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A Guide to Economic Valuation for OAR Research, Products, and Services

OFFICE OF CHIEF FINANCIAL OFFICER
OCEANIC AND ATMOSPHERIC RESEARCH
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Sandy Lucas discussing science goals of ATOMIC with (from the left): Bjorn Stevens, Max Planck Institute for Meteorology, RDML Tim Gallaudet, Assistant Secretary of Commerce for Oceans and Atmosphere, and David Farrell, Director, Caribbean Institute of Hydrology and Meteorology.

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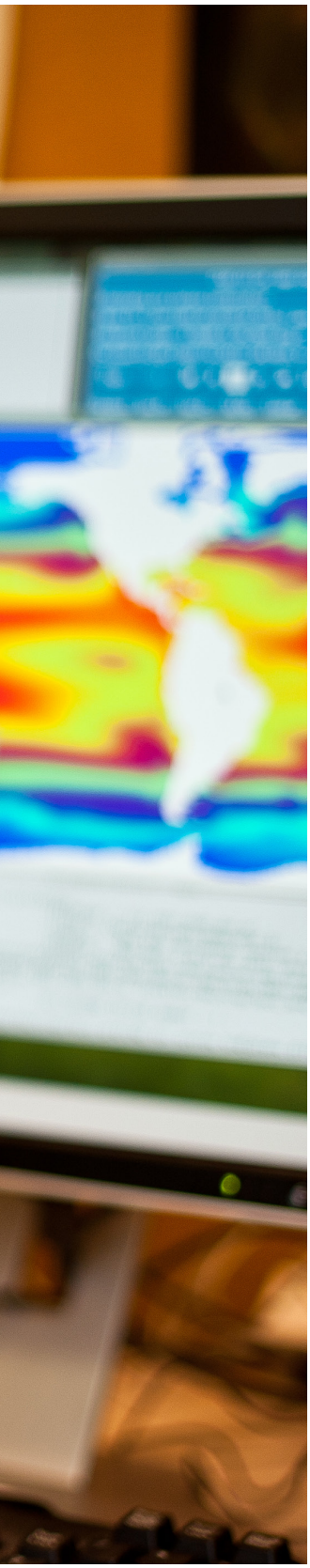
NSSL and academic partner employees calibrate instruments used for measuring tornadic wind speed and direction in preparation for deployment during VORTEX SE. (Credit: NOAA)

EXECUTIVE SUMMARY

Princeton University Graduate student Ilissa Ocko, analyzing data visualization results from climate experiments at NOAA's Geophysical Fluid Dynamics Lab (GFDL).

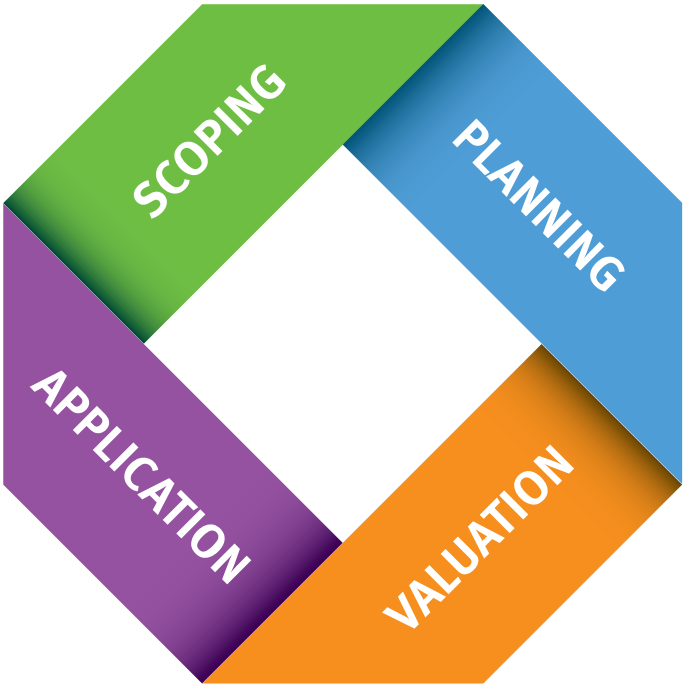


The Office of Oceanic and Atmospheric Research's (OAR) vision is to be a trusted world leader in observing, modeling, understanding, and predicting the Earth system. Its role is to provide unbiased science that informs decision-making and resource management nationally and globally. In 2018, OAR requested NOAA's Chief Economist's team to develop a strategic approach to ensure that analytical quality and consistency guide future valuation studies of OAR's research, products, and services.

This document contains a proposed strategic approach to valuation to aid OAR in the selection, scoping, and execution of socioeconomic studies. It focuses on the following areas:

- Providing a step-by-step guide within which to apply economic valuation consistently and accurately, and by which to address the common challenges encountered in the valuation of OAR's research, products, and services ("outputs").
- Explaining how to make economic valuation efficient by building a knowledge base that will reduce the cost of future valuation studies.
- Laying the groundwork for collecting critical information from projects on an ongoing basis; it describes the potential use of NOAA's Research and Development Database (NRDD) as a repository for this information, and explains how the NRDD can become a fundamental tool in economic valuation.

The step-by-step approach consists of four interconnected stages:



Scoping ensures that the study meets the needs of the OAR programs that support them. It also informs the remainder of the valuation stages, including helping to choose appropriate valuation methods.

Planning ensures that critical resources will be available for the valuation study, including the information that will be necessary to measure economic values. It also assigns roles and responsibilities and helps to develop a statement of work with clear guidance for research outputs and for selecting valuation methods that will achieve accurate results.

Valuation uses economic analyses to study how R&D outputs benefit society. Benefit-Cost analysis (BCA) and Economic Impact Analysis (EIA) quantify the benefits of R&D outputs to society as a whole or to specific sectors of society, respectively. EIA uses data on costs, and BCA uses data on costs and benefits.

Lastly, **Application** helps embed the results of valuation studies into OAR's strategic plans and communication materials, and uses the results to help build a knowledge base that will reduce the effort and cost of future valuation studies by informing the Scoping stage of other valuation studies. Consequently, the proposed valuation approach links Application and Scoping with a feedback loop.

The proposed guidance and the means for its implementation constitute a valuation guide. The following are key next steps that are recommended to begin implementing and testing the guide at OAR:

Conduct a pilot valuation study to test the valuation guide and generate information for its refinement. It is recommended that the following criteria be used to select the pilot study:

- The societal benefit that is the target of the valuation is likely high.
- Data is available to measure the value of the benefit.
- The contribution of OAR to the output that provides the benefit is well-understood and large.
- The output has a high Readiness Level.
- There is an immediate or clear need to measure the output's benefits to society.
- There is a need for the output's valuation in other Line Offices, so that resources and valuation costs can be shared.

An example of a pilot that could meet some or all of these criteria is the improvement in hurricane intensity forecasts resulting from the assimilation of data collected by underwater gliders. An improvement in forecasts can potentially result in high societal benefits from reduced damage costs, such as the costs of repairing affected infrastructure.

In very general and simplified terms, an economic valuation of the benefits of gliders in improving hurricane forecasts would require simulating the damages of a hurricane with and without the assimilation of glider data into the forecast models. The damages that are avoided by better preparedness resulting from improved forecasts would be part of the economic value of those data. An economic valuation study could help justify investments to increase the presence of gliders in the path of hurricanes and to continue building the case for glider-data assimilation in hurricane prediction models. Findings from such a study would be useful to OAR, IOOS, and NWS.

- Set up a process to explore what user data is available and to collect data for new and existing outputs. Identify data gaps and assign a person or work group to be responsible for addressing data gaps proactively and regularly. This process should be incremental and involve iterative evaluation that builds on success and

learning. Data collection efforts may change by lessons learned on what data is most valuable. The potential integration of these efforts with the work of existing data committees, such as the Environmental Data Management Committee, should be explored.

- Enhance the NRDD. The NRDD provides an ideal repository for the type of information that will build a knowledge base to support economic valuation across NOAA. For the NRDD to reach its full potential, improvements in the way that project information is being entered into the database, and an organization-wide appreciation of the database's importance and capacities, will be required.
- Create a valuation working group and draft a charter with staff from OAR and the Chief Economist's team that outlines purpose, membership, and strategic connectivity to other relevant workgroups, possibly including those in other Line Offices. The valuation working group could be a sub-committee of NOAA's Social Science Committee.

1. Introduction

NOAA's Office of Oceanic and Atmospheric Research (OAR) conducts research to understand and predict the Earth's oceans, weather, and climate with the purpose of advancing NOAA science, service, and stewardship and transition the results so that they are useful to society. Accordingly, OAR evaluates the performance of its enterprise based on scientific and technical quality, the effectiveness of its operations, and the contributions of the enterprise to achieving outcomes that are beneficial to society.

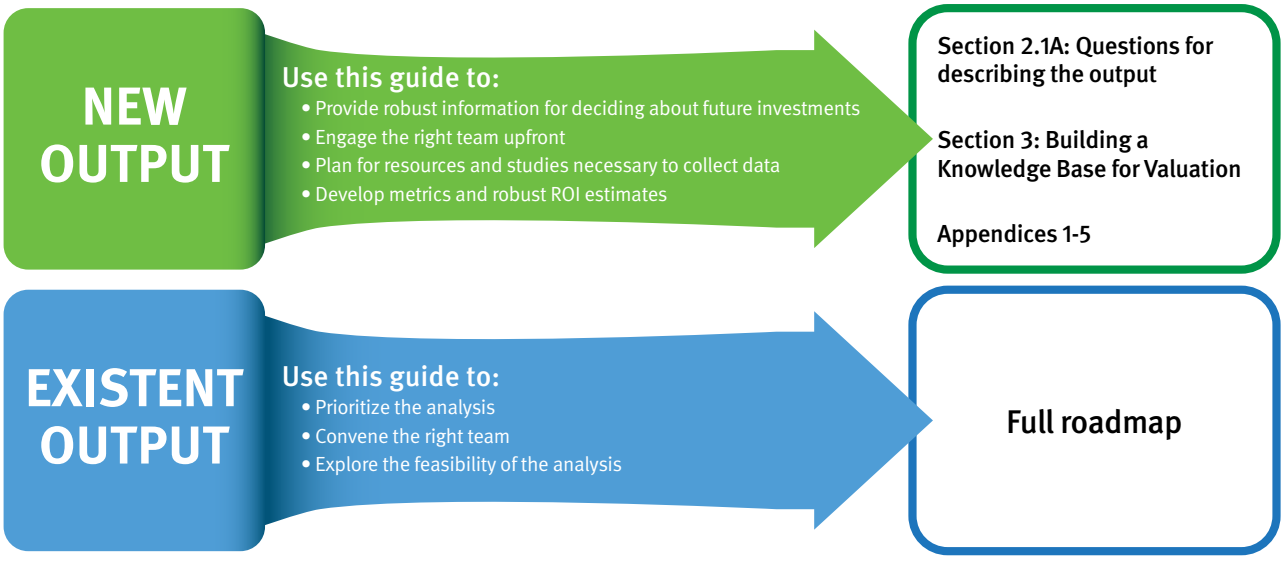
In 2018, OAR requested assistance from NOAA's Chief Economist's team to develop a strategic approach to ensure that analytical quality and consistency will guide future valuation studies of OAR's portfolio of research, products, and services ("outputs"). The proposed guidance and the means for its implementation constitute a guide within which to apply economic valuation.

This is a preliminary (pre-pilot) version of the valuation guide. It is organized in four sections containing a description of the processes and information necessary for a valuation study, five appendices with additional information, and a glossary of economic terms. Following is a brief description of the contents.

- Section 1, Introduction to the Guide, explains how the guide can be used in the valuation of new and existing outputs.
- Section 2, Step-by-step Guide for Economic Valuation, presents the key steps for developing a robust economic valuation study.
- Section 3, Building a Knowledge Base for Valuation, presents the groundwork for collecting critical information for future valuation studies.
- Section 4, Next Steps, presents suggestions for the development of a pilot study.
- Appendix 1, Challenges in the Economic Valuation of OAR's Research, Products, and Services, describes some of the unique challenges associated with assessing the economic value of R&D investments.
- Appendix 2, Federal and NOAA Rules Related to Economic Valuation, summarizes relevant rules.
- Appendix 3, Economic Analysis Approaches, provides a hypothetical example to illustrate the meaning and significance of key terms used in this report.
- Appendix 4, Categories of Societal Benefits from OAR Outputs and Examples of Methods and Applications, provides illustrations from past economic valuations.

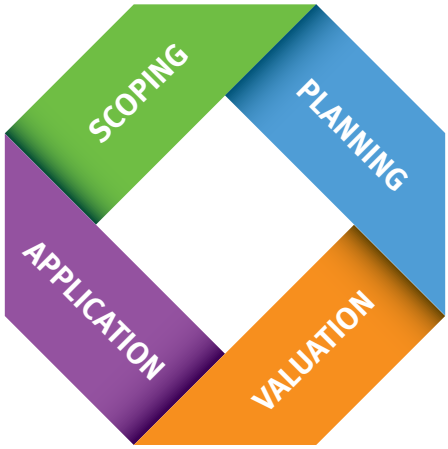
- Appendix 5, The NOAA Research and Development Database (NRDD) as a Strategic Tool to Support Economic Valuation, explains how this tool can be tailored to support economic valuation studies.
- Glossary of Economic Terms, defines and provides examples of key terms used in the document.

Economic valuation allows OAR to measure and track the societal contributions of its existing outputs. Economic valuation can also inform investment decisions by helping to identify new outputs that could potentially generate a high contribution to societal well-being. Valuation studies on existing outputs, and future valuation studies that are done on new outputs, will all rely on having good information about users and potential users of the outputs. The figure below illustrates how the guide can be used to support the economic valuation of existing and new outputs.



2. Step-by-step Guide for Economic Valuation

Measuring the societal contributions of existing research and its products poses a variety of challenges (see Appendix 1 for a discussion of these challenges).The figure below presents the interconnected steps to develop sound economic analysis for decision-making and planning purposes while addressing the challenges inherent in valuation.



PROPOSED STEPS FOR ECONOMIC VALUATION:

- **Scoping:** Define the **scope** of the valuation study.
- **Planning:** Develop a **plan** for the valuation exercise.
- **Valuation:** Employ **valuation** methods that are appropriate to the valuation question and that take into account the data needed before, during, and after the study.
- **Application: Apply** the results of valuation to strategic plans and communications and to building a knowledge base

2.1 Scoping

Scoping, an essential first step of any study, is the stage that identifies the specific questions that the economic valuation will address. Scoping ensures that the study meets the needs of the OAR programs that support them. It also informs the remainder of the valuation stages, including helping to choose appropriate valuation methods.

The first step in Scoping is to review legislative mandates (see Appendix 2) and Strategic Plans that may require measuring the contributions to society of a program, lab, or Line Office. Based on this exercise, a list of 3-4 outputs are considered for valuation. For example, the Weather Research and Forecasting Innovation Act of 2017 directs NOAA to focus resources and effort to provide better information to the public on high-impact weather events. Three NOAA outputs that aim at helping to achieve this societal benefit are improved tornado lead times, the integration of warn-on-forecast into the tornado forecast process, and improved models for tornado detection.

The second step is to identify if the valuation would be applied to an existing output or a new one. Valuation is a powerful tool for planning and decision making, and it can help with the allocation of scarce resources for new projects. It is highly

recommended that economists are involved early in the stages of the development of new outputs, and that the information that will be required in future valuations is collected from the onset. Valuation can also be used to demonstrate how existing programs and investments are creating value for end-users and meeting legislative mandates.

The third step is to use the following questions to describe the output that will be the target of economic valuation.

Questions for describing the output. Answer questions 1-5 for new outputs and all questions for existing outputs.

1. What is the output for which actual or potential benefit(s) will be measured?
2. What is the output's Readiness Level?
3. Who are the output's end-users? Market research studies can help understand the current and potential end-users of an output. For example, a 2016 survey funded by NOAA'S Integrated Ocean Observing System (IOOS) identified 57 companies that make use of NOAA's ocean data in the development of value-added outputs. When these types of studies are not available, OAR social scientists could help identify potential end-users of an output.
4. Are there beneficiaries of the output for whom the output will/was not originally intended (positive externalities)? For example, new technologies could be appropriated by unforeseen segments of the private sector to generate profits.
5. What would be the "state of the world" without the output (the counterfactual or baseline) and the positive changes to society that the output will bring?
6. Who are the stakeholders in the valuation? (Stakeholder is any party, including NOAA Line Offices and end-users of an OAR output, who has an interest or stake in the results of an economic valuation
7. Have economic valuations been done by NOAA for similar or related OAR outputs? Social scientists and economists can help search the literature for relevant studies.
8. What is the reason for the economic valuation (planning and decision-making, mandated by legislation, needed for policy and investment

decisions, budget requests, etc.)? Keep in mind that the reason may define the level of economic data and analysis needed.

9. Does the output align with OAR's historical patterns of investment? This provides an indication of where the output fits in OAR's overall knowledge base; for example, does it extend prior work or address a void in the knowledge base?
10. How do the expected societal benefits of the output compare to those of other OAR outputs that could also be the targets of valuation? (This is an indication of the relative importance of the output as a target for a valuation study.)
11. Compared to other OAR outputs that could also be the target of a valuation, is the contribution of OAR to the production of the output well understood and comparatively large?
12. How much has OAR invested in the OAR output? (This information is used in Benefit-Cost analysis.)
13. Are data available to quantify the output's societal benefits? Social scientists and economists can help conduct a search for any existing studies that would provide the necessary data for the analysis. In cases where the data is not readily available, social scientists can design and conduct the studies.
14. Is there a need for the output's valuation in other NOAA Line Offices (so that the costs of the valuation study can be shared)?
15. Have other Line Offices done any valuation work on the output, on which new valuation work can build upon?

In many instances, OAR outputs are inputs in the production or operation of another output that is closer to end-users. For example, OAR conducts research on the climatic mechanisms that lead to the onset of drought, and the results of this research (OAR outputs) are inputs into the National Integrated Drought Information System, which provides tools to aid decisions by farmers and other end-users.

The Scoping stage requires collaboration between scientists from the social and bio-physical sciences involved in the project. Participants should have a solid understanding of how the OAR output is used, and by whom. It is essential to engage social scientists (including economists) early, as there is key information needed for a robust economic analysis that is not always available after

the output is finalized. It is recommended that the Chief Economist's team, the project's Principal Investigator, the program manager, and portfolio staff also be involved in the Scoping discussion. The team should also involve a facilitator to guide the scoping phase toward a productive outcome.

2.2 Planning

Planning establishes a well-defined path for completing the valuation study. The goals of this stage are to ensure that all key resources that are required for the valuation study are available and accessible, and that roles and responsibilities are assigned with clear expectations for delivery. An outcome of this stage is a selection of the valuation approach via a statement of work for contract mechanisms or a vetted full proposal for cooperative agreements. These are guidelines that an economist internal or external to OAR will follow to complete the valuation study.

The staffing choice for valuation studies will be determined by the internal availability of specialized skills required by the study and the desired pace of progress for valuation, which may not be achievable with internal resources alone. In that case, a dedicated budget for hiring external contractors using a vehicle such as a Blanket Purchase Agreement (BPA), might be required. For contract mechanisms, the following list of milestones and deliverables is included as a reference for developing statements of work for valuation studies. The specific requirements of each study will vary, and the items listed below are provided as general suggestions.

Valuation Study Milestones

1. The funding program identifies the internal NOAA team that will monitor the progress of the economic valuation project. The team should consist of a technical lead, as assigned by the funding program, as well as team members including relevant managers, social and physical scientists (including a representative from the Chief Economist's Office), and other highly interested OAR parties who can help identify data needs, provide oversight, and consider policy implications.

2. Facilitator leads kickoff meeting with the economists conducting the valuation and the internal NOAA team. Economists present a draft work plan discussing potential valuation approaches, including the following:
    - Definition of the baseline and the beneficiaries (impacted population)
    - Data requirements
    - Estimated costs
    - Staff requirements (internal and external)
    - Estimated timeline
3. Selection of a valuation approach (see Valuation phase for a description of common approaches)
4. Monthly progress calls with economists
5. Review of interim deliverables by the internal NOAA valuation team lead
6. Review of draft final report by the internal NOAA valuation team lead
7. Presentation of final report by the valuation project lead to the internal NOAA team
8. Presentation of final report by the valuation project lead to a larger group of NOAA leadership (as determined in the Application phase below).
9. Submission of raw data and other products from economists to the technical team lead.

Valuation Study Deliverables

10. Preliminary report that includes:
    - Justification for selecting a valuation approach
    - Description of its data requirements
    - Data sources that will be used
    - Sampling strategy and justification
    - Valuation timeline
11. In-person presentation of preliminary report
12. Final report that includes:

- Valuation results
- Key assumptions and justifications
- Sensitivity analysis based on the key assumptions
- Recommendations for socializing the results with NOAA strategic councils and other audiences
- In-person presentation of final report

13. Raw data, spreadsheets, and other materials developed in support of the project. Costs of future studies will be reduced if these data and materials are archived in a searchable and accessible way.

For cooperative agreements, such as through the NOAA CIs or CSCs, once the internal NOAA team is defined (Milestone 1) above, Milestones 2 and 3 can take place as part of an iterative exchange between the internal NOAA team and the PI(s). The PIs can submit a full proposal for NOAA's consideration. Cooperative agreements allow for substantial involvement from the Federal Government. The internal NOAA team may review the proposal and provide direct feedback to the PIs. As part of the proposal, NOAA may request that PIs provide more frequent updates, and deliver a final report of findings.

Valuation studies ideally require the involvement of multiple disciplines from the social and bio-physical sciences, including economists, sociologists, geographers, anthropologists, and others, as applicable to the study's objectives, to fully account for the uncertainty regarding the potential benefits of OAR outputs. Members of the team should have experience in project management. As in the Scoping phase, it is recommended that the Chief Economist's team, the project's Principal Investigator, the program manager, and portfolio staff be involved in planning discussions.

2.3 Valuation

Using the valuation method and deliverables schedule from the Planning stage, the Valuation stage assesses the societal change or benefit provided by an OAR output. Whenever feasible, economic valuation attempts to measure this benefit in monetary terms so that it can be compared to the costs incurred by society in producing the output.

Two common analytical approaches that use monetary metrics are Benefit-Cost Analysis (BCA) and Economic Impact Analysis (EIA). BCA measures and compares the benefits and costs to society of producing and using an OAR output. EIA measures changes to economic activity in a region or an economic sector that result from the production and use of an oar output. Appendix 3 presents a detailed description and example of these approaches.

There are cases in which it might not be feasible or appropriate to use a monetary metric to evaluate changes. In those cases, change can be quantified using other metrics such as the number of people who benefit, or it can be described qualitatively as a "use story", which expresses, in narrative form, how an output contributes to a value chain whose end product leads to a societal benefit (see Appendix 1).

Markets provide information on the benefits of some outputs. For example, fish market prices are a result of supply and demand forces for the product, and innovative fishing gear that leads to higher quality can lead to higher demand and prices. However, there are outputs that contribute to benefits provided by non-marketed outputs. For example, many public beaches provide free recreational opportunities, and projects to remove marine debris contribute to these benefits.

Benefits related to the use of the environment can be classified as direct if there is close proximity between the beneficiary and the environmental good or service (for example, in recreation), or indirect if the beneficiary is not in close proximity to the good or service. For example, water that is filtered by an ecosystem could be used for human consumption in a place that is distant from the ecosystem (and after undergoing further treatment).

Economic benefits of R&D outputs that are the target of economic valuation can be grouped in the following broad categories[i]:

- **Information and technology benefits** aare benefits to economic sectors, and positive externalities, from knowledge and technologies. An example of an information benefit is the lead times that are provided ahead of extreme weather events, which provide societal benefits by reducing the potential damages from those events. The lead time is, in part, a result of improvements in the forecast models due to NOAA's investment in research. An example of a technology market benefit is a web-based application (INSITE) for identifying potential weather-related constraints to the National Airspace System, which is being developed by OAR's Earth System Research Laboratory.
- **Human capital formation** are benefits that people receive from trainings offered by OAR programs. For example, participants in Sea Grant training courses in aquaculture and improving fishing operations can apply new knowledge to modernize their businesses, which can result in efficiency gains. Through Sea Grant, OAR is exploring relationships between a warming ocean and the depth-wise and alongshore distribution of juvenile American lobster. This research will provide a market benefit to fishers by helping them respond appropriately to the changing marine environment.
- **Cultural values** aare non-market, indirect benefits from the environment that include aesthetic inspiration and cultural identity. An example of OAR's contribution to cultural values are inventories of underwater cultural resources (such as battlefield sites) conducted by the Office of Ocean Exploration to inform site management and preservation.
- **Non-use values** are benefits that are reflected by people's willingness to pay for knowing that something exists. It has two components: the value of existence per se (existence value), and the potential benefits that something might bring in the future (quasi-option value). NOAA's marine sanctuaries have non-use value; this non-market, indirect benefit is reflected in some people's willingness to pay for the conservation of the sanctuaries, for example by giving donations to support management, even if they don't otherwise enjoy them.

2.4 Application

The Application stage embeds the results of the economic valuation study in areas that are strategic to the organization. OAR can apply the valuation results in three areas:

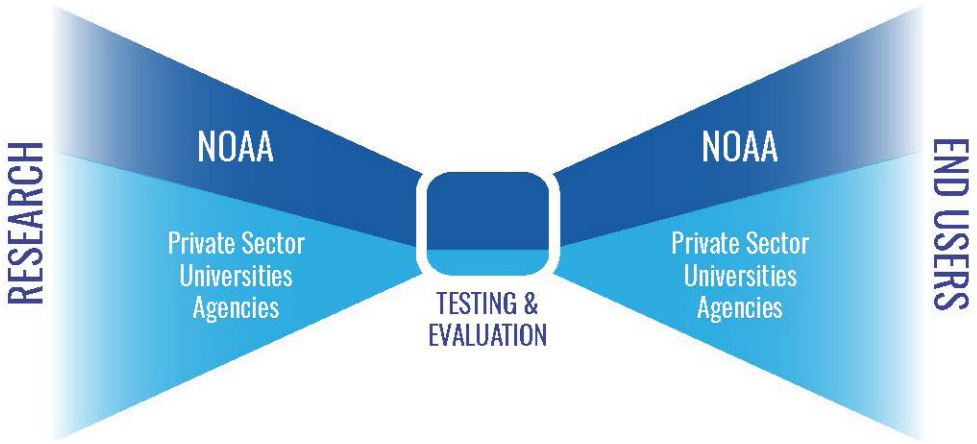
- Communication of the value of OAR outputs (using the valuation results in budget documents, NOAA by the Numbers, Sea Grant by the Numbers, etc.).
- Prioritization of investments in OAR outputs with high economic value. For example, valuation results can inform OAR's Strategic Plan and programmatic decisions on where to invest.
- Building a knowledge base that will reduce the effort and cost of future valuation studies (this is discussed in detail in section 3, below). Conducting valuation studies will identify additional gaps in knowledge and help to build up the human capital necessary to carry out this work within the agency. For example, as OAR engages in economic valuation work, it may uncover a need to acquire additional information about certain end-users, or to apply new methodologies to account for unavailable or inaccessible data. This learning will only occur with a sustained effort in valuation. The knowledge base that is created will inform the Scoping stage of future valuation studies.

Staff involved in the Application stage may include individuals in positions that can enable its communication and application as relevant to OAR and NOAA (for example, OAR's Chief of Staff, OAR's Portfolio Stewards, in addition to the core project team). These staff should be experienced in producing communications products for internal and external audiences, including publications on the value of NOAA research intended for the general public).

3. Building a Knowledge Base for Valuation

A lack of data about who uses OAR outputs and how these outputs are used will limit the ability for valuation studies to provide meaningful insights. A strategic approach for valuing OAR's portfolios requires laying the groundwork for collecting this critical information from its projects on a regular basis; it is essential to collect this information in advance (including for new outputs), as it will provide the foundation for valuation studies. Collecting this information proactively will also reduce the costs of valuation studies in the future, and it will help ensure that critical information is available for those studies. This will make valuation a more efficient and effective process.

In addition, for OAR outputs with low Readiness Levels, collecting information on the step-by-step investments required to take these outputs to maturity will allow estimating the total investment that was required for end-users to begin receiving benefits from the output. The ability to demonstrate the incremental progress necessary to apply research results can help to justify investments in a diverse portfolio of products and services that includes outputs with low Readiness Levels. The figure below shows the process by which different elements of the NOAA network contribute to the development of final outputs.



The following information should be collected and updated regularly for each OAR output to which OAR contributes:

- To what societal benefit(s) will the output contribute? The following are some examples of benefits (see Appendix 4):
  - » Reducing societal impacts from hazardous weather and other environmental phenomena
  - » Increased business opportunities from agriculture, fishing, and aquaculture

Improved recreational experiences from investments in coastal and marine management

- Is this contribution direct or indirect? An indirect contribution is an improvement to an output that in turn improves a societal benefit. An example of an indirect contribution is when OAR outputs are used to improve weather forecasts that are in turn used to reduce weather-related risks and losses.
- If the contribution is indirect, what outputs are supported or improved by the output? In the example above, which specific weather forecasts are improved by the OAR output?
- What are the categories of end-users external to NOAA who benefit or will likely benefit from the output? Examples of beneficiaries of improved weather forecasts could be large-scale farmers, local emergency managers, and the general public.
- Compared to existing outputs, what outcomes are improved by the use of the output? For example, an improved weather forecasting model can reduce the cost of crop irrigation and fertilization and increase agricultural productivity compared to the previous forecasting model.
- How do users obtain the output? Platforms from which users obtain outputs may provide insights into who is using the outputs and how often they use them. Analytics and statistics from NOAA websites, for example those used to obtain weather forecasts, will be useful. The gross economic value of outputs for which this information is collected can be measured as price multiplied by quantity, and data on usage will be an indicator of quantity (i.e., the times that an output is used). The price for usage might vary for each user type, so data on usage is required for each user type.

- NOAA's Research and Development Database (NRDD) could become a repository for this type of information (see Appendix 5). This will require broadening OAR's strategy on what type of data analysis, including economic, OAR wants to conduct, and subsequently what type of data OAR will need to collect. Such a strategy needs to consider that the NRDD is a data collection process, akin to a survey, and will require assessing the ease of data entry and the staff time required to conduct it. In addition, for the NRDD to reach its full potential, enhancing the flow of information between the NRDD team and the different Line Offices, and an organization-wide appreciation of the database's possible capacities, will be required[ii].

Image of NOAA CSL instruments measuring during COVID-19 "safer-at-home" orders. Credit: Jessica Gilman, NOAA CSL

4. Next Steps

Focusing on the following activities is recommended to begin implementing and piloting the economic valuation guide.

- **Conduct a pilot valuation study** to test the proposed valuation guide and to generate information for its refinement. An ad-hoc valuation working group will be formed with staff from OAR and the Chief Economist's team to test the proposed valuation approach. This group will (1) select a pilot valuation study (discussed below); (2) work with TPIO on developing value chains for OAR outputs; (3) refine the valuation guide with the lessons learned from the pilot study; and (4) continue working with the NRDD management team to improve the database.

Based on the criteria presented in the Scoping stage for prioritizing valuation studies, it is recommended that the pilot study have the following characteristics:

- The societal benefits that are the target of the valuation are likely high.
- Data is available to measure the benefits.
- The contribution of OAR to the output is well-understood (i.e., easily mapped) and large.
- The output has a high Readiness Level.
- There is an immediate or clear need for the output's valuation.
- There is a need for the output's valuation in other Line Offices, so that resources and valuation costs can be shared.

An example of a benefit from an OAR output that could meet some or all of these criteria is the improvement in hurricane intensity forecasts resulting from the assimilation of data collected by underwater gliders[iii]. Given the high costs incurred by society from hurricane events, an improvement in forecasts can potentially result in high societal benefits from reduced damage costs, including the costs of repairing affected infrastructure.

NOAA's Atlantic Oceanographic and Meteorological Laboratory is co-leading sustained and targeted ocean observations from underwater gliders in the Caribbean Sea and southwestern tropical North Atlantic Ocean. Other NOAA partners include the National Ocean Service's U.S. Integrated Ocean Observing System. Findings from a glider valuation study would be useful to OAR, IOOS, and NWS, and sharing the costs of the study might be feasible.

In very general and simplified terms, an economic valuation of the benefits of gliders in improving hurricane forecasts would require simulating the damages of a hurricane with and without the assimilation of glider data. The damages that are avoided from improved forecasts would be a measure of the economic value of the gliders. BCA would compare the benefits of gliders (the avoided costs) with the cost of gliders, and its results could help justify investments to increase the presence of gliders in the path of hurricanes and to continue building the case for glider-data assimilation in hurricane prediction models.

- **Set up a process to collect user data proactively.** A program of economic valuation for OAR would greatly benefit from the regular collection of the key information described above. It is recommended that OAR work on a data strategy plan to map out what type of data analysis it wants to conduct and subsequently what type of data is needed. The strategy should also outline who or what (i.e., a new program?) would focus on this. At this time, OAR does not have such a strategy.
- **Enhance the NRDD.** The NRDD has the potential to become a key support tool for valuation, and some enhancements are recommended to improve its immediate use (see Appendix 5).
- **Create a valuation working group.** Given the dependencies of data across all of NOAA for conducting economic valuation, it is suggested that OAR consider creating a valuation working group that includes staff from OAR and the Chief Economist's team, and create a charter that outlines purpose, membership, and strategic connectivity to other relevant groups in other Line Offices and to the Senior Research Council. The valuation working group could be a sub-committee of NOAA's Social Science Committee.

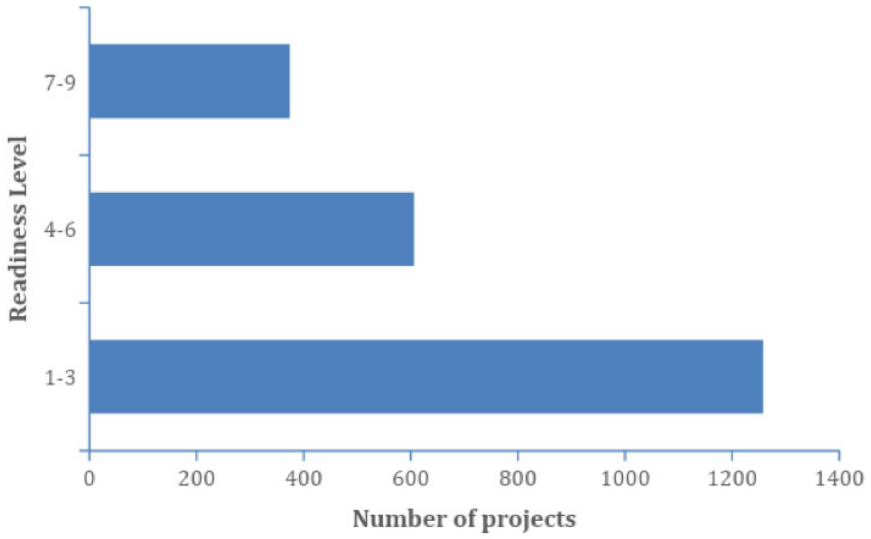
If its membership is wide enough, the working group will oversee economic valuations across NOAA, and its charge could include providing guidance on staffing each of the valuation stages. The valuation working group could also act as the technical team responsible for verifying compliance with the statement of work of valuation studies, and for evaluating their deliverables.

Appendix 1: Challenges in the Economic Valuation of OAR's Research, Products, and Services

The measurement of the societal benefits of OAR outputs present several methodological challenges. First, the benefits of outputs that are experimental or theoretical in nature and primarily geared towards acquiring new knowledge (i.e., outputs with low Readiness Levels) generally occur after the outputs pass through various stages of maturity (and reach higher Readiness Levels).

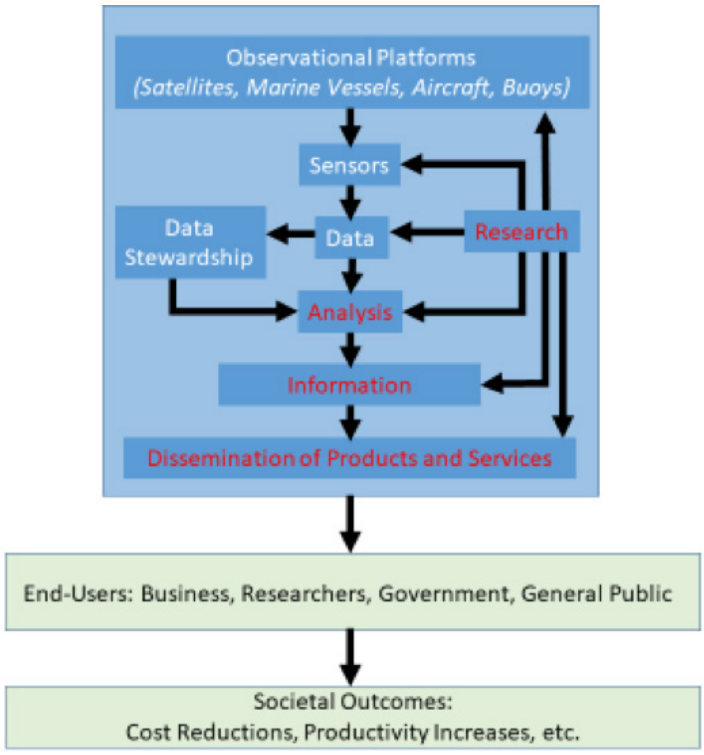
Additionally, the potential benefits provided by outputs that require a long time to mature can be affected substantially by discounting (see Appendix 3). Therefore, the scientific, technical, and institutional uncertainties as to when these benefits will occur need to be considered in valuation studies. Approximately 56% of OAR's current R&D portfolio are outputs with Readiness Levels 1-3 (Figure 1), and valuation studies of these outputs will involve a high degree of uncertainty.

Figure 1: Number of OAR projects by Readiness Level categories. Data were obtained from NOAA's Research and Development Database (NRDD)..



A related challenge is that OAR outputs can themselves be inputs in the production or operation of an output that is closer to the end-user. In this case, a good understanding of value chains is needed. Value chains map how an output is linked to other outputs and to societal benefits (Figure 2). They are used to show the sequence of activities that result in a societal benefit, and provide a blueprint for identifying the data and information necessary for valuation. Critically, value chains help establish a link between value creation (in this case by OAR) and the realization of value by an end-user. Value chains also help identify stakeholders of the valuation study, and they provide a qualitative expression of value that is important on its own as part of a value narrative of OAR outputs. "Use stories" are narratives that describe how an output contributes to a value chain whose end product leads to a societal benefit.

Figure 2: A generic value chain that illustrates the relationships between representative OAR outputs (in red) and other outputs (in white) required to achieve societal benefits.



NOAA already has a tool that can facilitate the construction of value chains. The NOAA Observing System Integrated Analysis (NOSIA-II) is a project created by NOAA's Office of Technology, Planning and Integration for Observation (TPIO) to document the relationship between available observing systems and their impact on NOAA's mission outcomes. The information that is needed for the generation of value chains is at the core of NOSIA-II, and it will likely be useful in OAR valuation studies.

An example of a previous development and application of value chains based on NOSIA-II concepts is NOAA's Office of Marine & Aviation Operations' work with TPIO to identify products and services that provide high socioeconomic benefits and are highly dependent on the fleet. A potential opportunity for OAR and TPIO to collaborate in valuation is discussed in the Next Steps section below.

Another consideration is that R&D that is publicly funded frequently produces unintended external benefits, such as new technologies that are appropriated by unforeseen segments of the private sector to generate profits. These positive externalities need to be considered as part of the societal benefits of a R&D portfolio. The Scoping phase should attempt to identify if such beneficiaries exist by means of basic market research and/or by consulting the technical teams that produced the output. Economists conducting the valuation will further explore if these externalities exist, and if so, they will apply valuation methods for information and technology benefits such as those discussed in Appendix 3.

Finally, there are cases in which it might not be feasible to measure economic values using a monetary metric. For example, there may be an immediate need to provide a description of the societal contribution of an OAR output, and the data to monetize the value may not be available. In these cases, it may be possible to quantify the benefit using other metrics (for example, the number of people who benefit or the area of a marine zone that is restored). Sea Grant employs "use stories" as one way of describing its contributions to society[iv]. They are narratives explaining how an output contributes to a value chain whose end product leads to a societal benefit.

It can be expected that future economic valuation work done by OAR will encounter these common challenges. In addition, a review of previous OAR work in economic valuation performed by the Chief Economist's team revealed the following issues[v]:

- The studies lacked scoping and planning. Many of the studies were related to the work being done by OAR programs, but they did not directly address the valuation question that OAR programs set out to answer. It was not clear that the scope of the research project or the research questions pursued in these studies would meet the needs of the OAR programs who had commissioned them.
- Many of the studies lacked access to important data, either because NOAA was not collecting the data or because the data that the agency had were difficult to access. These challenges with data were not identified before a valuation methodology was selected. Having done so would have allowed selecting a methodology with more realistic data requirements. It also would have allowed programs to invest their resources in collecting the necessary data before they funded valuation studies.
- Almost all of the studies had issues with sampling: Sample sizes were too small to generalize to the larger affected population, or were not representative. As a result, while these studies potentially answered interesting scientific questions, they may not have delivered the information that OAR was seeking when the studies were funded[vi].

Appendix 2: Federal and NOAA Rules Related to Economic Valuation

The following examples of legislation and a NOAA internal rule contain language related to economic valuation. Some examples of this language are included.

Coastal Zone Management Act establishes that "The Administrator, in consultation with the Secretary and the Director of the United States Fish and Wildlife Service and other Federal agencies, shall publish (and periodically revise thereafter) guidance for specifying management measures for sources of nonpoint pollution in coastal waters... (D) quantitative estimates of the pollution reduction effects and costs of the measures;..."

....

"16 U.S.C. § 1456b. Coastal Zone Enhancement Grants (Section 309)... The Secretary shall ensure that funding decisions under this section take into consideration the fiscal and technical needs of proposing States and the overall merit of each proposal in terms of benefits to the public."

National Marine Sanctuaries Act states:

"(a) STANDARDS "The Secretary may designate any discrete area of the marine environment as a national marine sanctuary and promulgate regulations implementing the designation if the Secretary determines that—

(1) the designation will fulfill the purposes and policies of this chapter;

(2) the area is of special national significance due to—

(A) its conservation, recreational, ecological, historical, scientific, cultural, archaeological, educational, or esthetic qualities;;

(B) the communities of living marine resources it harbors; or

(C) its resource or human-use values;..."

....

(b) FACTORS AND CONSULTATIONS REQUIRED IN MAKING DETERMINATIONS AND FINDINGS

(1) Factors For purposes of determining if an area of the marine environment meets the standards set forth in subsection (a) of this section [designation of a national marine sanctuary], the Secretary shall consider—...

(G) the public benefits to be derived from sanctuary status, with emphasis on the benefits of long-term protection of nationally significant resources, vital habitats, and resources which generate tourism;..."

Endangered Species Act states that "The Secretary shall designate critical habitat, and make revisions thereto, under subsection (a)(3) on the basis of the best scientific data available and after taking into consideration the economic impact, the impact on national security, and any other relevant impact, of specifying any particular area as critical habitat. The Secretary may exclude any area from critical habitat if he determines that the benefits of such exclusion outweight the benefits of specifying such area as part of the critical habitat, unless he determines, based on the best scientific and commercial data available, that the failure to designate such area as critical habitat will result in the extinction of the species concerned."

....

"COOPERATIVE AGREEMENTS.—In furtherance of the purposes of this Act, the Secretary is authorized to enter into a cooperative agreement in accordance with this section with any State which establishes and maintains an adequate and active program for the conservation of endangered species and threatened species... Such cooperative agreements shall provide for (A) the actions to be taken by the Secretary and the States; (B) the benefits that are expected to be derived in connection with the conservation of endangered or threatened species; (C) the estimated cost of these actions; and (D) the share of such costs to be bore by the Federal Government and by the States;..."

....

"The Committee shall grant an exemption from the requirements of subsection (a)(2) for an agency action if, by a vote of not less than five of its members voting in person—...

(ii) the benefits of such action clearly outweigh the benefits of alternative courses of action consistent with conserving the species or its critical habitat, and such action is in the public interest;..."

Executive Order 12866 of 1983 ("Regulatory Planning and Review") directs federal agencies to perform a benefit-cost analysis (BCA) for any new regulation that has an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities[vii].

Magnuson-Stevens Fishery Conservation and Management Act establishes:

"COMMITTEES AND ADVISORY PANELS.— (1)(A) Each Council shall establish, maintain, and appoint the members of a scientific and statistical committee to assist it in the development, collection, evaluation, and peer review of such statistical, biological, economic, social, and other scientific information as is relevant to such Council's development and amendment of any fishery management plan. (B) Each scientific and statistical committee shall provide its Council ongoing scientific advice for fishery management decisions, including recommendations for acceptable biological catch, preventing overfishing, maximum sustainable yield, and achieving rebuilding targets, and reports on stock status and health, bycatch, habitat status, social and economic impacts of management measures, and sustainability of fishing practices."

....

"Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, shall—...

(13) include a description of the commercial, recreational, and charter fishing sectors which participate in the fishery, including its economic impact, and, to the extent practicable, quantify trends in landings of the managed fishery resource by the commercial, recreational, and charter fishing sectors;

(14) to the extent that rebuilding plans or other conservation and management measures which reduce the overall harvest in a fishery are necessary, allocate, taking into consideration the economic impact of the harvest restrictions or recovery benefits on the fishery participants in each sector, any harvest restrictions or recovery benefits fairly and equitably among the commercial, recreational, and charter fishing sectors in the fishery..."

....

"REGIONAL IMPACT EVALUATION.—Within 2 months after a catastrophic regional fishery disaster the Secretary shall provide the Governor of each State participating in the program a comprehensive economic and socio-economic evaluation of the affected region's fisheries to assist the Governor in assessing the current and future economic viability of affected fisheries, including the economic impact of foreign fish imports and the direct, indirect, or environmental impact of the disaster on the fishery and coastal communities."

Executive Order 13563 of 2011 ("Improving Regulation and Regulatory Review") requires federal agencies to quantify anticipated benefits and costs of proposed rulemakings as accurately as possible using the best available techniques[viii].

Weather Research and Forecasting Innovation Act states that "the Under Secretary— ''(A) may partner with the commercial and academic sectors, non-governmental and not-for-profit organizations, and other Federal agencies; and ''(B) shall, consistent with section 107 of this Act, undertake quantitative assessments for objective analyses, as the Under Secretary considers appropriate, to evaluate relative value and benefits of future data sources and satellite architectures described in paragraph (1)."

NOAA's NAO 216-124 ("Policy on Development and Coordination of Economic Analyses and Statistics for NOAA") establishes that NOAA Line and Staff Offices "should consult with NOAA's Chief Economist during the design phase and schedule follow up(s) as needed for the following analyses:

1. Regulatory Impact Analyses of significant rulemakings (as defined by Executive Orders 12866 and 13563);
2. Economic analyses developed for budget justification, such as economic impact analyses, cost-benefit analysis and return on investment;
3. Economic analyses requested by the Department, Congress, or the Executive Office of the President;
4. Economic analyses developed to support performance measures and the Foundations for Evidence-Based Act of 2018;
5. Any other significant studies, on a case-by-case basis as determined by NOAA leadership."

Appendix 3: Economic Analysis Approaches

Government agencies use two types of economic analyses to assess the effects of government actions on the economy, including investing in R&D: **benefit-cost analysis** (BCA) and **economic impact analysis** (EIA).

BCA is used to assess the economic efficiency of government actions by comparing the resulting benefits and costs to society. **Benefits** are the direct positive effects of an action and **costs** are the direct negative effects including the expenditures associated with the action. For actions undertaken by the federal government, benefits and costs are considered from the perspective of the nation as a whole to determine if the benefits, to whomever they accrue, exceed the costs.

EIA assesses the effects of an action on the economy of a particular region or economic sector, and accounts for direct and indirect effects that can be measured in terms of jobs, income, output, tax revenues, or other metrics. In contrast to BCA, EIA only uses data on the costs of an activity, such as the costs of the resources required to produce an OAR output.

BCA is a broader measure of societal gain. It measures changes in welfare for the nation as a whole, and it can comprise benefits that are measured in market transactions as well as benefits for which there are no markets, such as many of the life-supporting services that ecosystems provide. In addition, BCA considers the opportunity cost of an investment (the loss of benefits that would have occurred if a different investment had been chosen.) When feasible, BCA is preferred to EIA, but it tends to be more data-intensive and requires the application of specialized valuation techniques designed to estimate the willingness to pay for non-marketed goods and services (see Appendix 3).

The following example shows the kind of information that BCA and EIA provide. For simplicity, the benefits presented in the example can be estimated using data available from markets.

Assume that a government-owned R&D lab produces an instrument that increases the navigational precision of aircraft. The intended beneficiaries could be the military, but the technology could also benefit the private sector, where it would generate profits for aircraft operators through reduced operational costs.

The following assumptions are made to simplify this example:

Benefits to the private sector begin on year 3 of the project, when the transition of the technology occurs.

- Private vendors are hired by the lab to make final modifications to the instrument so that it can be installed by private operators in their aircraft. Two vendors offer to make the modifications. Vendor **A** proposes to modify the equipment during the first three years of the six-year project at a total cost of $2.91 million. Vendor **B** submits an identical offer with a price of $4.37 million.
- To make the modifications, the vendors use contractors who live in the same state, where they spend all their contract pay. As a result, the impact of every dollar spent with Vendor **A** or **B** spills over to businesses supported by the contractors when they spend their pay.
- Assume that this **"multiplier effect"** would result in an additional $1.50 in spending within the state. In this case, the magnitude of the multiplier effect would be $2.50 for every dollar spent with either vendor ($1.00 + $1.50 = $2.50).

The hypothetical distribution of societal costs and impacts over the first 6 years of the project are shown below.

Vendor A	Millions of Dollars	
	Cost	Impact
2019	1.00	2.50
2020	1.00	2.47
2021	1.00	2.44
2022	0.00	0.00
2023	0.00	0.00
2024	0.00	0.00
Total	**$3.00**	**$7.41**

Vendor B	Millions of Dollars	
	Cost	Impact
2019	1.50	3.00
2020	1.50	2.96
2021	1.50	2.91
2022	0.00	0.00
2023	0.00	0.00
2024	0.00	0.00
Total	**$4.50**	**$8.87**

In this example, the use of Vendor **B** has a bigger economic impact in the state. However, spending more money than is needed to achieve the same societal benefit is not economically efficient.

To assess economic efficiency, benefits and costs are compared. When these occur at different points in time, the **"time value of money"** needs to be considered. People prefer to receive a benefit in the present rather than delay receiving the same benefit later. Waiting involves risk- "a bird in the hand is worth two in the bush". In addition, money received sooner by the vendors in this example can be invested, yielding an amount that is higher in the future. To account for this, economists use **"discounting"** to estimate the "present value" of benefits or costs incurred throughout a given time period. The **social discount rate** is the rate of time preference for society as a whole.

The tables below show the discounted costs and benefits and the total present value over the first 6 years of the project, using an assumed social discount rate of 3% per year[ix].

Vendor A	Millions of Dollars	
	Cost	Benefit
2019	$1.00	$0.00
2020	$0.97	$0.00
2021	$0.94	$1.89
2022	$0.00	$1.83
2023	$0.00	$1.78
2024	$0.00	$1.73
Total Present Value	**$2.91**	**$7.23**

Vendor B	Millions of Dollars	
	Cost	Benefit
2019	$1.50	$0.00
2020	$1.46	$0.00
2021	$1.41	$1.89
2022	$0.00	$1.83
2023	$0.00	$1.78
2024	$0.00	$1.73
Total Present Value	**$4.37**	**$7.23**

Using these figures, the following benefit-cost ratios (BCR) have been computed as the total present value of benefits divided by the total present value of costs:

Vendor **A** BCR: $7.23 million / $2.91 million = 2.5

Vendor **B** BCR: $7.23 million / $4.37 million = 1.7

Selecting Vendor **A** would be the most economically efficient alternative because the benefit-cost ratio is higher.

Another way to express the relationship between benefits and costs is through the use of a metric that is more commonly used in finance than in economics: **return on investment** (ROI). ROI is computed by dividing net benefits (benefits minus costs) by costs. Using the figures from the tables above, the ROI for these alternatives is:

Vendor **A** ROI: ($7.23 million - $2.91 million) / $2.91 million = 150%

Vendor **B** ROI: ($7.23 million - $4.37 million) / $4.37 million = 70%

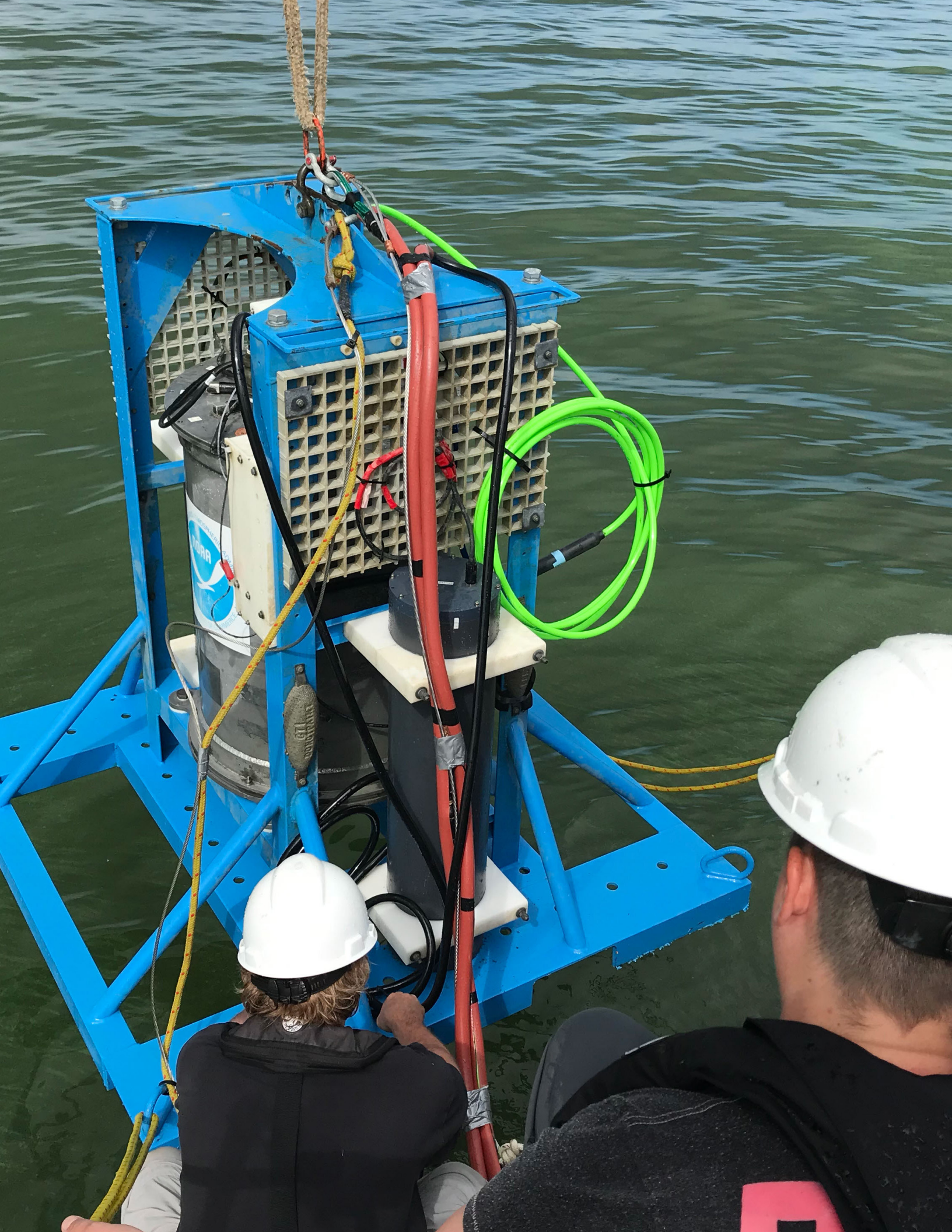
Note that ROI is equal to (BCR - 1). Both metrics result in the same efficient alternative.

Sources:

Haveman, R., Weimer, D.L. (2001) Cost-Benefit Analysis. In: Smelser, Neil J., and Paul B. Baltes, eds. *International encyclopedia of the social & behavioral sciences*. Vol. 4. Amsterdam. pp 2845-2851.

US Environmental Protection Agency (2011). Handbook on the Benefits, Costs and Impacts of Land Cleanup and Reuse. EPA-240-R-11–001.

Watson, P., Wilson, J., Thilmany, D., Winter, S. (2007) Determining economic contributions and impacts: What is the difference and why do we care? *Pedagogy in Regional Studies* 37: 140-146.



Appendix 4: Categories of Societal Benefits from OAR Outputs and Examples of Methods and Applications[X]

Benefit Category	What is measured	Examples of beneficiaries	Example of benefits valuation methods	Key data needs	Example from the literature	Value	Authors, year
Information and technology benefits	Increased business productivity and profits Estimated damages avoided with available information	Agricultural producers Commercial fishermen Communities along the path of a storm	Production functions Damage functions	Levels of investments in R&D Changes in Productivity Value of output Model that predicts outcomes that would have resulted without information	Economic benefits of public R&D spending in agriculture	Raising public R&D spending by 3.73% annually would increase U.S. agricultural output by 73% by 2050.	Heisey, P., et al., 2011 [xi]
Human capital formation	Incremental income or profits	Training program beneficiaries	Capital earnings functions	Salary or profits of program participants before and after program Labor market experience of program participants Other education and trainings of program participants	Increased profits from fish farming	Fish farming profits in Egypt were US$2,000/ha higher (1.8 times higher) if farmers received training in aquaculture best management practices.	Dickson, M., et al., 2016[xii]

Benefit Category	What is measured	Examples of beneficiaries	Example of benefits valuation methods	Key data needs	Example from the literature	Value	Authors, year
Consumptive value	Incremental income or profits Willingness to pay for additional resource use	Commercial, recreational, and subsistence fishermen	Production functions Contingent Valuation	Rate of resource use under different scenarios of resource quality and/or quantity Stated-preference methods, such as contingent valuation, use an interview setting to collect information on willingness to pay and socioeconomic characteristics of respondents.	Economic value of harmful algal bloom (HAB) prediction in the Gulf of Maine	Availability of HAB prediction allows shellfish fishermen and managers to make better decisions that can save the industry up to US$3.3 million annually	Jin, D., Hoagland, P., 2008[xiii]

Benefit Category	What is measured	Examples of beneficiaries	Example of benefits valuation methods	Key data needs	Example from the literature	Value	Authors, year
Cultural value	Changes in the use or in the costs of accessing ecosystems for leisure, aesthetic inspiration, or cultural identity.	Recreational users of beaches People who ascribe spiritual value to landscapes and seascapes	Choice modeling Travel cost	Stated-preference methods, such as choice modeling, use an interview setting to collect information on willingness to pay and socioeconomic characteristics of respondents. The travel cost approach, a revealed preference method, estimates the economic value of benefits by using data on the costs of reaching a destination and the points of origin of the visits.	Recreational benefits of reducing marine debris	Activities and technologies that would reduce marine debris on beaches in Orange County, California, would result in benefits of $13 per resident in a three-month period if debris were reduced by 25% to $42 per resident if debris were reduced by 75%.	Leggett, C.G., et al., 2018[xiv]

Benefit Category	What is measured	Examples of beneficiaries	Example of benefits valuation methods	Key data needs	Example from the literature	Value	Authors, year
Non-use value	Willingness to pay for the existence of a natural or man-made asset or for the option of benefiting from it in the future	People who value pure knowledge per se, without any actual use of it.	Contingent valuation	Stated-preference methods, such as contingent valuation, use an interview setting to collect information on willingness to pay and socioeconomic characteristics of respondents.	Large Hadron Collider (Switzerland)	Non-use value was estimated at €3.2 billion (US$3.5 billion) for a 30-year time horizon	Florio, M., et al., 2016[xv]

Appendix 5: The NOAA Research and Development Database (NRDD) as a Strategic Tool to Support Economic Valuation

The NOAA Research and Development Database (NRDD) is a web-based tool that is designed to house project management data for projects conducted by NOAA and its partnerships. It currently contains more than 3,000 project records[xvi].

The NRDD has multiple objectives:

- Facilitate the sharing of information to improve communication, collaboration, coordination, planning, and integration across NOAA and decrease project redundancy.
- Identify, track, and facilitate R&D transitions (the process of taking a project from its concept phase to maturity and societal applications).
- Strengthen the linkages between strategy and execution and across Line/Staff Offices.
- Provide corporate reporting of performance (as mandated in the reports for Government Performance and Results Act (GPRA), Annual Performance Plan (APP), Annual Operating Plan (AOP), and other ad-hoc requests).
- Plan and track execution and evaluation of progress.
- Track project funds with the source of funding.
- Identify, assess, and mitigate risk.
- Capture trends in R&D investments.
- Enable portfolio awareness for characterizing and balancing NOAA's R&D portfolio.

The NRDD provides a potential repository for information that is needed when framing a valuation study and communicating the results to a wide audience:

Scoping: The Project Description section contains fields for entering the project benefits and outcomes. This can be written in a way that provides clear information for answering the Scoping questions on what is the target population(s) and what are the expected changes that the project (output) will bring. The project records also contain information on the project's Readiness Level, as well as estimates of the general investment in the project.

Planning and Valuation: Project records can help identify some of the stakeholders of a valuation (there is currently a field for project stakeholders, some of which may also be valuation stakeholders). For economic valuation projects, the NRDD is a potential repository for raw data, spreadsheets, and other materials developed in support of the project.

Economic valuation projects can be identified by using a check mark in the Project Description section. A note should be added to the original project (the project describing the output) to make users aware that the project is being valued.

Application: The NRDD allows creating linkages between a project and the following strategy documents: Department of Commerce New Strategic Plan (2018-2022), Department of Commerce Strategic Plan 2014- 2018, NOAA Next Generation Strategic Plan, and NOAA 5-Year Research and Development Plan 2013-2018.

The Application stage can also include adding the final valuation report and other communication documents to the project's records in the NRDD. Valuation results will thus help build the knowledge base that can be used in the Scoping stage of future valuation projects.

For the NRDD to become an integral part of the economic valuation of OAR portfolios, several key challenges would need to be addressed[xvii]:

- There is currently incomplete and inconsistent data entry.
- Compliance to enter mandatory data fields is limited.
- The NRDD does not represent OAR's full portfolio of projects. Special considerations may be needed to include more inter or multi-disciplinary projects, in addition to more research projects from the social sciences.
- Observing/monitoring systems (or other data-generating systems) that are part of operational, administrative, or other activities that support other projects are not entered as projects in the NRDD.

To advance the NRDD's contribution to future economic valuations, it is suggested that OAR and the Chief Economist's team work with the NRDD management team to make the following basic enhancements:

- Refine project keywords and provide guidance for data entry so that projects that encompass any aspect of the economic value and/or economic impact of OAR outputs are clearly identified.
- Indicate if there are value-chain linkages to outputs generated by other NOAA offices. For example, the Partners section of the Project Description could contain a text box in which the relationship between partners is explained (who does what).
- In the Project Transition Information section, request a description of the "state of the world" without the OAR output. For example, for weather forecasting models that improve farmer decisions, what is the current model that generates forecasts, and what are the expected qualitative or quantitative differences in the quality of the forecasts.

Any additional requests for data entry will be accompanied by a detailed description and examples of the type of information that is requested. These are being produced by the Chief Economist's team.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Glossary of Economic Terms

Benefit-Cost analysis: A process used to estimate the equivalent money value of the benefits and costs to society of activities, projects, programs, or policies.

Benefit-Cost ratio: A figure that is used to summarize the relationship between benefits and costs. It is equal to benefits divided by costs. If the ratio greater than one, the activity, project, program, or policy is expected to deliver positive economic benefits to society.

Economic externalities: The effects on profits or costs beyond those of the agent that generates the activity or project. The externalities considered in this report are positive, such as increased profits in the private sector that result from R&D produced by a public agency. Another example of externalities are the benefits of habitat restoration projects that are implemented in a specific place and are often funded, at least in part, by state or local governments. However, the benefits of such projects often extend far beyond the jurisdiction that pays for the project. This can lead to under-investment in habitat restoration when the benefits to the funding jurisdiction are less than the costs, even though the total benefits of the project are greater than the costs, with the remainder of benefits accruing to "free riders."

Economic impact analysis: A methodology for evaluating the impacts of an activity, project, program, or policy on the economy of a specified region or on a specific sector of the economy. It is useful to study impacts on the production of goods and services and jobs.

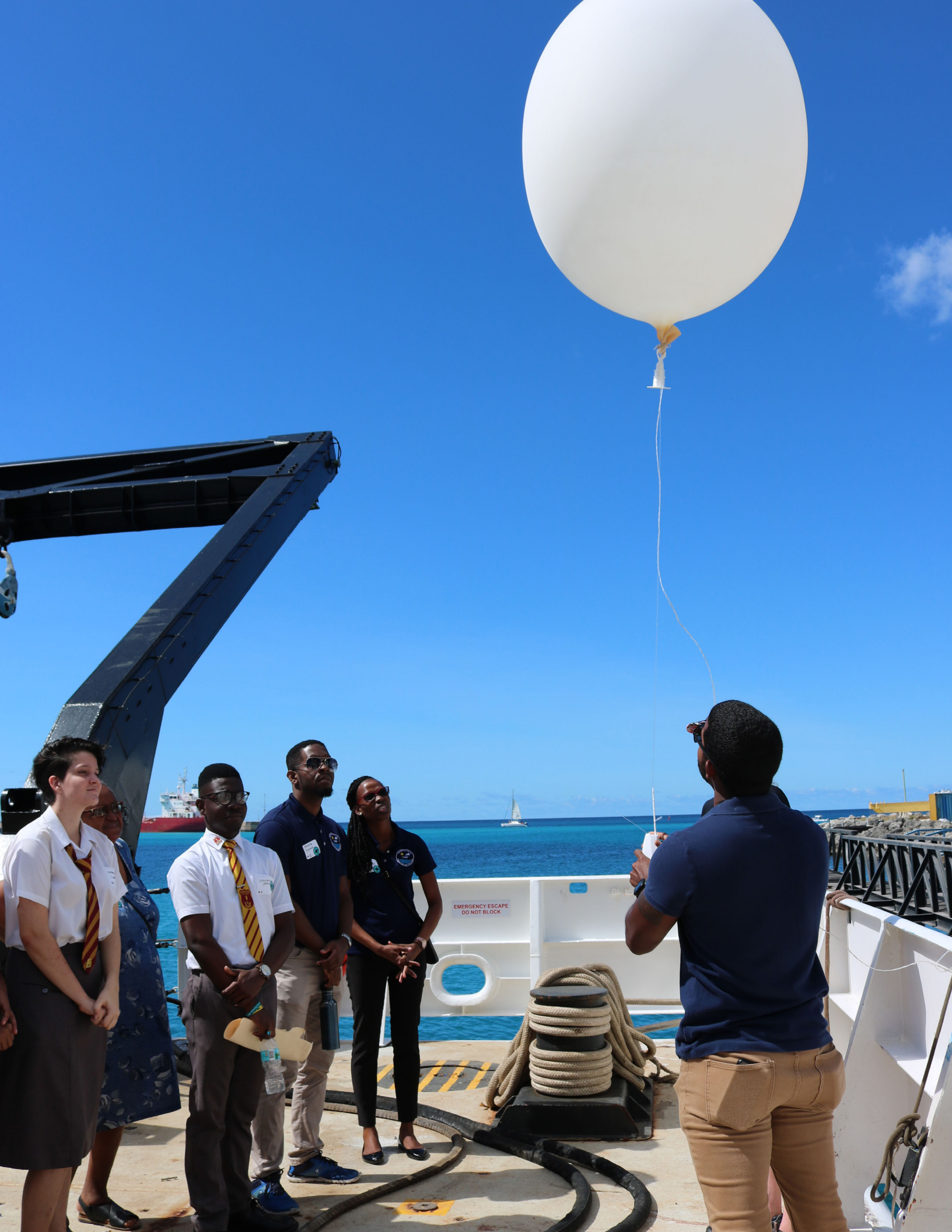
End-user: A party that receives a benefit (e.g., cost-reductions or productivity gains). End-users could be other Line Offices within NOAA.

Multiplier effect: The phenomenon whereby the spending that is done in a region on an activity, project, program, or implementing a policy is "multiplied" across the region as money is subsequently spent by its recipients.

Return on investment (ROI): The ratio between the net benefits (benefits minus costs) and the costs of an activity, project, program, or policy. It is used to express the gain or loss generated on spending an amount of money relative to the amount of money that was spent.

Social discount rate: A factor used to express the trade-off that society is willing to make in order to receive benefits today versus sometime in the future.

Stakeholder: Any party, including NOAA Line Offices and end-users of an oar output, who has an interest or stake in the results of an economic valuation.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Notes

[i] Categories were modified from Florio, M., Forte, S., Sirtori, E. (2016) Forecasting the socio-economic impact of the Large Hadron Collider: A cost-benefit analysis to 2025 and beyond. Technological Forecasting and Social Change 112: 38-53. The grouping of benefits into five broad categories was done for conciseness. Many other taxonomies are used in the literature.

[ii] A NOAA-wide conference to highlight the benefits and potential applications of the NRDD, and to provide training to data enterers, has been discussed as a possible platform to increase the database's visibility.

[iii] In combination with standard ocean observations, the assimilation of salinity and temperature data collected by gliders has been shown to improve forecasts of hurricane intensity. See: Dong. J., et al. (2017) Impact of assimilating underwater glider data on Hurricane Gonzalo (2014) forecasts. Weather and Forecasting 32: 1143-1159.

[iv] This guidance is available at https://seagrant.noaa.gov/Portals/1/Network%20Resoruces/Economic%20valuation%20guides/All%20Methodology%20Guides.pdf?ver=2019-07-11-133941-713.

[v] The review included webinars in which the principal investigators of five of the recently funded projects provided updates on their projects.

[vi] A protocol for estimating optimal sizes in Contingent Valuation is provided in https://publications.iadb.org/en/publication/11437/optimal-sample-size-contingent-valuation-surveys-applications-project-analysis and

[vii] Taken from EPA (2010, updated in 2014) Guidelines for Preparing Economic Analysis at https://www.epa.gov/sites/production/files/2017-08/documents/ee-0568-50.pdf and an EPA summary of this regulation at https://www.epa.gov/laws-regulations/summary-executive-order-12866-regulatory-planning-and-review.

[viii] Taken from an EPA summary of this regulation at https://www.epa.gov/laws-regulations/summary-executive-order-12866-regulatory-planning-and-review.

[ix] For regulatory purposes the Office of Management and Budget (OMB) uses 3% and 5% discount rates (https://www.reginfo.gov/public/jsp/Utilities/circular-a-4_regulatory-impact-analysis-a-primer.pdf).

[x] Categories were modified from Florio, M., Forte, S., Sirtori, E. (2016) Forecasting the socio-economic impact of the Large Hadron Collider: A cost-benefit analysis to 2025 and beyond. Technological Forecasting and Social Change 112: 38-53. The grouping of benefits into five broad categories was done for conciseness. Multiple other taxonomies are used in the literature.

[xi] Heisey, P., et al. (2011) Public Agricultural Research Spending and Future U.S. Agricultural Productivity Growth: Scenarios for 2010-2050. Economic Brief 17, U.S. Department of Agriculture, Economic Research Service.

[xii] Dickson, M., et al. (2016) Increasing fish farm profitability through aquaculture best management practice training in Egypt. Aquaculture 465: 172-178.

[xiii] Jin, D., Hoagland, P. (2008) The value of harmful algal bloom predictions to the nearshore commercial shellfish fishery in the Gulf of Maine. Harmful Algae 7: 772-781.

[xiv] Leggett, C.G., et al. (2018) Assessing the economic benefits of reductions in marine debris at Southern California beaches: a random utility travel cost model. Marine Resource Economics 33: 133-153.

[xv] Florio, M., Forte, S., Sirtori, E. (2016) Forecasting the socio-economic impact of the Large Hadron Collider: A cost-benefit analysis to 2025 and beyond. Technological Forecasting and Social Change 112: 38-53.

[xvi] "Project" as defined in the NRDD is synonymous with "R&D outputs", as used in this document.

[xvii] See https://researchprojects.noaa.gov/Welcome/Information/About for a discussion of these challenges. Although these challenges persist, steps are being taken to address them. For example, NRDD offers training on data entry, and a Community of Practice for data enterers is being created. In addition, video tutorials are being produce on completing the different sections of project descriptions.