in more predictable and effective ways…individuals who

> understand the complex interdependencies within an ecosystem - including their own roles - are more likely to act as stewards of that ecosystem. Given the central role of environmental literacy to NOAA's long-term effectiveness, NOAA places a high priority on formal and informal education efforts leveraging NOAA's distinctive scientific, technical, and operational expertise."[2]

The quotation suggests a close connection between the research mission of NOAA and environmental literacy. A better informed public will better understand and respond to information provided by NOAA, appreciate interdependencies of the ecosystem, and play a constructive role in environmental stewardship or conservation. This synergy between research, public awareness, and improved decision making involves several implementation challenges for the educational programs. One challenge, discussed later in the section on learning outcomes, is finding the right balance between knowledge about resources, negative human behavior, and conservation.

A second challenge is the role that NOAA researchers play in assuring the scientific validity of the programs, as expressed in the following goal of the Coral Reefs Conservation Program (CRCP): "collect, develop and distribute scientifically correct, educationally relevant tools and information to key audiences.[3] The background materials provided for this paper do not describe processes and mechanisms of quality control through which NOAA researchers review educational programs and materials for

[2] NMSP Education Evaluation Toolbox, December, 2007

[3] Appendix A, p. 29

technical validity and accuracy, and one possible task for management is reviewing the status of the research/ education interface.

Inputs: Educational management

The materials say relatively little about the management of NOAA educational programs, but some points are notable. The organization chart does not identify a central management function for all programs. The net impression is that NOAA's educational programs are managed independently in parallel branches, under a strong sense of common mission, with some mechanisms of coordination and distributed leadership, but nothing comparable to the central offices of school districts or the executive suites of major corporations.

Coordination across activities and branches does exist, for example, in what is described as part of Corporate NOS:

> The intent is to cover NOS offices that do not have a defined education office (e.g. Center for Operational Oceanographic Products and Services, National Centers for Costal Ocean Science, etc.) and link where possible to NERRS, ONMS, and Corals. They focus on topics such as tides, currents, charting, geodesy, invasive species, etc. They attempt to create educational products to translate that science into something palatable for students and educators. Finally,

the "corporate NOS" team has been heavily involved in providing professional development.[4]

Coordination is also mentioned as a function of the Climate Program office, which "manages competitive grant programs, leads NOAA climate international, education and outreach activities, and coordinates climate activities across NOAA."[5]

If the Office of Education will be the locus of agency-wide coordination and restructuring, it seems significant that its current business consists primarily of disbursing funds (environmental literacy grants, the Educational Partnership Program, B-WET grants for local experiential learning for K-12 students, Ernest Hollings scholarships, Nancy Foster Fellowships, and the grant for Sant Ocean Hall in the Smithsonian). The five environmental literacy grants made in 2007 (totaling 2.5 million dollars) support development of curriculum and instructional materials, an innovative approach to informal education in museums, and an update of survey research on environmental literacy of the public. All are tools for improving educational impact in society, but they do not involve managing current programs in operating branches. In effect, they represent a separate branch of educational programs similar to those operated by the other branches. For example, four of the five 2007 environmental literacy grants that support informal education or K-12 instructional materials and professional development are similar to those managed by other branches:

[4] Appendix A, p. 31
[5] Appendix A, p. 33

1) Pilot interpretative stations incorporating Smithsonian content at four coastal ecosystem learning centers. Four pilot Ocean Interpretive Stations will enhance ocean literacy among museum goers through multimedia offerings, providing current, newsworthy and foundational ocean topics to encourage learning for 3 million visitors.
2) Instructional materials and professional development for elementary teachers. This is a plan to increase elementary and undergraduate ocean science and related Great Lakes science literacy that aligns with the Michigan Curriculum, the National Science Education standards, and the Ocean Literacy Essential Principles and Fundamental Concepts.
3) Grade 3-5 curriculum development/ instructional materials development. This project will create an unprecedented Ocean Sciences Curriculum Sequence for Grades 3-5. The materials will be grounded in current research on teaching and learning and designed to connect to the National Science Education Standards, the Ocean Literacy Essential Principles and Fundamental Concepts, and to a large sample of state science standards.
4) Enhancement of instructional materials in middle school. This project centers on the curricular theme of "Seasons and the Seas." It builds on students' prior knowledge of the changing seasons in New England. Its goal is to incorporate NOAA resources and virtual visits by NOAA scientists to integrate authentic earth systems science content into existing instructional units.[6]

[6] http://www.oesd.noaa.gov/elg_projects.html

As one example of parallel activities in other branches, consider these findings from a NERRS needs assessment:

- Currently twenty-four Reserves are offering K-12 and PTD [professional teacher development] to a wide range of audiences.
- 84% of the Reserves have an educational facility.
- Approximately 66,000 to 67,000 students participated in K-12 programs in 2002.
- The most common K-12 program topics are estuary biology and ecology, human impacts on estuaries (including land use), and citizen stewardship.
- Sixth through eighth grades are the most common target audience for K-12 programs, followed by fourth and fifth grade.
- 51% of Reserves partnered with other organizations to deliver K-12 programs.
- Approximately 1,800 to 2,000 teachers participated in PTD programs in 2002.
- The most common PTD program topics are estuary biology and ecology, human impacts on estuaries (including land use), and chemical/physical/geological sciences.
- Sixth through eighth grade teachers are the most common target audience for PTD programs, followed by high school teachers, and fourth and fifth grade teachers.
- 84% of Reserves use part of their internal budget and 53% use partners to help fund PTD programs. [7]

[7] Inventory and Assessment of K-12 and Professional Teacher Development Programs in the National Estuarine Research Reserve System, June 25, 2003, Pandion Systems, Inc.

A different needs assessment of NERRS conducted by TERC[8] found that estuaries are common topics in K-12 education, and teachers are eclectic about where they acquire educational resources:

- Teachers overall currently spend an average of between one and three weeks each year teaching about estuaries, though nearly a third of those in schools, and over half of those in informal settings spend more than three weeks each year. Informal educators and those teaching in coastal areas spend somewhat more time teaching about estuaries than do school teachers, or those teaching away from the coasts.
- Teachers use a wide variety of websites to gather educational resources about estuaries and coastal issues. In particular, the NOAA Education website is used by 59% of respondents, with National Geographic, the National Science Teachers Association (NSTA), the US Geological Survey, NASA, and State educational sites all cited by over 40% of respondents.
- NOAA and NERRS curriculum materials are used occasionally by respondents—with 10% or more of respondents saying they've used Project WET Bays & Estuaries, NOAA data sites, NERRS website materials, NOAA Severe Storm Lab materials, EstuaryLive, materials from individual NERRS sites, and the Watersheds & Weather curriculum.[9]

Considerable gains in efficiency and effectiveness should be possible from more centralized management of multiple branches each presently conducting separate needs

[8] http://www.terc.edu/

[9] The State of Estuarine Education, K-12 Needs Assessment, Hammerman J.K.L., TERC September, 2007, http://www.nerrs.noaa.gov/Education/pdf/FullNAReport.pdf

assessments and managing independent but similar educational programs aimed at overlapping audiences like K-12 teachers that are not exclusive clients of particular programs or branches but rather draw eclectically on a variety of resources. A key question is whether -- when placed in a common matrix -- the extent to which all or clusters of programs collectively represent coherent strategies for reaching common goals.

Activities: Audience

NOAA educational programs seem to have three distinctive audiences, the mass audience of all citizens, K-12 students and teachers, and students enrolled in higher education (undergraduate and graduate), each of which has distinctive educational objectives, instructional activities, and delivery methods. To some extent, each audience has its own cluster of programs, with overlapping membership (i.e.., the same people appearing at different times in more than one audience).

The mass audience. Data gathered by NOAA (soon to be updated through an office of education grant, see above) apparently show a relatively low level of environmental literacy in the population as a whole:

> In the survey, three-quarters of Americans strongly agree that the health of the oceans is essential to human survival. However, the public's understanding of the oceans' importance and the damage now being done to them is superficial. The survey asked five questions to judge knowledge of the oceans and their functions. Americans on average fail to answer half correctly. The mean correct answer on

> this five-point knowledge scale is 1.9. Looking at individual responses, we find that only about one in ten Americans answers four or five of the questions correctly. About four in ten are able to give correct answers to only one or fewer of the five questions. Of the five questions, a majority correctly answers that humans are the main cause of extinction of plant and animal life in the oceans and that the oceans affect the climate and rainfall. However, large majorities of Americans do not know that the plant life in the oceans produces more oxygen than plant life in forests and that runoff from yards, pavement, and roads is the cause of most ocean pollution.[10]

The implementation challenges to mass education are daunting. One issue is the overlap with K-12 education. To the extent that oceanic content is delivered effectively through the K-12 system, it is not clear how extended instruction over years of education could fail to produce a minimum level of environmental literacy. A second challenge is the voluntary nature of informal education through zoos, museums, and natural sites. Voluntary attendance is probably selective for patrons with a with a relatively high level of knowledge and predisposition for conservation. A three-year study conducted by the Association of Zoos and Aquariums found that visitors had more change in attitudes toward conservation than in objective knowledge:

> Overall, visitors enter with a higher level of knowledge about basic ecological concepts than was expected. A small percentage of visitors (approximately 10%)

[10] Communicating About Oceans: Results of a National Survey, Belden Russonello & Stewart and American Viewpoint, October 1999. http://www.theoceanproject.org/images/doc/final_report.pdf

did show significant positive changes in their conservation-related knowledge. However because of the higher than expected entering knowledge of most visitors, there were no statistically significant changes in overall knowledge. Most visitors (61%) found that their zoo and aquarium experience supported and reinforced their values and attitudes towards conservation. Visits to accredited zoos and aquariums prompted many individuals (54%) to reconsider their role in environmental problems and conservation action, and to see themselves as part of the solution. Roughly half (42%) of all visitors believed that zoos and aquariums play an important role in conservation education and animal care. A majority (57%) of visitors said that their visit experience strengthened their connection to nature.[11]

A third challenge is the extent of redundancy between the environmental literacy goals of NOAA and other government and private agencies. Enormously attractive and popular programming and resources seem to be readily available in a wide variety of media, and NOAA is far from the only player. Think, for example, of the Discovery Channel series Blue Planet and Planet Earth[12] (but, of course, entertainment value and beauty are not the same as environmental literacy). Attractive websites exist apparently not sponsored by NOAA, for example, Ocean World.[13] World famous aquariums like those in Chicago and Atlanta have educational content and programs. A fourth and final puzzle is the extent to which environmental literacy has a local component. Education of people who live in the

[11] NMSP Education Evaluation Toolbox, December, 2007

[12] http://dsc.discovery.com/tv/blue-planet/blue-planet.html; http://dsc.discovery.com/convergence/planet-earth/planet-earth.html

[13] http://oceanworld.tamu.edu/

vicinity of natural resources is surely one mission of NOAA, and natural sites and exhibits are probably visited heavily by local patrons ("think globally, act locally").

A useful mental experiment might be thinking about the existing configuration of programs along with alternative venues and asking what are the most powerful and cost effective ways of reaching broad audiences with targeted educational content producing appropriate levels of environmental literacy. Diverse venues might include T.V. programs, advertisements, public service campaigns[14], and popular science websites like WhyFiles[15] and NOAA's WeirdFins.[16] Within NOAA, Sant Ocean Hall at the Smithsonian seems dramatically appealing and state of the art (with a website that links to material from the science section of the elegant intellectual website TED)[17] and may have a distinctive, national and local audience of visitors, but other programs aimed at minimum levels of environmental literacy for local audiences may not have such a strong comparative advantage.

K-12 students and teachers. Creating instructional materials for K-12 education and professional development for K-12 teachers are major activities for many of NOAA's branches. A useful set of goals for such programs was articulated by TERC in an assessment of NERRS:

> Curriculum materials that focus on interdisciplinary learning opportunities, use authentic contexts that are relevant to local communities, and that support

[14] See the Ad Council, http://www.adcouncil.org/default.aspx?id=61
[15] http://whyfiles.org/
[16] http://www.nmfs.noaa.gov/rss/podcasts/weirdfins/
[17] http://ocean.si.edu/ocean_hall/; http://www.ted.com/

students to understand about human impact on the environment and to develop into responsible citizens who can make a difference about important global issues are especially interesting to teachers. However, materials also need to address state or local curriculum requirements and standards, be interesting, at the appropriate level, and do-able with equipment and materials available in classrooms, and teachers need to understand the content itself, if they are to be adopted. Successful curriculum materials and programs will likely need to reflect and address these interests and concerns.

Teachers say that professional development around a wide range of topics would be at least moderately useful. Support for making new curriculum materials relevant to students, integrated into existing curricula/ standards, and incorporating new labs, as well as developing teachers' own science content are rated highest. Middle school teachers expressed special interest in professional development around the use of real-time data, use of visualizations of data, and use of data analysis software.[18]

Research on instructional guidance has established that shaping K-12 instruction (e.g., getting topics into the classroom), coupled with professional development that helps teachers be more effective in conveying that content, are challenging tasks. Instructional guidance (including curriculum materials, professional development, and student assessment) must have a high degree of horizontal and vertical coherence (alignment

[18] Inventory and Assessment of K-12 and Professional Teacher Development Programs in the National Estuarine Research Reserve System, June 25, 2003, Pandion Systems, Inc.

across policies oriented to state and district standards and operating coherence at the school level)(Clune, 2009). A national study of the effectiveness of professional development for teachers (Garet, Porter, Desimone & Yoon, 2001) found the following:

> Our results indicate that sustained and intensive professional development is more likely to have an impact, as reported by teachers, than is shorter professional development. Our results also indicate that professional development that focuses on academic subject matter (content), gives teachers opportunities for "hands-on" work (active learning), and is integrated into the daily life of the school (coherence), is more likely to produce enhanced knowledge and skills.

The challenge for NOAA is how to manage numerous parallel support programs in a way that effectively melds with the district and school delivery systems. Success requires strong interventions, careful design, and skillful implementation. Programs that offer a "little bit" of enrichment are generally not very effective. On the other hand, NOAA's goals for influencing K-12 classroom are necessarily modest. Science is only one part of the curriculum, and oceans are a small part of science. NOAA does not have direct control of classrooms. But development of specific operational goals for the K-12 curriculum and professional development could sharpen the analysis. For example, suppose goals were proposed of having NOAA materials included in major textbooks, NOAA content in educational standards, NOAA modules in curriculum guides, and NOAA training as part of the regular professional development offered teachers in large districts. Such goals could be evaluated for consistency with the NOAA mission,

advantages and disadvantages compared with the existing eclectic approach, and feasibility within budget constraints. Management could evaluate which operational strategies necessary for such a program are and are not available in current programs. In sum, what seems be called for is an agency-wide needs assessment and strategic plan similar to the one done by TERC for NERRS addressing the question of how multiple programs can have the greatest impact on instruction and professional learning.

Students of higher education (undergraduate and graduate). The higher education programs managed by NOAA, scholarships and partnerships with universities aimed at building institutional capacity have the same ultimate goals as the instructional programs (advancement of environmental literacy), but are distinctive in several ways. Rather than providing instructional resources they support the instruction offered by institutions of higher education, and they focus on specialized training at the highest levels of environmental literacy. Scholarships support students in existing educational programs and raise their own distinct set of criteria for success, such as access by demographic groups (e.g., low income), adequacy of support, persistence and completion of programs, and influence on choice of field and careers. Capacity-building partnerships would have logic models built around goals (e.g., capability and diversity of the workforce), partnership functioning, and intended institutional outcomes. One question about the effectiveness and efficiency of these programs concerns the relative size of their budgets (e.g., for partnerships and scholarships, approximately 25% and 8% respectively of the total educational budget[19]). But the relative benefits -- the relative contributions to common goals -- may be difficult to estimate for three reasons: first, the programs almost

[19] Email from Michael Feder, 3/13/09

certainly yield some substantial benefits (they are not a complete waste of money); second, higher education is much more expensive than K-12 education and makes distinctive, non-comparable contributions to the mission (such as the most advanced training for students, future professors, and researchers); third, one expensive item, the Educational Partnership Program for minority serving institutions, is based on considerations of equity as well as efficiency. Given their statutory basis, distinctive missions, and custom tailoring, there is probably less reason for restructuring these programs than of the more numerous and fragmented programs aimed at audiences at lower levels of the education system.

Activities: educational content (instructional materials and pedagogy)

Educational content, combining instructional materials and pedagogy, are the core and presumed agent of change of NOAA's educational programs. One striking feature about the educational content of NOAA's educational programs is the distinction between "meta-content" common across many (or even all) programs and topics specific to particular programs and sites. Examples of meta-content include the goal of sustainability, the value of natural resources, common environmental threats, common damage from environmental threats, the importance of conservation, the possibility of combining use and conservation of natural resources, and ideas about global and localized systems and system dynamics. Specific content includes applications of the meta-content to specific contexts as well as facts distinctive to those contexts (reefs, estuaries, oceans, rivers, fisheries). The combination of common and specific content

across multiple educational programs raises such questions as whether the common content could be conveyed more efficiently in fewer programs and about the quality of the common content enacted in the large array of existing programs.

Also notable about instructional materials was the sheer number of times that materials are mentioned, raising questions about duplication of effort, variation in quality, extent of sharing of expertise and best practice, and so forth. Education tends to be a factory spewing forth vast quantities of instructional materials, but the standards movement in education, well as the field of curriculum evaluation, show the importance of reviewing materials for conformity with common standards of content and quality. Some branches and their web sites have materials for both students and teachers that are well organized (e.g., by topic, grade level) and cross referenced with K-12 educational standards. One example, reflecting the assistance of a well known K-12 consulting organization (TERC), is the following:

> NOAA's National Estuarine Research Reserve System (NERRS), together with NOAA's Chesapeake Bay Office and TERC, has developed "Estuaries 101," a curriculum that will include student activities, professional development and training using SWMP data. The first modules developed are for grade levels 9-12 and are designed to help teachers and students use real scientific data to explore estuaries and understand the connection between humans and estuaries.
>
> The Estuaries 101 Curriculum consists of four curriculum modules – three

described here as the core Estuaries 101 modules (in Life Science, Earth Science and Physical Science), and a fourth web-based module focused on theChesapeake Bay.

The modules all have a common vision, structure and pedagogy. They use estuaries as the vehicle to develop the big ideas in science (as called for in the above-cited standards study). They feature inquiry-based learning, in which students are actively engaged in exploring estuaries (through classroom, lab and field experiences), sparking questions and pursuing answers (as called for by the results of the above-cited needs assessment study).[20]

The Sea Grant Bridge program for educators refers to a National Marine Educators Association, offers lesson plans by grade level (which superficially seem more like free standing topical resources than fully developed curricular units), as well as professional development resources (seemingly a list of workshops and other PD opportunities for teachers).[21] The Education Office also has well organized materials for students and teachers.[22]

But to an outside observer thinking about the logic model for the whole agency, the presence of pockets of materials that are well organized within some programs, together with a large volume of scattered and less well organized materials, suggests the absence of agency wide educational content standards and possible opportunities for

[20] http://www.estuaries.gov/GetInvolved/Default.aspx?id=117
[21] http://web.vims.edu/bridge/?svr=www
[22] http://www.education.noaa.gov/

consolidation. The standards movement in K-12 education aimed to produce a single authoritative set of standards for entire states (standards which resemble national standards as much as they do each other). The ultimate purpose of the standards movement -- selection of topics and materials that embody core scientific content at a high level of academic depth and quality -- seems just as appropriate for NOAA as it is for K-12 education (which NOAA serves as one constituency). Tools exist for measuring educational content across standards, instructional materials, assessments, and instruction. The Survey of Enacted Curriculum (SEC)(Porter, 2002) is a standardized instrument for measuring content, which operates by cross-classifying each "unit" of instruction according to topic (from a standard list of topics) and "cognitive demand" (from five options: memorize, perform procedures, communicate understanding, solve non-routine problems; and conjecture/ generalize/ prove). The SEC already covers a full range of science content in K-12 education and in principle could be adapted for other grade levels, audiences, and delivery sites (for example, by carefully distilling common standards-based topics for informal and higher education).

Regarding pedagogy, the most striking feature was mention and blending without careful distinction (at least on the surface) of different pedagogical goals of conveying specific facts, teaching depth of understanding, and stimulating interactive, inquiry learning. All three pedagogies have value but need to be carefully designed and evaluated. Depth of understanding and the inquiry method are particularly challenging to design and implement. Here again, standards and measurement tools might be valuable. For example, considerable work has been done on the goals, structure, and process of inquiry

education, for example, as modeled around the "5 E's" (Bybee et al, 2006). The 5E model is ubiquitous in education (undoubtedly appearing in NOAA programs) and is mentioned here not as the only or best approach but rather to illustrate the value of common standards of inquiry education. In K-12 education, both content and pedagogy standards have proven valuable as tools for quality control and management.

Activities: Delivery methods (geographical sites, web sites, partnerships)

NOAA's educational programs differ from K-12 education in delivery sites and methods. K-12 education is delivered to captive audiences in schools for extended periods of the day and for many years. NOAA provides direct instruction through online education, informal education at natural sites and museums, and attempts to influence K-12 instruction by providing resources (many online) for both instruction and professional development and through partnerships with providers (e.g., through the educational literacy grants).

The heavy reliance on non-classroom instructional methods, like online education, museums, and natural sites, raises questions about both educational effectiveness and coordinated management. On one hand, to what extent have the programs -- even the best programs -- relied on research and best practice about how to design the most effective educational experience in these settings? On the other hand, to what extent has the best practice embodied in particular programs served as a model for similar programs located in other branches? Given that online education can be more or less effective across a very

large range (such as totally ineffective to reasonably effective), how well do the many uses of the technology in NOAA measure up to a standard of good practice, could some existing models serve as exemplars, and how might a program of continuous improvement be designed and managed? Regarding the technology side of online education, to what extent are expertise and resources shared across programs and branches, and should technology be more centralized (e.g., a single set of servers and technology support services)? Regarding partnerships with organizations that deliver instructional content and materials, which partnerships are substandard and which are exemplary?

Outcomes: learning, behavioral, and societal

Though they are the last element in the causal chain, outcomes often are considered first in formative evaluation ("plan backward, implement forward")(Kellogg Foundation, 2004, p. 15). Starting with outcomes generates thinking about a broader range of potentially effective strategies than starting with and therefore feeling constrained by the planned (or existing) activities. Even with well established activities, as in this case, planning backward makes sense because all of NOAA's programs can be evaluated (and potentially restructured) in light of how well they implement common outcomes. Designers of curricula, professional development, and assessment usually start with knowledge outcomes in thinking about the content of their products and activities -- the knowledge that students are supposed to gain from instruction. In a similar way, NOAA can use a specification or model of the learning outcomes to evaluate the content of its

instructional programs. This section of the paper is a version of such a model that can be used to stimulate further discussion.

Table 1 described these outcomes in three phases: learning outcomes, behavioral outcomes, and societal outcomes:

Table 2. Outcomes of NOAA Educational Programs

OUTCOMES	**Learning outcomes**
	knowledge about:
	(1) Natural resources
	Reefs, estuaries, fisheries, etc.
	(2) Negative human behaviors
	Pollution, overuse, climate change, etc
	(3) Stewardship
	Ameliorative decisions, policies
	Conservation
Medium and long term outcomes and impacts	**Behavioral outcomes**, including positive:
	Decisions
	policies
	operations
	politics
	that lead to:
Impacts	**Societal outcomes**, including:
	conservation
	restoration
	sustainable use and development

Note that the learning outcomes (what students are expected to know) include knowledge about natural resources, negative human behaviors, and stewardship, and that this knowledge is expected eventually to lead to better behavioral outcomes that track or reflect the learning outcomes such as better decisions and conservation.

The first two learning outcomes are expressed in the agency mission:

> **Environmental Literacy** – a fundamental understanding of the systems of the natural world, the relationships and interactions between the living and non-living environment, and the ability to understand and utilize scientific evidence to make informed decisions regarding environmental issues (National Oceanic and Atmospheric Administration, 2008).

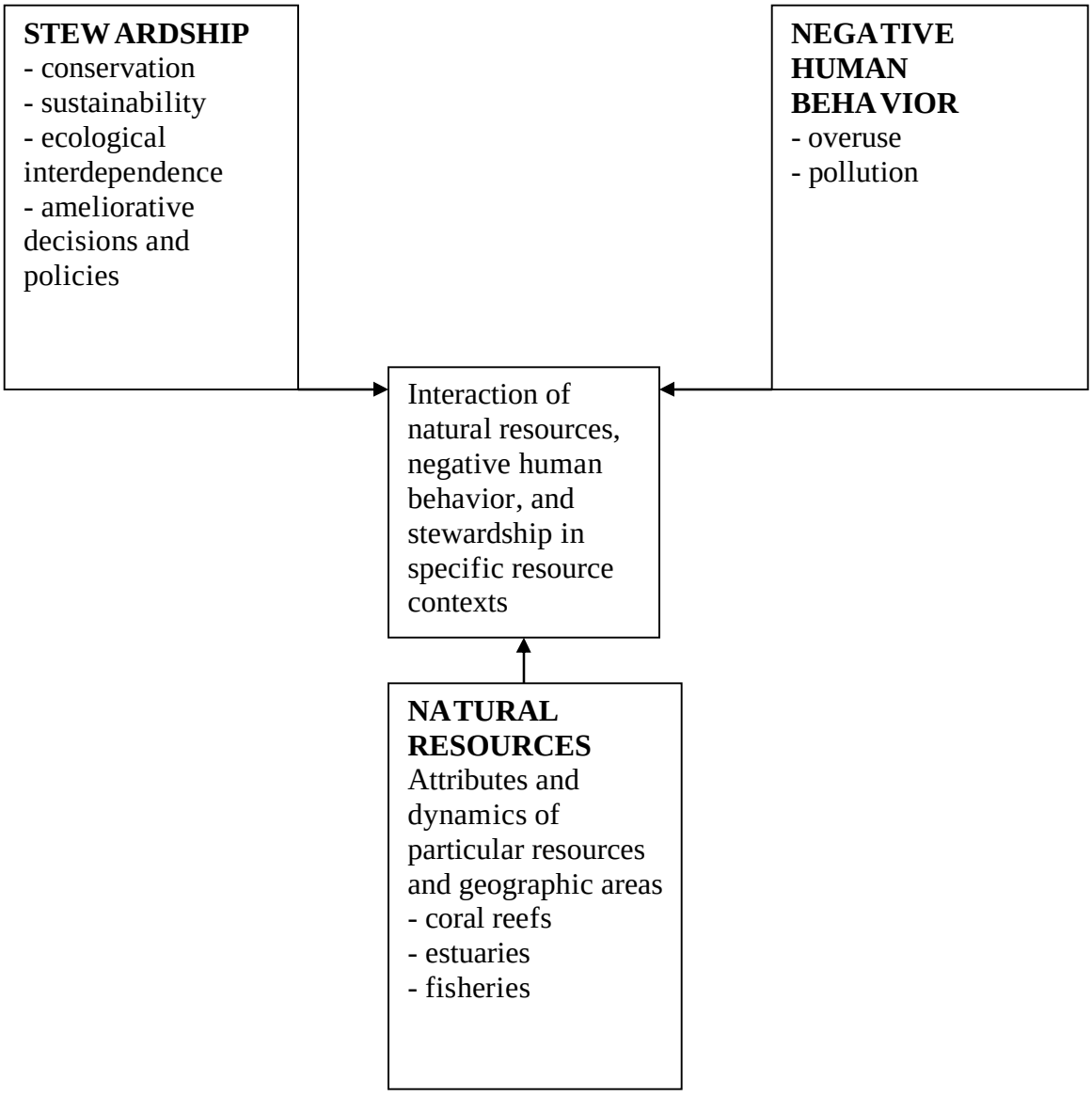
These elements plus the third learning outcome of conservation or stewardship can be seen in a contrast between the value of natural resources and threats posed by negative policies in two of the four main "messages" of the Coral Reefs Conservation Program (CRCP):

> (1) Coral reefs are valuable resources. They provide food, recreation, marine habitat, coastal protection, and medicines and sustain American livelihoods and economic development.
>
> (2) The health of coral reef ecosystems is at serious risk due to a variety of human activities both local and global. The three big issues are: climate change, land based sources of pollution and over fishing. Protecting and conserving coral reef

> ecosystems (are) urgent issues, we can protect them if we act now. (See Appendix A., p. 2)

Generalizing, the learning outcomes sought by NOAA can be represented as the intersection of three domains of knowledge shown in the text boxes of Figure 1 below: natural resources, negative human behavior, and stewardship:

Figure 1
KNOWLEDGE DOMAINS OF NOAA ENVIRONMENTAL LITERACY



The domain most easily associated with NOAA and the natural sciences is the bottom box, natural resources, the attributes and dynamics of particular natural resources and geographic areas, such as coral reefs, fisheries and estuaries. The top right box, negative human behavior, contains the problem, the threat to natural resources. The top left box, stewardship, contains remedies for the problems that lead to positive social impacts like sustainability. NOAA education is applied and problem oriented, that is, not just about reefs, estuaries, and fish populations in isolation, but also about the threats and problems confronting these resources and methods of protecting them. NOAA educational programs and topics seem to be located in the center box at the intersection of the three domains of knowledge. Programs tend to concern specific natural resources like coral reefs and make connections between technical attributes of the resource, current threats from human activity, and the dynamics of conservation. Note that, in principle, knowledge about threats to natural resources and stewardship is just as objective as knowledge about natural resources, but it is not commonly a part of science instruction. Consider, for example, the 6th grade "immersion" unit in plate tectonics studied as part of the SCALE MSP partnership (Clune, 2009). The unit stressed hands-on, active learning about natural processes (e.g., an activity with a slinky designed to model shocks moving through the earth), but it did not include human behavior or stewardship. Human behavior could have been included if the unit were expanded to include human risk-taking (e.g., cities built on faults) and stewardship activities such as earthquake mitigation (certainly relevant for California students).

The emphasis on all three elements -- natural resources, negative human behavior, and stewardship -- seems to be ubiquitous in NOAA educational programs. Consider, for example, this guidance from a Teacher Guide—Life Science Module Final Assessment in the NERRS estuaries curriculum for grades 9-12:

> Provide a list of NERR sites to students with their home Internet address. Find the list on page two of this Final Assessment document.
>
> • Break your students into small groups and either assign each group a NERR site or have them select their own to investigate.
>
> • Student groups should select three endangered or threatened species in their chosen estuary to study.
>
> • Students focus on one monitoring station within their estuary.
>
> • Direct students to (http://cdmo.baruch.sc.edu/) where they can download their NERR's abiotic parameter data for the most recent complete year available.
>
> • Students produce a PowerPoint, poster, or other presentation outlining the following items:
>
> a. What research studies focusing on endangered or threatened species in your NERR have been completed or are underway? What are the results of these studies?
>
> b. Display your data graphs and discuss the water quality in your estuary.
>
> c. Have hypoxic or anoxic conditions occurred in your estuary during the year? Can you determine the cause of the hypoxia or anoxia (natural cause, human activity cause)?

d. Are populations of your three chosen species increasing, decreasing or stable?

e. Name some interventions that you think could increase the number of each of your chosen species in your estuary.

f. How does a decreasing population of each of your species affect other plant and animal species in your estuary?

• Grade student presentations for clarity, presentation style, and depth of research and analysis.[23]

In thinking about NOAA's educational programs, managers might wish to consider four issues about the outcomes: (a) the mix of the three outcome domains in the goal of environmental literacy; (b) the theory of change that explains how knowledge leads to better decisions and the inclusion of non-cognitive as well as cognitive learning outcomes; (c) the depth of knowledge required for environmental literacy (e.g., a deep understanding of complex relationships and an interdisciplinary perspective); and (d) minimum levels of literacy acceptable for different audiences of NOAA programs.

The relative importance of the three domains in the goal of environmental literacy. The presence of all three domains of learning outcomes in particular instructional programs like coral reefs does not answer questions about the relative importance of each in the general goal of environmental literacy. For example, does literacy require detailed understanding of the principles as they apply to every natural resource (reefs, estuaries, fisheries, etc.), or is just one resource sufficient ("seen one resource, seen them all")? Clearly each resource must be understood in depth by some group of people, but how

[23] http://www.estuaries.gov/estuaries101/Doc/PDF/LS_FinalAssessment.pdf

much is to be generalized across wider audiences? In higher education, each domain of knowledge and many sub-domains are the subject of academic specialization -- different disciplines, majors and graduate degrees. Practical problems implicating all three domains often require interdisciplinary cooperation. Thus, in higher education, literacy cannot possibly include all knowledge in all domains applicable to problems but rather must allow for different domains of understanding depending on academic training. At lower levels of literacy, mass education or K-12 education, conscious decisions are required about how much of each domain will be part of the educational program, as illustrated in which natural contexts. This issue came up previously in the paper in the discussion of meta- and specific content -- to what extent does the same meta content (e.g., overuse) appear repetitively in instructional programs organized around specific natural contexts (coral reefs, etc.), and does repetition represent inefficient redundancy in the allocation of instructional resources.

The theory of change connecting knowledge to decision-making and the inclusion of non-cognitive learning outcomes. Logic models contain a theory of change about why the activities in control of the implementers (here instruction) are predicted to lead to changes in behavior.[24] In the model depicted in Table 1, learning is a proximate change in behavior (what the learners know and are able to do) that leads to the ultimate outcomes of better decisions, policies, and societal impact. But why does knowledge lead to action?

[24] Weiss (1998) posited that the theory of change of a program has two components—implementation theory (i.e., the intended implementation) and program theory (i.e., the anticipated behavioral responses of those affected by the implementation)—both hypothesized to lead to the achievement of the program's intended outcomes.

The paper does not discuss a major category of this connection, which might be called actionable knowledge. Actionable knowledge is information delivered to decision makers who are already in a position to make decisions based on the knowledge. Many NOAA programs convey information through outreach and technical assistance, e.g., to governmental agencies, individuals, and businesses known to be conducting activities that have a potential impact on natural resources. Local natural sites might be thought of as conveying information to populations living in or visiting affected areas. In a broad view, perhaps we might include laws and regulations as conveying information (e.g., fishing limits).[25] The paper does not focus on technical assistance because it seemed outside the scope of "education," or instructional programs, which can be thought of as conveying "potentially actionable knowledge" to citizenry whose decisions might have an impact on natural resources in many possible ways in the future. Because it is targeted, actionable knowledge seems the more efficient means of influencing decisions, but instructional programs that convey potentially actionable knowledge to a large group of citizens might ultimately have a broader impact.

In the instructional programs, the connection between knowledge and action does not appear to be indoctrination or advocacy as such. Good decisions are expected to result from presentation of objective facts. Normative dimensions are among those facts, as with all applied problem solving (e.g., the value of natural abundance and beauty). The link with action is not certain or inevitable. Some people in some situations will not change their behavior regardless of how much knowledge they acquire., but the

[25] I spent some time in February admiring a sign on a pier on Sanibel Island, Florida, that had pictures of different fish species and corresponding catch limits.

assumption is that many people in many situations will be responsive, and the collective movement toward environmental (or ecological) literacy will create additional opportunities for conservation. One can sense the elements of a social movement in this description (and a very successful social movement at that), but it is a movement built upon valid scientific knowledge.

A practical issue arising from the emphasis on behavior and better decision-making concerns non-cognitive goals such as engagement, enthusiasm, goodwill, and trust, for various audiences. Museums, natural sites, and classroom visits by the National Weather Service might (or might not) be less efficient in conveying "book" knowledge but more efficient at generating engagement and goodwill. Different types of experiences may be complementary and mutually reinforcing, a conventional rationale for supplementing classroom instruction with field trips. Another explanation for field trips is giving a break to exhausted teachers and students at the end of the year -- nature is fun! Most if not all of these goals potentially fall under the pedagogical concept of student engagement which in turn is strongly linked with inquiry (hands-on) learning. More engaged students are able to learn more content and are more likely to persist in their education and specialized training. One risk is engagement without content (e.g., in high school Biology, the teacher has students dress up in lab coats but not do any science). Keeping "minds on" as well as "hands on" is a never-ending task of inquiry education for both teachers and educational management. Another problem is the blurred line separating knowledge from advocacy. At one level, the message that nature is bountiful and beautiful is a statement of fact containing normative elements. The experience of beauty and the enjoyment of

natural bounty are facts about human psychology. The experience of nature in natural sites may intensify esthetic appreciation of nature. Likewise, messages about the harmful effects of human action are facts. But environmental literacy cannot possibly consist primarily of aesthetic sentiments and political convictions, and advocacy is a threat to the intellectual credibility of the goals. Soylent Green and Wall-E are entertaining and moving, but they are polemical rather than educational. Where to draw the line between appropriate an inappropriate inclusion of non-cognitive goals is an essential part of defining environmental literacy, and it seems to have been well formulated in the programs examined in this paper.

Depth of understanding. Depth of knowledge and understanding is a conspicuous feature of the learning goals depicted in three domains of the learning goals in Figure 1. Students do not learn facts in isolation but rather facts as embedded in theoretical and applied frameworks from more than one academic discipline. Given that teaching for understanding and depth of knowledge are understood as challenging goals in education and educational policy, how realistic is depth of knowledge as a component of environmental literacy, especially at minimally acceptable levels? Can people walk into a museum and walk out with greater depth knowledge? What makes an affirmative answer to that question more plausible is the enormous diffusion of the ecological model going back to widely accessible works of people like Aldo Leopold and John Muir (not to mention the English naturalist, Charles Darwin). The "web of nature" is everywhere, appearing in fractal form even in small contextualized conservation programs like fishing and hunting limits and guidelines for green wilderness camping. In a profound way, the

"fact" of conversation is a dynamic relationships which requires some depth of understanding. But the goal of depth may not be universally realized and be lacking in particular programs and applications.

Levels of environmental literacy The question here is how the word "literacy," often associated with minimum levels of competency, applies to NOAA educational programs of greatly different duration, sophistication, formality, and level of academic instruction. The question can be sharpened with reference to educational testing which includes both content standards (topics and depth) and performance standards (what students know and are able to do, e.g., as measured on standardized tests). Clearly there must be different levels of literacy appropriate for different levels of training. Suppose, for example, that there is a performance standard for mass environmental literacy (as measured, for example, by the surveys described earlier in the paper). How would such literacy be defined, with what elements of factual knowledge and depth of understanding? More precise definitions and measurements of literacy may facilitate deeper and more meaningful questions about programs and policies, for example, what sort of programs targeted to which audiences through which media offer greater and less value added in meeting the performance standards. One interesting question will be discussed in the section of this paper on audience -- the match of program to its educational audience (for example, the presence at museums of adults who already exceed any minimum level of literacy -- well run science museums do seem to offer a range of topics and sophistication).

Summary and conclusion: the logic model, gaps and redundancies, and central management

This paper employed a logic model common to NOAA instructional programs as a method of identifying possible gaps and redundancies across programs. Here the gaps and redundancies are summarized as questions, leading to a discussion of possible corrective action by central management.

The main question about the management of educational programs was where coordination of different programs is presently located in the agency and where it might be located assuming an intensified restructuring effort. Questions raised about audience concerned the three audiences of mass education, K-12 instruction and professional development, and higher education. One question about mass education was the extent to which programs delivered to one audience enhance rather than duplicate the learning outcomes available to the same audience through other programs. For example, what is the value-added of informal education for K-12 students who have reached an intermediate level of environmental literacy, and how many K-12 students do receive instruction corresponding to intermediate proficiency? For the K-12 audience, an important question is how much of the desired instructional content and pedagogy actually appear in state and district standards, textbooks, curriculum guides, standardized assessments, and the enacted curriculum, for example, in large urban districts, and, in light of those targets, how the multiple NOAA programs aimed at K-12 education might be configured more effectively. Questions about instructional materials included possible

duplication of meta-cognitive content (e.g., principles of conservation) across programs focusing on different natural resources (e.g., coral reefs, estuaries, fisheries), as well as the desirability of agency-wide standards of content and pedagogy that might be used for quality control of instructional materials dispersed in different branches and programs. Questions about delivery methods and sitesasked whether methods such as online education reflect basic research on best practice and whether exemplary practice within NOAA has been identified and disseminated. Questions about learning outcomeswere organized around the components of environmental literacy (natural resources, human behavior, stewardship), the link between knowledge and action, non-cognitive learning outcomes such as engagement and trust, and the operational definition of minimum and higher levels of literacy, including the depth of knowledge. Clarification of the intended outcomes might lead to improved appraisal of the content of both informal and formal educational programs.

Possible corrective actions by central management.Many candidates for corrective action have been mentioned in the text of the paper in the discussions of each component of the logic model. Framed generically, those actions, varying roughly from least to most in the extent of restructuring required of existing programs, include:

- *Reviews and dissemination of basic and applied research.* Many questions raised in this paper could be illuminated through research: the extent of environmental literacy in various demographic groups, standards of effectiveness of online education, the extent that NOAA content appears in K-12 standards and curricula

- *Reviews of program redundancy and effectiveness.* NOAA educational programs could be reviewed for duplication and evaluated against standards of program effectiveness.
- *Identification of best practice within existing programs.* Programs could be reviewed for the purpose of identifying best practice within the agency with dissemination of results or management efforts directed at replication.
- *New initiatives aiming for increased effectiveness in selected areas.* Assuming availability of new resources, new initiatives could be launched in areas with the highest priority for an increase in overall effectiveness, for example, a concerted effort to see more NOAA materials in the K-12 curriculum.
- *Consolidation, termination, and expansion of existing programs.* Basic research, reviews of redundancy and effectiveness, and identification of best practice could be used to phase out certain programs, consolidate others, and expand those that are deemed to be most effective.

Management will require close and detailed attention as part of any restructuring. The organizational agent of change should be carefully located and have sufficient authority and resources to make a difference. One possibility is reallocating the budget for external research grants in the Office of Education (approximately 2.5 million dollars per year) to an internal review process, managed by NOAA staff but likely including external consultants. About management, this paper said:

> Considerable gains in efficiency and effectiveness should be possible from more centralized management of multiple branches each presently conducting separate needs assessments and managing independent but similar educational programs aimed at overlapping audiences like K-12 teachers that are not exclusive clients of particular programs or branches but rather draw eclectically on a variety of resources.

An internal review process might start with an agency-wide needs assessment built around the gaps identified in this paper and the corrective actions suggested above. Restructuring will require vision, resources, cultivation of buy-in, and overcoming obstacles. A change strategy should be formulated. Logic models used for formative assessment at the beginning of programs have the advantage of a clean slate free of prior commitments. In contrast, formative evaluation of mature and institutionalized programs must identify what can and cannot be changed and include a plan for working with available options.

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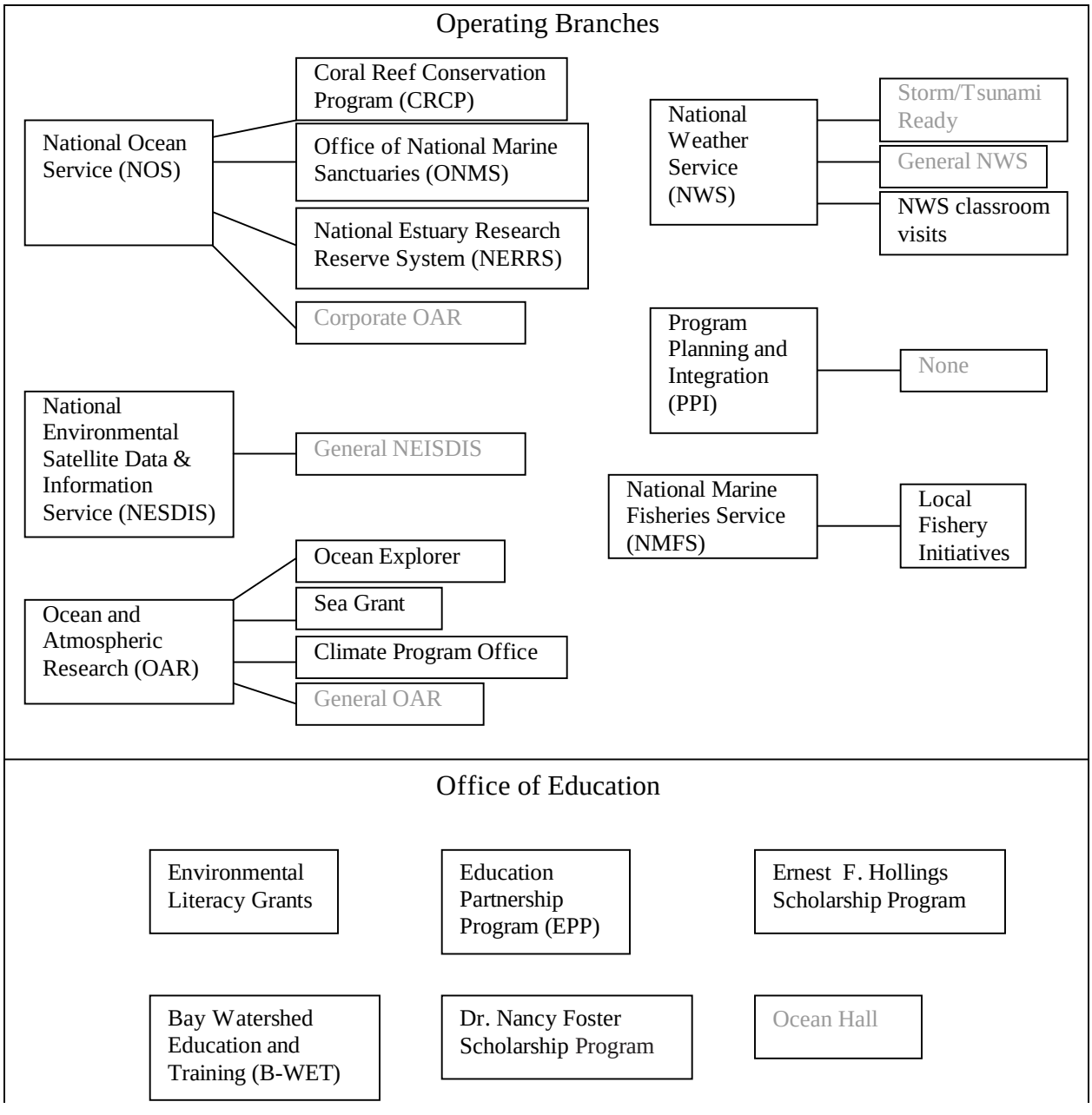
Appendix A

NOAA Education Initiatives to Consider in writing the Logic Model Paper

There are education initiatives run by the Operating Branches, the Office of Education. The figure below illustrates what initiatives are supported by each Branch and the Office of Education. Programs in black are those that should be focused on for the logic model paper. Programs in grey do not need to be included in the paper.



Program Descriptions

Below are brief descriptions of each of the programs listed on the previous page. Along with the descriptions I list the documents related to each program that have been provided and links to more information available on the web.

NOS programs

CRCP: A relatively new education effort that is still determining its education and outreach strategy. CRCP has developed an education strategy that follows theCRCP Road Map that lays out the strategic plan for CRCP endeavors through 2015 The education strategy states that the main messages of their education programs are:

1. Coral reefs are valuable resources. They provide food, recreation, marine habitat, coastal protection, and medicines and sustain American livelihoods and economic development.
2. The health of coral reef ecosystems is at serious risk due to a variety of human activities both local and global. The three big issues are: climate change, land based sources of pollution and over fishing. Protecting and conserving coral reef ecosystems is an urgent issues, we can protect them if we act now

The programs key audiences are:

1. Formal Educators (classroom teachers)
2. Informal Educators (museums, aquariums, zoos, NGOs, government agencies)
3. Education Groups (elder hostels, boy/girl scouts, home school)

4. Students K-12
5. Students 12+

Its education goals are:

1. Promote an informed society that understands the value of coral reef ecosystems, the threats they face and actions individuals can take to reduce human impacts on coral reefs through formal and informal education
2. Strengthen infrastructure for dissemination of information and tools to key audiences by building and maintaining strategic partnerships
3. Collect, develop and distribute scientifically correct, educationally relevant tools and information to key audiences
4. Evaluate effectiveness of education programs

For more information on the CRCP education initiatives see CRCP education strategy.

ONMS: The National Marine Sanctuary System was established by the Marine Protection, Research, and Sanctuaries Act of 1972. The act authorizes the Secretary of Commerce to designate and manage areas of the marine environment with special national significance due to their conservation, scientific, cultural, historical, or educational qualities as national marine sanctuaries. The system now includes 13 marine sanctuaries and one national monument. ONMS works with the public and federal, state, tribal, and local officials to promote resource protection while also facilitating public and commercial uses that are compatible with resource protection in the sanctuaries, such as commercial and recreational fishing, diving, and repair of seawalls. Sanctuary program

officials coordinate with other NOAA offices on scientific research, marine zoning, commercial and recreational fishing, ocean resource economics, enforcement, emergency response, and damage assessment. . Educational materials for students and teachers are provided online through the National Marine Sanctuaries Program (NMSP) and hands-on education experiences are also available at each sanctuary. There are a wide range of formal and informal education activities supported by each sanctuary. The goal of the education programs is to promote public understanding of national marine sanctuaries and marine environments. Each project has a specific target population; from children to educators, from the general public to under-represented populations. Information regarding the education programs at each sanctuary is found on their websites, which are lined to the main site.

NERRS: The system is a network of protected areas established for long-term research, education and stewardship. This partnership program between NOAA and the coastal states protects more than one million acres of estuarine land and water, which provides essential habitat for wildlife; offers educational opportunities for students, teachers and the public; and serves as living laboratories for scientists. National Estuarine Research Reserves are federally designated "to enhance public awareness and understanding of estuarine areas, and provide suitable opportunities for public education and interpretation." Educational programming linked to research and stewardship was incorporated at the Reserves since their inception in 1972. Twenty-four Reserves are offering education activities to a wide range of audiences. In addition, the reserves invite students and teachers to learn about estuaries by actively participating in theEstuaryLive

program, an interactive field trip over the internet. The goals of NERRS education activities are to enhance public awareness and understanding of estuarine areas, and provide suitable opportunities for public education and interpretation. Each project has a specific target population; from children to educators, from the general public to under-represented populations. An assessment of the current state of NERRS education activities was evaluated by TERC in 2007.

Corporate NOS: The products and activities listed at this website, http://oceanservice.noaa.gov/education/ are considered "corporate NOS". The intent is to cover NOS offices that do not have a defined education office (e.g. Center for Operational Oceanographic Products and Services, National Centers for Costal Ocean Science, etc.) and link where possible to NERRS, ONMS, and Corals. They focus on topics such as tides, currents, charting, geodesy, invasive species, etc. They attempt to create educational products to translate that science into something palatable for students and educators. Finally, the "corporate NOS" team has been heavily involved in providing professional development and you will find those activities and resources here http://oceanservice.noaa.gov/education/pd/welcome.html

NESDIS

General NESDIS Program: NESDIS provides timely access to global environmental data from satellites and other sources to promote, protect, & enhance the Nation's economy, security, environment, & quality of life. To fulfill its responsibilities, NESDIS acquires

and manages the Nation's operational environmental satellites, provides data and information services, and conducts related research. NESDIS provides the resulting information to NOAA and other agencies, allowing them to provide products and services such as severe storm warnings, short- and long-term weather forecasts, climate analyses, and satellite-aided search and rescue services. NESDIS contributes to the national economy by providing environmental data that support resource management in areas such as energy, water, and global food supplies. Our environmental satellite observations are important for national security, providing users information for aircraft, ships, and facilities around the world. There are links to a variety of educational resources on their website.

OAR

Ocean Explorer: The NOAA Ocean Exploration program coordinates the agency's exploration efforts and facilitates research expeditions. It strives to engage broad audiences to enhance America's environmental literacy through the excitement of ocean discovery. Increasing this literacy requires high-quality, effective collaborations between ocean explorers and America's teachers. NOAA is forming such collaborations to reach out in new ways to the public to improve the literacy of learners with respect to ocean issues. The Explorer website serves as a public archive of the exploration program, chronicling many of the missions with detailed daily logs, informative background essays, and rich multimedia offerings. It also offers over 130 hands-on, standards-based lesson plans and a curriculum based on the explorations. The education materials are

developed through collaborations between ocean explorers and America's teachers, and range from curriculum to on-line games. The materials and activities strive to engage broad audiences to enhance America's environmental literacy through the excitement of ocean discovery. The web site was developed to provide an innovative way for individuals of all ages to learn about the oceans by offering near real-time access to a series of multidisciplinary ocean explorations. It also provides compelling imagery, video, and topical essays related to the ocean. The more robust initiatives on the Explorer website seem to be the Lesson Plans, Expedition Education Modules, Curriculum, Professional Development, and Education Alliances.

Sea Grant: Sea Grant research, outreach and education are integrally connected. Sea Grant scientists throughout our national network make discoveries–discoveries that solve problems, answer questions and save lives–in short, science that offers real world solutions. Then, Sea Grant's national outreach team of extension agents, educators and communicators, translate this research into usable information and products for a variety of audiences. Their outreach component strives to ensure that science is delivered to those who need it in ways they can use this information. There are three types education initiatives of the Sea Grant program: the Sea Grant Educators Network, Sea Grant Fellowships, and Marine and Aquatic Science Literacy Programs. The Sea Grant Educators Network operates both locally and as a national force, providing highly respected marine and aquatic science education nationwide and partnering (links to partnerships page) with other national education efforts. The common goal of all Sea Grant programs is to provide educators with insights into contemporary marine and

aquatic science issues and research, and to also provide strategies to bring this information to their students. Sea Grant also sponsors the John A. Knauss Marine Policy Fellowships, and the Sea Grant/NOAA Fisheries Graduate Fellowship. In addition each of the Sea Grant Colleges run a number of education activities.

Climate Office Program: NOAA's Climate Program Office manages competitive grant programs, leads NOAA climate international, education and outreach activities, and coordinates climate activities across NOAA. Much of the work they conduct is covered at the CPO education web site, http://www.climate.noaa.gov/education/. They were involved in the development of the Climate Literacy document. The website offers links to information for students and teachers, as well as information on teacher professional development opportunities, a post-doctorate fellowship program, seminars, and the field research that they sponsor.

General OAR: On the OAR website there are links to education resources for students and teachers. The links provide educational materials regarding general information, climate, weather, and oceans Great Lakes and Coasts.

NWS

Storm/Tsunami Ready: As part of NOAA's responsibility for tsunami and storm warning and as part of the national effort for tsunami and storm hazard mitigation, the National Weather Service developed the TsunamiReady and StormReach Programs. They are

designed to help cities, towns, counties, universities and other large sites reduce the potential for disastrous tsunami-or storm-related consequences. The programs help community leaders and emergency managers strengthen their local operations. The programs strive to prepare communities to save lives through better planning, education and awareness.

General NWS: The NWS Education activities are, with the exception of one program (Xtreme Weather CD) are all informal education activities. There are no NWS programs established to look at the effectiveness of NWS education activities across the National Weather Service field offices. The Xtreme Weather CD was created by the Illinois Education Association with the NWS one of several partners with the project. Other projects include: a partnership with the American Meteorological Society (AMS) to conduct science teacher training programs; a partnership with the Department of Homeland Security to supply free NOAA WeatherRadio to all Public Schools. During the past 3 years, the DHD-DOC-DOE federal agencies delivered to all public schools a free NOAA WeatherRadio. There is also a suite of education materials for teachers and students on the NWS website.

Classroom Visits: NWS tracks the number of school visits NWS field offices make each year (approx 2400/year, slight growth each year), and the supply and demand of publications requested by NWS field offices for local school visits. We will learn more about the field visits at our December committee meeting.

PPI

There are no PPI education activities that we are aware of. I am awaiting response from the PPI Administrator.

NMFS

General NMFS: National Marine Fisheries Service is responsible for the management, conservation and protection of living marine resources within the United States' Exclusive Economic Zone (water three to 200 mile offshore). Using the tools provided by the Magnuson-Stevens Act, NOAA's National Marine Fisheries Service assesses and predicts the status of fish stocks, ensures compliance with fisheries regulations and works to reduce wasteful fishing practices. Under the Marine Mammal Protection Act and the Endangered Species Act, NOAA's*Local Fishery Initiatives:* National Marine Fisheries Service recovers protected marine species (i.e. whales, turtles) without unnecessarily impeding economic and recreational opportunities. With the help of the six regional offices and eight councils, NOAA's National Marine Fisheries Service is able to work with communities on fishery management issues. NOAA's National Marine Fisheries Service works to promote sustainable fisheries and to prevent lost economic potential associated with overfishing, declining species and degraded habitats. NOAA's National Marine Fisheries Service strives to balance competing public needs. WeirdFins is a NOAA Fisheries Service website and weekly podcast "feed" about strange - and sometimes just plain bizarre - creatures that inhabit the sea. Each edition is only two

minutes long, and is designed to teach children something new. Each NOAA Fishery has developed or supports education initiatives that are tied to local issues. The NMFS staff are preparing a list of each of the current education initiatives.

Office of Education

Environmental Literacy Grants: The NOAA Education Initiative provides environmental literacy grants. Each year the requests for proposals are focused on different priorities. In 2005 the two priorities were partnerships that promote systemic change in NOAA-related science education and innovative presentation of NOAA science and earth observing data through educational data visualizations and other educational tools. In 2006 the three priorities were to further the use and incorporation of the Ocean Literacy Essential Principles and Fundamental Concepts in formal and informal education and/or measure ocean literacy among the public; to strengthen the capacity to develop a workforce knowledgeable about weather and climate; and to develop exhibits, such as, Science on a Sphere, that build environmental literacy among the general public through increased use of NOAA or NOAA-related data and data products in informal education institutions. In 2007 the two priorities were to support environmental literacy in formal K-12 education and to support complementary efforts in free-choice learning. All funded projects are encouraged to incorporate NOAA data, data visualizations, and resources, and to further the use of Earth System Science concepts related to NOAA's mission goals. Projects are also encouraged to collaborate with NOAA entities as partners and/or connect to projects

previously funded by NOAA's Environmental Literacy Grants. Current and past projects are listed on the NOAA Office of Education website.

EPP: Established in 2001, NOAA's Educational Partnership Program (EPP) provides financial assistance through competitive processes to minority serving institutions that supports research by and training of students in NOAA-related sciences. The program focuses on under-represented populations in these fields through partnerships with Minority Serving Institutions (MSIs). EPP now consists of robust training initiatives designed to address the full spectrum of capacity-building opportunities, including student training; peer and collaborative research; and faculty staff exchanges. Financial assistance is provided through four competitive program components: the Cooperative Science Centers, the Environmental Entrepreneurship Program, the Graduate Sciences Program, and the Undergraduate Scholarship Program. Information on each program is provided on the EPP website.

B-WET: NOAA B-WET provides grants in support of locally relevant experiential learning in the K-12 environment. The program currently operates in the Chesapeake Bay, California, and Hawai'i, and may be expanding in 2008 to three new regions: Northeast, Gulf of Mexico, and the Pacific Northwest. Each program is managed by a different part of NOAA. Funded projects involve meaningful watershed educational experiences addressing regional priorities and provide hands-on watershed education to students and teachers to foster stewardship. Meaningful experiences are defined as those that: 1) include direct connections to the marine or estuarine environment; 2) related to

what is occurring concurrently in the classroom; 3) support sustained activity; 4) consider the environment a system; and 5) include NOAA products, services, or personnel where appropriate . The program also calls for systematic, long-term professional development of educators' ability to teach, inspire, and lead young people toward thoughtful stewardship. Detailed information on each program can be found through their websites: Chesapeake Bay, California, and Hawai'i.

Ernest Hollings Scholarship: The Hollings Scholarship Program was initiated in 2005 and is named after retired South Carolina Senator Ernest F. Hollings. The program is funded at 1/10th of 1% of NOAA appropriated funds. It provides undergraduate students with awards that include academic assistance (up to a maximum of $8,000 per year) during the 9-month academic year; a 10-week, full-time internship position at a NOAA facility ($650/week) during the summer; and, if reappointed, academic assistance for a second 9-month academic year (up to a maximum of $8,000). The purpose of the internship after the first year of the award is to provide scholars with ''hands-on"/ practical educational training experience in NOAA-related science, research, technology, policy, management, and education activities. Awards also include travel funds to attend a mandatory Hollings Scholarship Program orientation, conferences where students present a paper or poster, and a housing subsidy for scholars who do not reside at home during the summer internship. More than 600 scholarship applications were received in 2008 up from over 400 in 2007, and the program expects 800 applications in 2009. About 100 students will be awarded a 10-week, paid ($650/week) internship during this summer at NOAA or a NOAA approved facility.

Nancy Foster Fellowship: Dr. Nancy Foster Scholarship Program recognizes outstanding scholarship and encourages independent graduate level research -- particularly by female and minority students -- in oceanography, marine biology and maritime archaeology. Congress authorized the Program, as described in the National Marine Sanctuaries Amendments Act of 2000. Dr. Nancy Foster Scholarships may provide, subject to appropriations, yearly support of up to $32,000 per student (a 12-month stipend of $20,000 in addition to a tuition allowance of up to $12,000), and up to $20,000 support for a four to six week research collaboration at a NOAA facility. A maximum of $84,000 may be provided to masters students (up to 2 years of support and one research collaboration opportunity) and up to $168,000 may be provided to doctoral students (up to 4 years of support and two research collaboration opportunities).

Ocean Hall: In 2003 $2M was earmarked for the museum and preliminary design workshops. The Sant Ocean Hall — which opened on September 27 at the Smithsonian Institution's National Museum of Natural History — combines 674 marine specimens and models, high-definition video experiences, one-of-a kind exhibits, and the newest technology, enabling visitors to explore the ocean's past, present, and future as never before. It was created in partnership with the National Oceanic and Atmospheric Administration (NOAA) to show the ocean as a global system that is essential to all life on Earth. The exhibition refers to ocean in the singular because the ocean is one huge, interconnected body of water that spans several basins.

Office of Marine and Aviation Operations

Teacher at Sea (in the Air): Teacher at Sea (TAS) and in the Air (TIA) programs strives to provide teachers a clearer insight into our planet, a greater understanding of maritime and atmospheric work and studies, and to increase their level of environmental literacy by fostering an interdisciplinary research experience. The programs allow kindergarten through college-level teachers to work under the tutelage of scientists and crew on board NOAA research survey ships or NOAA aircraft. By participating in this program, it becomes possible for teachers to enrich their classroom curricula with a depth of understanding made possible by living and working side-by-side, day and night, with those who contribute to the world's body of oceanic and atmospheric scientific knowledge. Since its inception in 1990, the program has enabled more than 500 teachers to gain first-hand experience of science and life at sea.

Materials Received

Branch	Program	Document
General Education Information	N/A	NOAA strategic education plan
		NOAA Education Budget Table
		Climate Literacy Document
		Ocean Literacy Document
		NOAA Org Chart
NOS	CRCP	CRCP Education Activities
		CRCP Roadmap for the Future

		CRCP Flow Chart
	ONMS	ONMS Overview 2007
		ONMS Education 2007
		ONMS Education Evaluation and Overview
		ONMS Program*
	NERRS	NERRS Eval and Overview 2003
		NERRS Program
	General NOS	None
NESDIS	General NESDIS	None
OAR	Ocean Explorer	Ocean Exploration*
	Sea Grant	Sea Grant Educators Network
		Sea Grant Program Description*
	Climate Office	None
	General OAR	None
NWS	Tsunami/Storm Ready	Tsunami/Storm Ready*
	General NWS	None
	Classroom Visits	None
PPI	NA	NA
NMFS	Local NMFS	NMFS Strategic Education Plan
		NMFS Outreach Plan
		NWFSC Education Tracking 2007
		Fisheries Education Activity Summaries

Office of Education	Environmental Literacy Grants	NOAA Education Initiative*
	EPP	EPP Overview
		EPP*
	B-WET	B-WET Evaluation
		B-WET Meaningful Definition
		B-WET*
	Nancy Foster Fellowship	NFF Establishment Act
		NFF*
	Ernest Hollings Scholarship	Ernst Hollings Scholarship Program
		Hollings*
	Ocean Hall	None

*Project descriptions developed by NRC Staff