

## ***Interactive comment on “Assessing economic impacts of environmental research infrastructures: overview of methodological tools” by Régis Kalaydjian***

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General Comments \_\_\_\_\_

I carefully reviewed your paper together with my colleague Kim Juniper, Chief Scientist, Ocean Networks Canada. These comments reflect our combined reactions.

We found your paper to be thought provoking and topical. The issue of assessing economic impacts of ENV RIs is important, as many organizations struggle to justify the investments required to establish and maintain their facilities. Improved methodologies for estimating economic impact will be of great interest to the operators of ocean ob-

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serving facilities in many countries, since public money is often critical for continued operations.

A primary issue that stood out was the treatment of ENV RIs as purely operational facilities. Many (all?) big science infrastructures address both basic science and applied applications. For example, a large part of what our facility (Ocean Networks Canada) does is in support of basic science; there may be some eventual spillover into forecasting or hazard mitigation, but the emphasis is on supporting the basic research community, not the operational community. Also, many large infrastructures support educational audiences and outreach activities. This is especially the case with ENV RIs that are housed within the higher education sector, as opposed to public sector (government) operated programs.

We noted with interest, the author’s observation that “the decision over how much to invest in an ENV RI development project depends on its present and expected economic value.” Perhaps, despite the basic research focus for many ENV RIs, there is a tacit underpinning of anticipated economic return, in terms of improved forecasts or reduced societal risks. Another assertion that caught our attention was the “development of ENV RIs is mainly motivated by environmental risks and the need for improved observations and efficient forecast.” Our first reaction was that this is not always the case – for example, with BGC Argo or Deep Argo, how much of the resulting data gathered translate directly into improved forecasts? We felt the question of dual use (basic and applied), could be expanded on in your paper. However, we recognize that estimating the potential economic benefits stemming from basic science research is likely much more difficult. This is an area where non-economic metrics (e.g. research impact, facility efficiency & reliability, society/community/policy impacts) may be come into play. But for the purpose of your paper, perhaps that part of the equation could be set aside. Since your focus is on forecasting and risk reduction benefits, we wondered if it may be useful to consider subdividing costs between research/education vs. operational applications for your cost-benefit analysis (CBA)?

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We were also hoping to see something more from your CBA discussion. You introduce different methodologies and discuss some example applications in the marine sector. But we would have liked to see your recommendations of best approaches to CBA for the Argo example. In addition, an order-of-magnitude CBA for Argo would be of great interest, if within scope for this paper.

Specific Comments \_\_\_\_\_

P2, lines 13-17: Discussion focusses only on forecast uses of data, while data archival for long-term studies or applications is also an important responsibility for ENV RIs. Proper management of archival and data access systems requires significant personnel and technology investments.

P2, lines 18-21: Here is a place where you could expand on the discussion of “dual-use” nature of ENV-RIs.

Section 2.1.1: Please include Deep Argo in your list of Argo platforms. Also, you mention the initial objective and float increase rates, but we would like to see the current total count as well.

P3, line 10: In addition to the platforms you mention, there are in-situ observing systems, both autonomous and cabled.

P3, line 14: Satellite systems play 2 distinct roles: communications satellites acquire the telemetered data from ocean observing platforms, while environmental observing satellites acquire remote sensing data from the ocean.

P3, line 23: Would like to see a summary statement explaining that analyzing Argo’s economics impacts in isolation does not capture the full up- and downstream benefits deriving from the combined applications of these different observing systems.

P4, line 14: We note that many geologic, habitat, marine chemistry, and biological data products are not developed for forecast-specific or operational audiences.

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P3, line 24: You note that most suppliers or government owned or funded entities, it would be good to somehow indicate in Figure 5 which parts of the system are in which sectors.

P5, line 10: You mention Brazil and Canada – are these included in AtlantOS? Please revise sentence to explain more clearly.

Section 3.1.3: Costs reflect purchases only, but in our experience, there are also significant costs associated with maintenance (recovery, refurbishment, recalibration, re-deployment). These generally exceed the initial purchase costs, but could perhaps be accounted for by the facility’s operational budget.

P8, line 13: You discuss instrument inventories, however infrastructure costs are not included. In the case of some ENV RIs, infrastructure costs can greatly exceed instrumentation costs. But, perhaps this is not a significant cost factor for Argo.

Section 3.2.1: You introduce DAC/GDAC KPIs and complementary sources of KPIs. This could represent a study topic in itself (would be of interest to us), since different ENV RIs use different and sometimes widely varying KPIs. In the case of our facility, we focus on measurements to estimate research impact, facility efficiency & reliability, and societal impacts such as inter-organizational collaborations and influences on public policy.

P14: As mentioned above, we would like to see a stronger and more comprehensive conclusion to section 3. What is the take-home message of this section of your paper? Could you offer your assessment of the best approach to CBA for the Argo example? In addition, an order-of-magnitude CBA for Argo would be of great interest, if within scope for this paper.

Figure 1: Equipment supply industry is included, but not the significant contributions of the deployment and maintenance industry, including ships, remotely-operated vehicles, etc. Figure caption needs to be expanded – all figures must be stand-alone, so the

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caption explains everything needed to understand the figure.

Figure 2: Figure caption needs to be expanded – all figures must be stand-alone, so the caption explains everything needed to understand the figure.

Figure 3: Figure caption needs to be expanded – all figures must be stand-alone, so the caption explains everything needed to understand the figure.

Figure 5: We find the diagram complicated to understand. The flow from Argo to DAC to end users is not very clear in the diagram. Would like to see the main flows emphasized. Is archive only at NODC, nowhere else? Also, as mentioned above, if sector (public/private) distinctions are important to your discussion, these should be indicated in the diagram. Which parts of these system incur costs or produce benefits that are accounted for in your CBA discussion?

Figure caption needs to be expanded – all figures must be stand-alone, so the caption explains everything needed to understand the figure. Thus, “Schematic representation of the Argo data flows from . . . . to . . . ., including . . . .”

Table 1: There are a lot of blank cells in this table and we find it difficult to compare across areas. If US data are not available, it might be preferable to leave that column out entirely. We would like to see updated 2019 or 2018 economic data in this table. Suggested title: “Argo Programme Costs.” Perhaps you could simplify this table by combining all categories (core, deep BCG) under each of the three areas. Could you extend the workforce FTE numbers across all three areas?

Table 2: We would like to see more up-to-date data if available.

Figure 6: Figure caption needs to be expanded – all figures must be stand-alone, so the caption explains everything needed to understand the figure.

Table 4: Suggested caption: “Four examples of cost benefit analyses of observing infrastructures used for ocean forecasting and climate monitoring.” Please explain or spell out all acronyms.

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#### Technical Corrections \_\_\_\_\_

There are numerous small grammatical errors in the text, for example the usage of “forecast” when “forecasting” or “forecasts” is preferred. Another example is the use of “scale” when “scales” is often preferred. We suggest you have the paper edited by a skilled English editor to eliminate these small errors and improve the readability.

P2, line 20: “. . . observations and accurate forecasts.”

P2, line 25: “. . . observations at a global scale. It operates a growing array. . .”

P3, line 12: instruments are not just being mounted on marine mammals, so “animal-mounted instruments” instead of “sea mammal born.”

P6, lines 3-4: “. . . instruments, airborne or waterborne platforms, data transmission technology, but also. . .”

P7, line 26: “Where information on. . .”

P8, line 8: “. . . Nation Centre for Scientific Research.”

P8, line 30: “. . . latter; in such cases, the resolving power of the available information is critical to appraising the. . .”

P9, paragraph 1: “observational” data not observation data; “evaluate” performance rather than value

P10, line 7: “. . . and forecasting rely on. . .”

P10, line 14: “Forecasts are the outcome of . . . by comparing forecasts to natural runs.”

P10, line 18: At “the global scale” or At “global scales”.

P11, line 17: “While RMSD is used as a key statistic for. . .”

P 14, line 10: “. . . observation and forecasting is therefore considered beneficial. This conclusion is limited by the fact that the scenarios. . .”

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P14, lines 22-24: “Problematically, the two above conditions. . .CBAs are designed to meet immediate needs for making decisions. . .”

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