Report of study on Support Provided to Global and Regional Ocean Observing Systems

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Support Provided to Global and Regional Ocean Observing Systems

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Executive Summary

This study was commissioned to assess the efficacy of support arrangements for global and regional ocean observing systems. The support included, but was not limited to offices established to support the observing system or its components; offices supporting specific domains, networks or platforms; committees, expert teams and other groups assisting in the development of strategy, plans, coordination and implementation; technical coordination; and activities and people supported through intergovernmental arrangements.

This study specifically examined the form and function of present support arrangements, including requirements and resourcing, and considered strategic options for the future. Evidence for the study was drawn from publications on observing system governance, decisions of the Intergovernmental Oceanographic Commission, and from surveys and interviews with stakeholders (over forty in total).

The Report provided twenty-five findings and nine recommendations. From an historical perspective, the Report noted that it may have been unwise to establish a permanent model for the Global Ocean Observing System and its supporting structure at inception without first fully testing the fitness and sustainability of that model and structure. Fundamental issues remained and we now have both confused governance and stressed supporting arrangements. Major growth in observational assets and in the ocean observing community attested to the actual and potential interest in ocean observing and related activities, but this growth has not been accompanied by robust integrated support arrangements.

The study introduced a new framework for understanding and developing support, built around tiered levels of support and primary asset classes centred on (a) observations, (b) data and information management and (c) production and forecasting. Applications and services were identified as a possible additional class.

Recommendation 1. *The GOOS community should reconsider its structure within the governance discussions, aligning GOOS uniquely with ocean observation activities, and recognizing a Global Ocean Information System and a Global Ocean Processing, Modelling and Forecasting System as the two other elements of a world ocean system.*

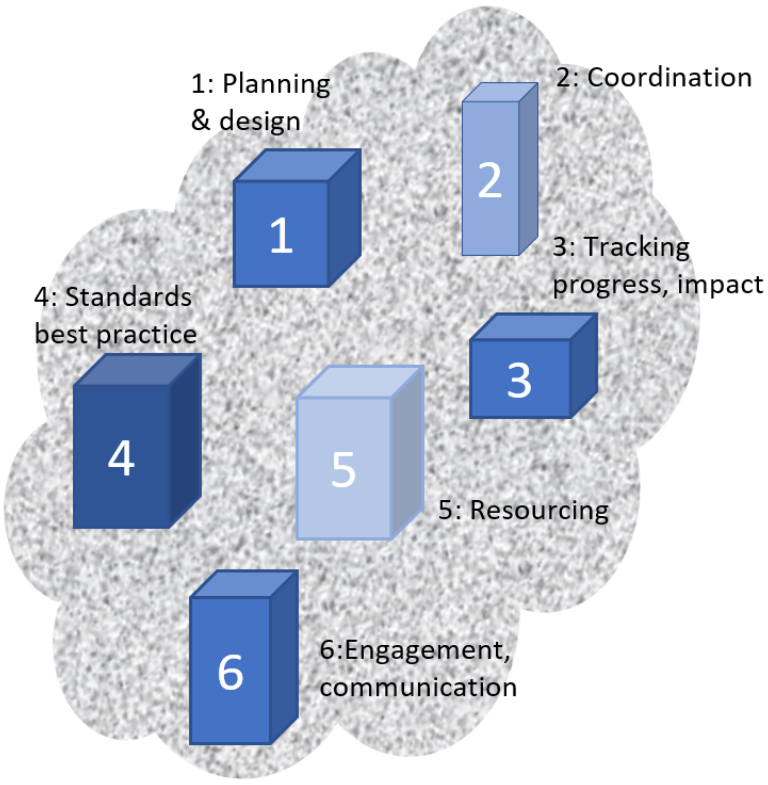
The tiered levels ranged from global high-level planning, coordination, and strategy (Level 1) to national activities at level 4. Level 2 was arranged around asset classes and domains, while Level 3 included networks of various forms. There were around 53 full-time equivalent staff who worked across the three upper levels of support.

The survey and interviews revealed pockets where the support structure was seen to be working well and served requirements, but elsewhere, performance and achievement were less satisfactory

and uneven, in part through lack of resourcing, but also in part because the support was fractionated, disconnected and complex (Finding 1). The efforts of individuals and agencies who contributed support were recognized and welcomed but there were also heavy workloads, short-term outlooks, and unreasonable expectations in terms of delivery (Finding 2). Support was found to be effective in some areas but in general had not met expectation (Finding 3).

The efficiency of the support structure was compromised by the fragmented approach and insecure lines of support, particularly in core areas (Finding 4). There were gaps, specifically around data systems and model/production systems, and the interface to national activities and users was poorly served (Finding 5). Upward impact, into UN conventions and related fora and into national policy and decision-making arenas was also poor; The system of national GOOS focal points appeared dysfunctional (Finding 8).

The support arrangements for global and regional ocean observing systems were poorly documented with no record of operational expenditure or volunteer/in-kind efforts. Unmet requirements were often partially picked up by the latter (volunteers), partially masking the extent of the gap for core priority functions (Finding 6). There were no master plan or agreed priorities across GOOS, or the ocean observations community more generally, which led to confusion around roles, responsibility, accountability, leadership, and cross-support system engagement and coordination (Finding 7, Finding 9). The study proposed six pillars (primary objectives) for support (Figure 4, and below).



Recommendation 2. *A plan for rejuvenating national engagement should be developed, including for communicating progress with all parts of the support structure. Communiques should be issued*

immediately upon the conclusion of any major activity (e.g., Committee or Panel meetings) to inform stakeholders of areas of discussion and decisions to create a sense of timely action. Such activity was at best only partly resourced as part of the present support structure.

This study found that (i) planning and coordination, (ii) vision and strategy, (iii) creation and maintenance of standards, and (iv) coordination and support for activities were ranked highest among the required support (Finding 10). Capacity building, education and training were found to be important, and thus prioritised, but this study concluded that while needs should be determined by the ocean observations community, they should be met specialised groups externally (Finding 11).

The mobilization of resources and investment for support should be managed in a more strategic way, with greater focus on the whole, rather than on the many different individual actions spread over Level 1, 2 and 3 activities (Finding 12, Finding 20). Business cases/proposals for assets should be developed and argued at the national and regional level, not by the system support structure (Finding 13).

The study likened the present form to a hub-and-spoke model, with one hub arranged around GOOS, and secondary hubs and other centres of action located on the spokes. The weakness of the spokes (poor connectivity) and the lack of clarity around the relative responsibilities of hubs blunted the effectiveness of the model (Finding 14, Finding 15). The study concluded regional engagement and support must be prioritised (Finding 23).

Recommendation 3. *Regional networks should be recognized as part of the support structure when and where they offered advantage and value for implementing the six pillars of the support strategy* and for regional user/societal engagement.

The present form of support arrangements for global and regional ocean observing systems lacked authority, clarity and transparency, and its effectiveness and efficiency were determined to be unsatisfactory for many stakeholders. For some the current form was not investible (Finding 16). While the values brought to the structure by the intergovernmental partners were highly regarded, many believed the ocean observing system would not prosper if it remained wholly within the current intergovernmental support structure. A hybrid hub-and-spoke model was favoured (Finding 17).

Several gaps were identified though some were best considered as governance issues. The more urgent gaps were around (i) coordination support for data management assets; (ii) support for implementation beyond the scope of the former JCOMM; and (iii) technical support for emerging areas similar to that provided by OceanOPS (Finding 18).

The current arrangements for resourcing and investment were problematic, with issues of prioritisation and misalignment; mismatches between the mission and ambition and available resources; insecurity among the people; and resources spread too thinly (Finding 19). Resourcing and investment should be managed in a more strategic way (Finding 20).

The community has not developed a persuasive case and narrative to support investment in the support structure (Finding 21). Current investors/partners generally believed they were getting good value, but several identified difficulties with the mechanics of making contributions (Finding 22). The

study concluded support from the regular budgets of IOC and WMO was likely to remain flat in real terms, at best, so other avenues must be explored (Finding 24). The gap in support could not be quantified at this time. The framework of this study should be used to develop a budget outline (Finding 25).

The study examined the role of research and associated support and concluded it should not be coordinated within the support structure. However, the links to research were important at Levels 2 and 3 and in terms of research as a user. The study further concluded that a balanced approach was needed, with the need for research infrastructure recognized alongside operational users on the output side, and research- and operationally supported contributions acknowledged on the input side.

Recommendation 4. *Experimental and ad hoc research contributions to observations, data and information management and modelling and forecasting should be recognized, but not necessarily coordinated through the support structure. Research use of products and system services should be captured in the user and uptake strategy.*

Engagement and dialogue with users remained a work in progress, despite the emphasis in the FOO and in the GOOS Strategy. There were instances where the end-to-end chain was managed well (for example, CMEMS and EuroGOOS in Europe; IMOS in Australia; IOOS in the USA) but the community lacked an effective overall strategy. Such a strategy should build from the instances where it was managed well using, for example, real case studies and testimony from existing users. Consideration should be given to developing a (virtual) champions or reference group as a focus for this work.

Recommendation 5. *A plan for show casing user uptake and energising the dialogue and engagement with the user community more generally should be developed. Such an activity was presently not resourced as part of the* support structure.

We have suggested that capacity building education and training requirements should be identified, but that a bespoke capability should not be built into the architecture of the framework for support. However, its absence from the proposed support structure was likely to be a concern for some. Many correspondents stressed its importance but were less clear on how it should be resourced or organised.

Recommendation 6. *A small study group should be formed from the major supporters of capacity building, education, and training to provide guidance on how activities should be identified, prioritised and executed within the framework of support.*

The study outlined some of the main elements of the support structure, using assets and asset classes for organisation, and tiered levels to reflect the different priorities as we moved from high-level global strategy and coordination to networks and national efforts/plans. Further development of the architecture should be undertaken as a matter of priority. An issue that needed to be addressed was the place of applications and value-added services. Recommendation 5 emphasised the importance of user engagement but does not explicitly recommend coordination of such activities.

Recommendation 7. A high-level description of the architecture of the ocean system should be developed and put out for public comment and feedback. The architecture should include clearly delineated observation, information and data management, and production and forecasting elements and a virtual 'cloud of support' that ensured it operated effectively as a system, with effective connectivity internally and externally.

Options for future support structures were provided. Option 1 was business as usual but reinforced (act on recommendations that can be implemented without regret), while Option 2 is effectively a stand-by option, dependent on guidance from other governance discussions.

The third option provides a major reset of the support structure, with a renovated and rejuvenated hub-and-spoke model. A strategy for support should be developed, using the primary pillars (strategic goals) identified through this study as a starting point:

(1) Planning and design
(2) Coordination
(3) Tracking progress and impact
(4) Developing, setting, and maintaining standards and best practice
(5) Resources and Investment
(6) Engagement and communication

For each pillar, a set of primary actions should be agreed. These actions should focus on change, not business as usual. The changes should be aimed at making the support system more responsive; more purposeful; achieve greater clarity around objectives; more transparent; achieve greater efficiency and effect/impact; more adaptable; improve sustainability; support authoritative processes; and/or improve performance and accountability.

Recommendation 8. *The framework for support should be further developed, along with a 5-10-year strategy based on the guidance provided in this Report.*

The Decade does provide an opportunity for such a transformation by 2025.

Recommendation 9. *The community supporting relevant ocean activities should be engaged to renovate and rejuvenate the current hub-and-spoke arrangement, consistent with whatever changes in governance that might be agreed elsewhere and following the other Recommendations and Findings of this Report. The change should be in place by 2025 and follow the roadmap outlined in this* study.

Support Provided to Global and Regional Ocean Observing Systems

1. Background

1.1. Introduction to this study

Despite several reforms of the Global Ocean Observing System (GOOS) since its launch in March 1991, the System continued to experience challenges and the level of support appeared well-short of what was required[1]. The Eighth Session of the GOOS Steering Committee[2] held a special session on ocean observing governance and considered principles and governance options[1]. In parallel, a separate study examined the challenge of sustained ocean observing[3], driven by an earlier Report from the US National Academies[4]. Lead authors of those studies also participated in a side session held at OceanObs'19 and several side events have been held since.

A theme running through those discussions and discussions elsewhere was that the level of support for the ocean observing system falls short. To quote one[1], there are "sub-optimal financial and management support levels for many of the [GOOS] efforts". However, none of the above-mentioned studies or others in the published and grey literature provided evidence or further analysis in relation to support arrangements.

This study was commissioned to address that gap; the terms of reference are provided in Attachment 1. It was recognized that governance discussions were on-going and not likely to conclude and/or lead to major change in the short-term, which created an immediate challenge for this study to look at support arrangement for current and future ocean observing activities. Reasonable assumptions were made about future arrangements and options provided as appropriate.

The current project was not a review of the GOOS Office, an Office that is part of the Intergovernmental Oceanographic Commission secretariat, though to the extent the study shed light on the adequacy and effectiveness of current arrangements, there will be implications for the Office. The current Terms of Reference of the GOOS Office date back to 1997/98 when an MoU for cross-sponsorship of the GOOS Steering Committee was agreed (see Attachment 2).

The next section 1.2 provides a short discussion of current and possible future governance arrangements, and this is followed by the presentation of a framework for describing and implementing support. A short description of the methodology of this study follows in section 1.4. Section 2.1 discusses the strengths and weaknesses of current arrangements, based on stakeholder discussions. Section 2.2 provides an analysis of the requirements (needed functionality) and section 2.3 analyses the form of current support arrangements and offers conclusions with respect to

[1] See for example, Tanhua et al (2019)

[2] GOOS SC 2019

[3] Weller et al (2019); https://doi.org/10.3389/fmars.2019.00105

[4] National Academies of Sciences, Engineering, and Medicine (NASEM), 2017)

possible future arrangements. Section 2.4 examines resourcing and investment and the barriers and roadblocks to improving present arrangements. Section 3 summarises the conclusions and provides transformation options for strategic change. Closing remarks are provided in section 4.

1.2. Governance frameworks of ocean observing activities

1.2.1. A short history

While the history of ocean observing dates back to the middle of the 19th Century (marine observations to support merchant sailing vessels in the North Atlantic), the roots of the current systematic approach lie in several global research experiments conducted during the last decades of the 20th Century:

- The First GARP Global Experiment (FGGE) during the 1970's.
- The Tropical Ocean-Global Atmosphere (TOGA) program[5] 1985-1994
- The World Ocean Circulation Experiment[6] 1990-1997
- The Joint Global Ocean Flux Study 1987-2003

These pathfinder initiatives provided the basis for early observing system design studies[7] and encouraged the formalisation of a global ocean observing system in 1991[8]. The early governance structure comprised an intergovernmental part (I-GOOS) and a Technical and Scientific Advisory Panel, known as J-GOOS. A GOOS Support Office was also established. J-GOOS reflected some of the governance experience from TOGA and WOCE with the GOOS Support Office playing a similar role to the Offices that supported those research programs. In hindsight it can be argued that the establishment of a permanent Office and governance arrangement, and the drawing of parallels with operational systems supported by WMO, was premature; from the outset there was little opportunity to grow and expand inside UNESCO/IOC, even with the strong support provided by Member States and WMO. A pilot arrangement may have worked better, recognizing that both the governance and secretariat support arrangements needed to be tested and structured in a way that they could evolve as the participation in the system and needs grew.

These arrangements were modified in 1998 under the MoU signed by IOC, WMO, UNEP and the then ICSU for the co-sponsorship of the renamed GOOS Steering Committee; the terms of reference for the GOOS Secretariat were annexed to the MoU (see Attachment 2) and remain in place, despite several further changes to governance arrangements[8, 13]. The terms of reference noted the primary functions are to "assist in the promotion, planning, coordination and implementation of GOOS" and elaborated further on some of the detailed functions. In keeping with its status as a Secretariat, the

[5] McPhaden et al (1998): The TOGA observing system: A decade of progress. https://doi.org/10.1029/97JC02906

[6] See Siedler et al (2001)

[7] E.g., Nowlin et al. 1996: An ocean observing system for climate. Bull. Amer. Met. Soc., 77, 2243-2273

[8] The IOC document IOC/INF-1361 (2018) provides a detail timeline of the history of GOOS.

terms of reference specified lines of responsibility to the Chair of the GSC and identified specific tasks.

Several domain-based expert panels were created from 1993 onward based on agreed modules for GOOS, beginning with the Ocean Observations Panel for Climate (OOPC), and then expanded to include living marine resources (LMR Panel), health of the ocean (HOTO), and coastal zone management and development (Coastal Panel); marine meteorological and oceanographic services was a 5th module. The GOOS Secretariat provided support to all panels. The Global Climate Observing System (GCOS) and Global Terrestrial Observing System (GTOS) were also established in the early 1990s with co-sponsorship of some panels, such as the OOPC. While the co-sponsorship matrix was strongly supported, it immediately created some ambiguity in reporting lines and accountability and added an overhead that sometimes proved burdensome.

One of the few documents to explicitly refer to the requirements for support was the GOOS Prospectus 1998[9]. Attachment 3 is an excerpt of the relevant paragraphs. The overarching purpose and specific goals remain relevant today, even if circumstances and governance arrangements have evolved. There was a clear expectation that operational agencies would emerge to support sustained activities, and interestingly the notion of "collective impact" was raised, long in advance of its emergence as an alternative governance model[10]. The Prospectus noted that planning, coordination, and standard setting support should be sustained through the same agencies that contributed assets, and that the return on investment came through increased efficiency and effectiveness.

Two other important innovations happened around that time. The first was the creation in 2001 of the Joint WMO/IOC Commission for Oceanography and Marine Meteorology (JCOMM)[11] to oversee the implementation of the physical and climate components of the ocean observing system. This event was an important milestone in the maturing of the ocean observing system, providing a support structure for oversight, coordination, and management of implementation. Support responsibilities were shared by IOC and WMO. JCOMM was superseded by a Joint Collaborative Board[12] in 2019. The JCOMM Observation Coordination Group (OCG) now reports through the IOC-led side of the governance structure.

The second was the convening of a series OceanObs Conferences, beginning in 1999 and held every ten years since. They were conceived as a way of bringing the ocean observing community together to debate and agree design and plans for implementation, to discuss the impact of particular observing assets, to progress the shared understanding and integration of the observing system, and to celebrate achievements. The community role was central. The first, OceanObs'99 laid the scientific foundations for the design and implementation of the physical/climate parts of the observing system. The second OceanObs'09 broadened the scope to other parts of the observing

[9] https://www.goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=171

[10] Some individuals are associated with both!

[11] Peter Dexter has compiled a personal history of JCOMM, published as WMO-No. 1250.

[12] See IOC Resolution XXX-2 of the 30th Session of the IOC Assembly, 2019.

system and led to development of a Framework for Ocean Observing[13]. The most recent meeting, OceanObs'19[14] took the OceanObs community-building to new heights and embraced the user community and the private sector in ways that had not been done before. While the series will likely further evolve, the engagement and participation built through this series provided a unique and important way of supporting the ocean observing system.

The services provided by the GOOS Secretariat and the advice developed by the GSC (since reformed and restructured) remain core elements of the support structure today, but only the OOPC remains from the original domain-based expert panels (with substantially changed terms of reference). The FOO recommended the GSC establish biogeochemistry (the IOCCP/BGC panel) and biology and ecosystems (Bio/Eco) Panels; both were in place today. The panels drew on external contributions to enhance support for their work; all have contributed advice into this study.

1.2.2. Synopsis of existing support arrangements

The documentation on support effort was sparse at best. Table 1 provides an estimate drawn from web pages or direct advice provided through interviews. Twenty-eight sources of support were identified with an estimated equivalent fulltime effort of just over 50. For the national GRAs (IOOS, IMOS) support was focused on their national activities, but their contribution to the global effort warranted inclusion in the table. Much harder (perhaps impossible) to estimate were the in-kind contributions from institutions and agencies that supported experts and other parts of the support infrastructure on an in-kind basis.

As one example, Figure 1 shows the effort devoted to the review of IndOOS, a review that was principally supported through the CLIVAR Office. The Workshops required travel support and all authors, reviewers and editors committed professional and/or personal time to the effort.

Figure 1. A summation of the effort devoted to the decadal review of IndOOS. [From IndOOS-2: A roadmap to sustained observations of the Indian Ocean for 2020-2030. Synthesis]

[13] http://www.oceanobs09.net/foo/FOO_Report.pdf

[14] http://www.oceanobs19.net/

Institution/Group	Comments	Effort (FTE)
AOML	Drifter program	1
Argo Support Office		1
BGC/IOCCP Panel		2
Biology/Ecosystem Panel		2
DOOS	Little info on support	0.4
EuroGOOS	GRA	5
G7/Mercator Ocean	New	3
G7/NOC UK		1
GCOS		1
GEO Blue Planet		2
GHRSST Project Office		1.5
GO-SHIP	JCOMMOPS hosts	
ISC	Some Future Earth support	0
IMOS	GRA	3
Indian Ocean GOOS	Unconfirmed	2
IOC Coordinator in Africa		0.5
IOC/UNESCO	GOOS Office only	4
IOCARIBE		0.5
JCOMMOPS		6
Ocean Predict Office		1
OceanSites	JCOMMOPS hosts	
Perth Programme Office		1
POGO		3.5
SCOR	Relevant projects	0.5
SOOS		1
US IOOS	GRA	6
WCRP/CLIVAR	Various	1
WESTPAC	NEARGOOS, SEAGOOS	1
WMO	Estimated	2
TOTAL		**53**

Table 1. Estimate of person-effort in support of OceanObs[15]; sources include web sites, published documentation, interviews and personal communications. Some efforts are unlikely to be full-time and vary from year-to-year. The attribution of national GRA efforts to the global OceanObs effort is not precise.

Such in-kind contributions are replicated throughout the OceanObs effort, largely in the manner and for the reasons set down in the GOOS Prospectus cited above. The ocean observing system effort (estimated at around 53, Table 1) was significant but probably short of reasonable expectations. Estimates of the required support effort do not exist but several of the correspondents ventured estimates (as a fraction of their total effort) of between 4-10%, including operational costs (see

[15] As in the survey and in the interviews, this study uses the term OceanObs as shorthand for the ocean observing community.

section 2.4 for additional discussion). The identified people-effort was less than 1% of the total estimated investment in OceanObs.

1.2.3. Recent discussion of possible new governance arrangements[16]

As discussed in section 1.2.1, there were several different incarnations of GOOS governance[8]:

1991: GOOS conceived and a GOOS Support Office created.
1992: I-GOOS and J-GOOS created, with co-sponsorship; GCOS established.
1993-4: Specialist panels formed, some co-sponsored; first GRAs appeared.
1997-8: J-GOOS becomes GSC; Terms of Reference for GOOS Secretariat (now Office) agreed.
2001: JCOMM created
2012: I-GOOS closed; GSC reformed

For the first decade or so, as GOOS matured, the buy-in and engagement from the OceanObs community was solid, notwithstanding that many observations were collected through research funding and many research/experimental campaigns collected data beyond the purview of GOOS. The growth of observing capability accelerated after the first OceanObs conference in 1999, with the launch of Argo, increased satellite power and capability, and a growing interest from and participation by the biogeochemistry and biology/ecosystems communities. However, by 2001, some cracks began to appear as the weight of expectation created by the rapid expansion in scope were not being matched by progress with implementation, other than in observations for climate where JCOMM provided a solid platform. At about this same time, a review of GOOS was initiated and the conclusions and recommendations were presented to the 22nd session of the IOC Assembly in 2003. The review acknowledged a level of confusion in the governance, specifically between the relative roles of I-GOOS and J-GOOS, and in areas of implementation: " … there was confusion over the appropriate mechanisms to achieve implementation of an ocean observing system". The place of the GRAs was also a concern. The matter was passed to an open-ended intersessional group and finally resolved at the 23rd Session of the Assembly[17] in 2005 where it was agreed to revise the Terms of Reference of the primary Committees, but no adjustment to the terms of reference of the GOOS Secretariat was made, reasoning this was a task for the Executive Secretary[18]. Those changes more clearly defined the responsibilities, with I-GOOS responsible for formulation of policy, principles and strategy, and for planning and coordination of GOOS, and the GSC for providing scientific and technical advice to I-GOOS.

The creation of the Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS) in 2005 did not necessarily emerge because of the faltering GOOS, but it

[16] Perhaps more than any other section, the thoughts and conclusions here draw heavily on the author's own experiences, as well as the cited literature.

[17] http://legacy.ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=2050

[18] This seems rather odd given the 1998 MoU clearly sets up the GOOS Secretariat as a group dedicated to GOOS and not simply another part of the IOC Secretariat.

immediately created some confusion about leadership, with GOOS, GEO, GCOS, JCOMM and POGO all having high-level visibility. Such confusion has persisted.

The most recent change to GOOS governance followed from the decisions of the 30th Session of the Assembly in 2011 to strengthen and streamline GOOS, decisions that were in turn driven by the conclusions of the Framework for Ocean Observing. I-GOOS was closed and Member State regional representatives were included in the GSC. No changes were made to supporting arrangements.

In 2019, the GOOS SC and other OceanObs parties external to GOOS initiated separate discussions on governance, once more driven by perceived underachievement and lack of clarity in the governance arrangements. These issues were documented in previously cited publications[1, 2, 3]. Tanhua et al. (2019) [1] characterised current arrangements as a weak "hybrid model" with top-down governance provided by GOOS within the UN system, and bottom-up arrangements sourced in the OceanObs community. The paper concluded: "… a polycentric governance model is appropriate for GOOS, and that a set of Principles should be agreed to ensure the basis for this model aligns with stakeholder needs and expectations … the model would include governance action at the global, basin, regional and local/national levels, coordinated according to polycentric methods; not all nations, regions or basins need be explicitly represented, but the needs must be. GOOS governance should be recognized within the UN and intergovernmental system, but may need some separation to fulfil ideals of responsiveness and adaptability". Subsidiarity was also an important concept.

The Weller et al. (2019) paper and follow-up discussions from OceanObs'19 focus on a collective impact model[19] with the aim "… to develop an Ocean Partnership for Sustained Observing that will incorporate the growing needs of a broad constituency of users beyond climate and make the case for new resources. To be most effective this new Partnership should incorporate the principles of a collective impact organization, enabling closer engagement with the private sector, philanthropies, governments, NGOs, and other groups … with the intent of establishing it early in the UN Decade of Ocean Science." They note that Collective Impact requires Backbone Support: "a separate organisation(s) with staff and a specific set of skills to serve as the backbone for the entire initiative and coordinate participating organizations and agencies"; their Fig. 6. They further noted "The backbone support organization is key to the success of efforts at developing collective impact. The importance and role of the backbone organization include "… guiding the vision and strategy, coordination and support for the aligned activities, tracking metrics of success, communicating results, and mobilizing funding."[20]

To our knowledge, neither of these proposed transformations is near to reaching conclusion or implementation. The notion of collective impact was raised in early GOOS documents[9] and elements

[19] For example, "Collective Impact Organization" (Kania, J., and Kramer, M., 2011). In Stanford Social Innovation Review 9, 36–41.

[20] Turner et al (2012). "Understanding the value of backbone organizations in collective impact: Part1," in Stanford Social Innovation Review.

of such a model exist in some of the current arrangements. One correspondent noted the US CLIVAR Office[21] has many attributes of the Collective Impact model.

Elements of both these studies were included in the survey circulated for this study, as well as aspects of current arrangements. The Principles mentioned above[1] also guided both the survey and interviews: Responsive; Purposeful; Clarity of objectives; Transparency; Efficient and Effective; Adaptive; Sustainable; Authoritative; and Performance and accountability.

1.3. A framework for support

Before introducing the results and conclusions from stakeholder consultation, we pose a framework upon which the OceanObs[15] System support discussion can be based. The GOOS Framework for Ocean Observing[13] had a similar purpose for GOOS. The framework builds on the history of ocean observing; concepts in the FOO and the current GOOS Strategy; and other published papers but cast in a way that the role of support/facilitation is revealed more clearly.

Two crucial elements of the framework are, first, the division of contributions into assets and asset classes, and second, the introduction of tiered levels of support (Table 2). The discussion below does go beyond the terms of reference of the study but without it, it becomes difficult to develop a coherent narrative around the challenges and future opportunities for OceanObs System support.

Tier level	Description of support provided
Level 1	Highest level, responsibilities including overarching strategy, planning and coordination among asset classes
Level 2	Support specific to an asset class or domain, responsibilities including implementation plans, standards, coordination of individual assets and networks.
Level 3	Coordination and planning at the level of networks.
Level 4	National and local support levels.

Table 2. Description of tiered levels of support. See the following sections for more detail.

1.3.1. Level 1 Support

The OceanObs System comprised four primary asset classes[22] (Figure 2):

- Observation – assets in the form of the collective of instruments that have taken samples of the state of the ocean.
- Data management – assets that assembled observations into a form that was accessible and fit for purpose.
- Production – assets that processed data into a form that is more easily used.

[21] https://usclivar.org/about/usclivar-project-office

[22] It is dangerous to introduce new terminology into a complex world already over-flowing with terms, often misunderstood or misused. However, this terminology is apt to identify those resources that deliver value and that yield benefit now and into the future; these are usually referred to as assets and the terminology is widely adopted, in government agencies, corporations and other enterprises. An asset class in the present context is thus a subsystem, grouping resources that have similar characteristics within the OceanObs System.

- Applications and services – assets that tailored products for specific applications and user classes.

At this level, over-arching planning, coordination, and management (collectively, the support) are needed to ensure the assets together provide the desired functionality and effect, according to design and plans. The OceanObs System asset classes are mostly implemented and operated independently, but systematically and to design in an ideal world. The OceanObs System needs a sound governance structure to ensure the asset classes and individual assets work together, and to make sure that the System responds to client and user requirements.

There is nothing unique about this division of classes; they could be grouped differently, or into a different set of classes. Note that a rather similar breakout was referred to in the Framework for Ocean Observing[13] (their Fig. 4) and used for the GOOS 2030 Strategy[23] (their page 16). We can also draw parallels with the architecture of WMO, with the first three Asset classes corresponding to WIGOS, WIS and the Global Data Processing and Forecasting System, respectively.

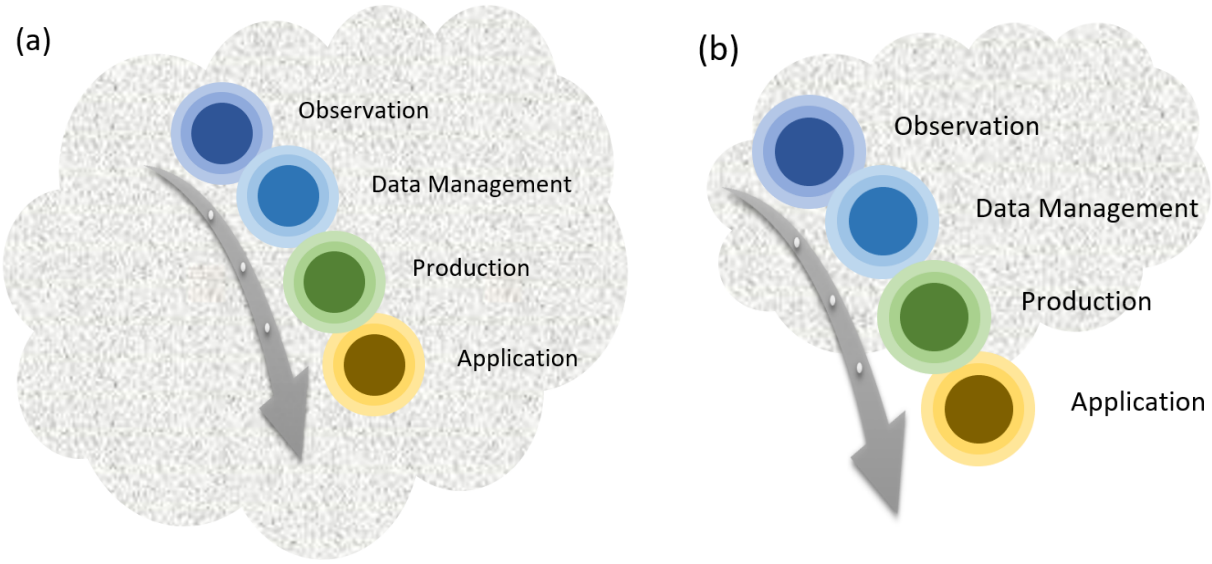


Figure 2. Schematic showing the different core asset classes of the OceanObs System and variants of the "cloud" of support and governance that facilitates systematic operation. (a) Support covers all assets; (b) support does not fully embrace the value-adding Applications.

Figure 2 shows two options in terms of support scope – in one (a) all asset classes are in scope, while in (b) the application and service activities are largely external and not coordinated by the OceanObs System; this latter mode most closely matches the current situation and was assumed as the basis for consultations in this study. The OceanObs System will inevitably have some external data and product dependencies which must be managed (not shown in the figure).

[23] Global Ocean Observing System 2030 Strategy

At this high level (which we refer to as Level 1 Support), the primary requirements and responsibilities include[24]:

(a) Develop and agree strategy, design and plans for the OceanObs System.
(b) High-level coordination of asset classes and management of external dependencies and relationships.
(c) Track targets and milestones from (a), including impact.
(d) Agree and implement standards and standard procedures.
(e) Develop business plans for the long-term resourcing of Level 1 Support.

Part of this high-level support will be provided by committees, expert panels and other groups as needed, backed by an administration office (probably distributed) with operational resources. The details and scope and range of Level 1 Support will depend upon the governance arrangements. We anticipate implementation teams responsible for each of the asset classes, but also domain- or theme-based expert groups to advise on strategy and scientific design.

An argument can be made that research and innovation should be included explicitly within this architecture, though they were not an asset class[25]. Indeed, much of the OceanObs System existed because of R&D effort and its importance was recognized in OceanObs literature and in the FOO and GOOS Strategy. However, at this stage of development and with no evidence to suggest any of the proposed governance models will seek to bring R&D within scope, we leave its explicit consideration to Level 2.

1.3.2. Level 2 Support

Rather than pre-empt the advice and guidance arising from the consultations (and from governance debates), we simply provide an outline of a possible architecture for Level 2 support arrangements, using one of the Asset Classes, Observation to illustrate.

The Asset Classes were comprised of networks[26], each contributing value or a value-add for the OceanObs System, ideally on a sustained basis. In contrast to Level 1, Level 2 is more about the "doing" and action; the taking of observations and implementation; management of various data types in real-time; running large model and data assimilation schemes; issuing of data and model products. Technical and R&D involvement rise to the foreground in the architecture.

[24] The consultation process considered requirements and priority amongst those requirements, but without reference to the different levels of support. Section 2.2 provides further elaboration of this list.

[25] It is common to recognize knowledge assets in a company, but it seems research and development is no longer considered an intangible asset, principally because value accrues indirectly and is difficult to quantify.

[26] This Report uses the term "network" in a more open and general way compared with the literature, and FOO and GOOS Strategy. We consider a network to be *any* grouping of interconnected OceanObs elements; the grouping may be national, local or regional, by basin, or global; be aligned with a particular platform or instrument; or identified with a specific Essential Ocean Variable or field. The networking usually aims to achieve sharing of knowledge and best practices, and/or to increase efficiency and effectiveness.

Support actions at this Level will be in similar areas to Level 1 (Planning and design; Coordination; Tracking progress and impact; Standards and best practice; Resources and Investment; Engagement and communication), but with different foci and priorities. Specific support requirements may include:

(i) strategic and implementation plans based on identified sub-system requirements.
(ii) coordination with other parts of the OceanObs System and external stakeholders, as well as for activities as required.
(iii) promoting and coordinating impact studies.
(iv) documentation of standards and best practice.
(v) coordinating and facilitating resourcing where appropriate.
(vi) managing engagement and communication with providers and users of the capability/asset.

The Observation Example

Observation activities can be broken into three sub-classes[27]:

- Sustained
- Experimental
- Ad hoc and short-term project campaigns such as for research or technology innovation

Figure 3 provides one way of presenting this schematically. Two recent studies[28] have offered definitions for the first two sub-classes. The definitions were similar and help to define and prioritise where support was required. Sustained observations were primarily responding to the multiple requirements identified at Level 1; that is, they were user driven, whether that is for applications and other socio-economic activity, or as part of research infrastructure (serving the broader research community, not individual endeavours). Experimental observations often have a similar long-term ambition, but further testing and experimentation was required. The last sub-class (ad hoc/short-term) was important to recognize since it constitutes the nursery for new ideas and technological innovation but does not come within the OceanObs System support structure.

The "cloud of support" includes liaison and consultation on user requirements; coordination and interoperability with other subsystems; and protocols around the subsidiary relationship with Level 1 (and other levels as appropriate).

The existing Observation Coordination Group[29] and its associated expert teams provide some of the required functionality but focused on the most mature physical/climate domains and on global

[27] These sub-classes are somewhat related to the readiness levels detailed in the FOO (viz. mature, pilot, concept) but are not used as barriers/gates for progress.

[28] Cravatte et al 2016: First Report of TPOS 2020; Moltmann et al. 2019: A Global Ocean Observing System (GOOS), Delivered Through Enhanced Collaboration Across Regions, Communities, and New Technologies. Front. Mar. Sci. 6:291. doi:10.3389/fmars.2019.00291

[29] See https://www.jcomm.info/index.php?option=com_oe&task=viewGroupRecord&groupID=103

networks that have clear lines of impact and relevance to socio-economic drivers. OceanOPS[30] provides technical support for coordination of activities and tracking progress of implementation, including for some of the emerging networks. The existing domain Panels (OOPC, IOCCP/BGC, Bio/Eco), which in theory cut across the Asset Classes, provide specialist expertise in (i), (iii) and (vi), but tend to engage in all support areas.

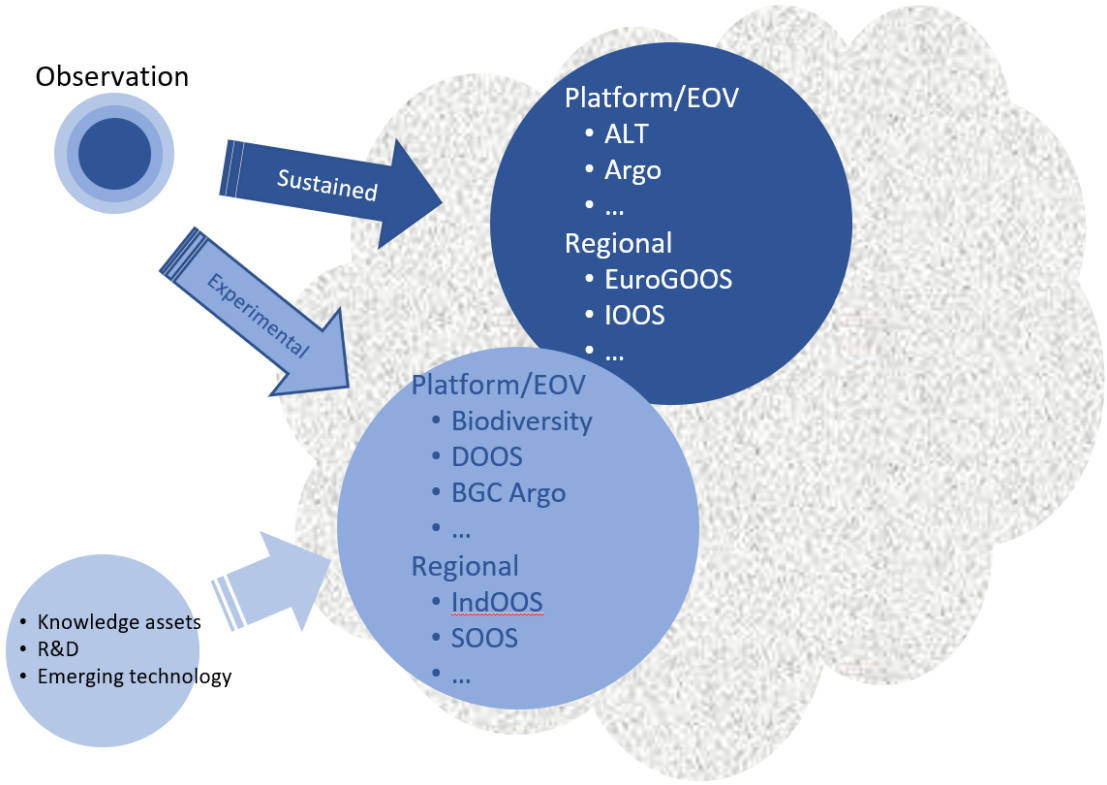


Figure 3. Schematic depicting components contributing to the Observation asset class. The contributing Networks take different forms (platform, regional, …) and these in turn might be classified as sustained or experimental. The cloud of support embraces these elements but is also dependent on significant contributions coordinated beyond this cloud, like research, emerging technologies, and knowledge assets.

The networks contributing assets in this Class were organised in a variety of ways. While the OCG provided a focus for some coordination, some of the support functionality was built into the networks themselves (e.g., Argo managed its resource mobilisation and its strategic planning and implementation, among other things). Such arrangements can be highly effective but do pose challenges for downward coordination and management at this Level.

There were also effective networks operated at the regional level (e.g., EuroGOOS, IOOS, IMOS)[31]. They vary greatly in terms of structure, capability, and capacity, and often cut across (or provide additional coordination for) the platform and/or variable-specific networks. Some regional networks

[30] www.ocean-ops.org

[31] Moltmann et al (2019) discusses regional partnerships in some detail.

have geo-political foundations or intergovernmental origins, while others were focused on oceanographic considerations (basins, oceanographic areas).

1.3.3. Additional Levels?

As described here, the networks were examples of Level 3 activity, and they in turn include contributions which might be coordinated at Level 4 (many national activities might be classed as Level 4). Subsidiarity was implied in the descriptions above[32], and was needed to introduce order and to manage risks and issues at the most appropriate level, among other things. It also promoted efficiencies and reduced duplication in the OceanObs System if managed appropriately. Subsidiarity does not imply subservience. Similar principles were included in most governance arrangements.

1.4. Methodology of the present study

Published references were used to inform the background for the study and assisted in framing lines of inquiry. The study included consultations with the ocean observing community, through a series of surveys (Attachment 4) and interviews (Attachment 5). The consultations gathered views on the status of OceanObs support, its functionality and form, resourcing, and investment models. The correspondents were provided a brief background on the study. Attachment 6 provides a list of the experts contacted for either the survey or for an interview. Together, this information provided the evidential basis for the findings and conclusions.

2. Results from Consultation

The scope of consultations expanded considerably from the point of project conception (around 10-12 interviews), through the initial agreement (16 interviews and order 20 surveys), to the conclusion of the project (22 interviews and 35 completed surveys, and 70 contacts overall). Noting that some correspondents completed both a survey and interview, and others simply provided comment, there were 45 independent sources of input. The overall response was excellent, to the point that we were unable to close out either the interviews or the surveys as early as planned; too many of the key stakeholders wished to participate.

The following analysis broadly follows the structure of the survey and interviews. Note that the survey correspondents did not always offer views on each topic, and sometimes offered comments outside the questions that were posed. Similarly, the interviews, while all working to the same "script", tended to go in different directions. For those able to provide written input prior to the interview, the conversations focused on clarification of input and deeper discussions depending upon the role of the correspondent or organisation. Those conducted without any prior input were harder to manage and it was not possible to go into detail. Several of the interviews were with more

[32] Here subsidiarity involves the principle that higher-level functionality (e.g. Level 1) should perform only those functions which cannot be performed at a more local level (Level 2 regional and specific asset Networks), and so on. All levels should have a subsidiary function.

than one person; these too tended to be harder to manage. The interviews ranged in time from 30 minutes to 90 minutes.

Below, we try to capture the range of views[33] before presenting conclusions and recommendations. We note that terminology and the "language" of the ocean observing community represented a barrier to efficient discussions. We used the term "OceanObs" to represent the broader community engaged in ocean observing activity (c.f. GOOS), and this seemed to work well. However, one respondent thought we were talking about support for the OceanObs conference! For some, the ocean observing system was just the observational assets (networks), while for others the system stretched over the end-to-end chain as described in the Framework FOO and in section 1.3. Many correspondents reverted to discussion of observing assets/networks rather than the structures that support them, while others preferred to comment on governance more broadly, neither of which were within scope.

2.1. The strengths and weaknesses of current arrangements

2.1.1. Results from consultation

Almost all correspondents considered the present support arrangements were sub-optimal, but to differing degrees and for different reasons. We found optimism mixed with uncertainty and frustration. Many recognized and acknowledged that significant progress has been made and that good work was being done, with dedicated individuals and teams, sometimes under stress and with uncertain financial outlooks. Argo, IMOS, POGO, the Ocean Coordination Group, OceanOPS and EuroGOOS were among the most cited examples of effective arrangements and support, but with the recognition that even in those cases resources were tight and there was little headspace for strategic planning and future expansion.

The global approach was generally considered to be a strength. This view was in part related to the global information needs for climate and other global-scale phenomena where no single player had the solution, somewhat like the mission of WMO. However, there was also a global perspective driven by common needs, for example around biodiversity and monitoring of coral reefs, in which the ocean observing system was seen as world infrastructure supporting diverse needs of all nations. Correspondents recognized the latter as a strength of the present approach.

Where correspondents identified issues, it was often put down to lack of resources and a fractionated and complex governance system. The community struggled to pull things together (act as one) and available funding fell well short of expectations and ambition, and the implicit mission of the OceanObs enterprise. The debate and decisions by WMO and IOC around a Joint Collaborative Board[12] showed we know broadly what is needed and how we should go about developing an optimal system, but translating that into a shared undertaking and commitment across the OceanObs community with agreed actions and effort (cf. discussion) remained a challenge.

[33] The correspondents will not be identified or associated with any of the specific results. However, we draw heavily on their statements.

There was fragmentation so that, for example, the climate communities often did't feel connected to disaster risk reduction communities, and in turn there was separation from the marine pollution and ecosystem health communities. Correspondents identified issues in support for coordination at global, regional, and local levels. Many also pointed to issues in support along the value-chain of the end-to-end system, citing gaps in implementation of non-physical observing networks; major gaps in the data systems; and deficiencies in the coordination and support of the modelling and processing systems. Those working in the early stages of development ("concept" for FOO) were frustrated about the lack of recognition and an identifiable pathway to build toward participation. Building coherence and connectedness was emphasised as important if we were to realize a true System.

Many drew attention to the absence of effective institutional governance and drew comparisons with the strong institutional governance provided by WMO for the national meteorological and hydrological services. This often led to uncertainty around lines of support and loss of accountability and responsibility.

The current intergovernmental arrangements for GOOS were regarded as both a positive and a negative. It was recognized that intergovernmental agreement was important for some networks and systems, and that the global nature of both IOC and WMO matched the global (world) view needed for cooperation and collaboration (e.g., on standards) and the global scales of some domains, such as climate. The intergovernmental umbrella allowed ocean observing to be inclusive of all States who were members of that structure. Both IOC and WMO also brought in support around capacity building, education, training, and research which was important.

Conversely, many saw the intergovernmental system as ponderous and inflexible, without the ability to quickly scale-up and adapt to the fast-moving world of ocean observing and user demand. Several remarked that the ocean community was agile and close-knit, and this has led to an energised and powerful bottom-up contribution. However, this was also identified as a potential issue when working with structured and slower-moving enterprises such as an intergovernmental organisation. The prominence of research and research funding on both the provider and user side led to too much science push and too little user pull as one correspondent observed. The ocean research community had a strong history of success acting together to solve large, global scale problems (e.g., TOGA, JGOFS, WOCE), and in one of those cases there was a strong intergovernmental overlay, so it was interesting to find that the OceanObs community was challenged by intergovernmental processes.

An issue was identified around the lack of upward impact (high-level recognition) and the community's inability to influence national policy and decisions (influence at government policy formulation levels). Some saw great opportunity in the emergence of the ocean and ocean observation as a world issue, for example through the Decade of Ocean Science; discussions of the Blue Economy; informing national accounts; and attention in the CBD and SDG goals, but felt that it needed improved revealing and advocacy. Some reasoned that the lack of a strong and unified approach meant upward engagement was problematic: too many voices spoke for the observing system and conveyed different messages, thus reducing impact.

The OceanObs community were also hampered by the fact we have not agreed on exactly what we need, both in terms of the observing system assets (observations, data management, modelling and production) and the support required to allow them to operate as a system. The present

intergovernmental arrangements contributed to the issue. Decisions of IOC were not binding on Member States compared with the WMO, and neither IOC nor WMO have strong mechanisms and authority for linking to national ocean actors. There were examples of effective "incursions" to the national level, but these were rare.

Many correspondents noted strengths generated from the people involved, the vast majority of whom were volunteers. This was to be applauded. However, without a strong core of permanent staff for coordination and planning, people power led to fragmented and disjointed contributions. A strong core of support would extract the best from these engagers, including through planned and purposeful communication externally and perhaps more importantly, within the ocean observing system and at the interface with national efforts.

In a small, but nevertheless significant portion of the correspondents the dissatisfaction with current arrangements were more extreme. GOOS was seen by some to promise a great deal (and has almost since inception), but deliver too little; the support structures were spread too thinly, including in the GOOS Office: what they have done was generally done well, but the ask had gone way beyond their means. We tended to create structures, sometimes prematurely, without secured lines of long-term support. The support that was available often lacked funding security and the reliance on in-kind, volunteer support often led to delays and uncertainty around delivery. The current system lacked authority and, in places, credibility and respect; some parts of the OceanObs community learned to live independently and succeed. At the most extreme end, correspondents suggested we should consider locating part, even a substantial part of the support functionality outside the present structure, for example, into a collective impact-style organisation. We do not wish to overplay these views – they were not dominant – but it signalled the malaise was deep and broad and that it should not be ignored.

The previously introduced Table 1 provided an estimate of existing support, in part based on feedback from correspondents. The Table attested to the thinness of support around the core (hub) of observing system support, and to the distributed form (nearly thirty nodes in the Table 1 account). Correspondents saw issues in this arrangement but also felt that such a distributed system can and must be made to work more efficiently and effectively. One correspondent cited the effectiveness of ICES which had permanent core staff of around 60 compared with 53 identified in Table 1 (many of whom were on short-term contracts). ICES undertook monitoring and other activities to inform decision making and policy in European fisheries and have "right-sized" the support to meet that challenge. In general, correspondents felt the present way of resourcing the OceanObs support structure – in essence, piece by piece – was a major contributor to its weakness. No correspondent was able to provide an estimate of the needed effort for a well-resourced support structure, but there was general agreement that the place to begin a rebuild was at the core.

2.1.2. Findings

Finding 1. *General health of support structures: The survey and interviews revealed pockets where the support structure was seen to be working well and serving requirements within a specific area of operation. Elsewhere, performance and achievement were less satisfactory and uneven, in part through lack of resourcing, but also in part because of the nature of the support (e.g., fractionated, disconnected, complex).*

Finding 2. *People: Consultations revealed a strong appreciation of the effort of individuals within the support structure, and of the agencies contributing resources and effort. However, it also revealed significant pressures arising from an unreasonably heavy workload, short-term outlooks, and unreasonable expectations in terms of delivery.*

Finding 3. *Effectiveness: The current support structure was effective in some areas but in general was not meeting expectation for the vision and mission of GOOS, or for the OceanObs community more generally.*

Finding 4. *Efficiency: The efficiency of the support structure was compromised by the fragmented approach and insecure lines of support, particularly in core areas where small resources were being spread thinly over many different tasks.*

Finding 5. *Relevance and functionality: The response to support requirements was patchy, with some aspects served well, and others not. There were clear gaps in parts of the cycle, specifically around data systems and model/production systems. The interface to national activities and users was also poorly served.*

Finding 6. *Extent: The present effort was estimated to include around 53 FTE, but this was poorly documented with no record of operational expenditure or volunteer/in-kind efforts. Unmet requirements were often partially picked up by volunteers, partially masking the extent of the gap for core priority functions.*

Finding 7. *Architecture of the support system: The support structure was built in an ad hoc bottom-up manner and there was no master plan or agreed priorities across GOOS, or the OceanObs community more generally. This led to confusion around roles, responsibility, accountability, leadership, and cross-support system engagements and coordination. There were also important functional gaps across the end-to-end system and across networks.*

Finding 8. *Impact and national connections: The survey found upward impact, into UN conventions and related fora and into national policy and decision-making arenas to be poor. The system of national GOOS focal points appeared dysfunctional.*

2.2. Functions and requirements

Following the lead of the FOO and of the framework for support outlined in Section 1.3, this study separated out support requirements prior to consideration of the form and structure of support arrangements, and issues around the response to the requirements (resources, investment).

Correspondents were provided an indicative set of support functions, derived from terms of reference for existing support entities and literature associated with governance discussions[1, 3, 12, 20] and other documention[13, 23] and asked to advise whether they should be regarded as a priority and to rank them from 1 to 10. They were also asked to nominate other requirements that might be considered.

2.2.1. Results

The results of the survey are summarized in Table 3. Planning and coordination emerged clearly as the top priority, but with the caveat that it should embrace all planning and coordination, not just international planning. Vision and strategy development were ranked next highest, and this was of

course closely related to planning. Correspondents emphasised the need for strong core secretariat support as well as effective teams/groups at Levels 1 and 2 (see section 1.3) organised around their specific responsibilities.

The ranking and importance of requirements (c) to (i) depended on the lens through which correspondents viewed the system. Indeed section 1.3 was drafted early in the study, motivated by the diversity of views and the clear relationship of perceived importance with the level of different actors. For example, (c) was ranked more highly by those engaged in project development and execution (emerging capabilities) than those working near the mature end and/or at high levels of the structure.

Creation and maintenance of standards, across all assets and including references, standard operating procedures, validation, quality control and verification were a prominent theme in the feedback. Correspondents noted that for full effect, a stronger institutional structure may be needed. Many cited the WMO as a good example of best practice and WMO itself expressed its willingness to contribute its experience and know-how to satisfy those requirements.

SUMMARY		**Count**	**Yes?**	**No?**	**Unsure**	**Score**
(a)	International planning and coordination	35	35	0	0	8.51
(b)	guiding the vision and strategy	35	29	1	5	8.00
(e)	creation and maintenance of standards	35	29	0	6	7.72
(c)	coordination and support for the activities	35	30	1	4	7.45
(g)	promotion, communication, engagement	35	32	2	1	7.15
(h)	mobilizing funding to sustain support	35	27	2	6	7.06
(f)	capacity enhancement and training	35	25	3	7	6.93
(i)	mobilizing funding for OceanObs	35	20	3	12	6.50
(d)	tracking metrics	35	25	1	9	6.47

Table 3. The results from survey and interview input to the analysis of requirements for support, ordered by how they were ranked (see Attachment 4 for details on the survey). The second column is the number of inputs. Columns 3, 4 and 5 show the response against priority (yes, no or unsure). The final column shows how each function was scored.

Promotion, communication, and engagement were also prominent in the feedback but there were diverse views on how important it was as part of the core functionality. Those at the project/development end rated "doing" more highly (be known for what you achieve rather than for what you said you would achieve). As discussed in the previous section, we need smarter and more coordinated upward engagement and communication (acting and speaking as one).

The debate about capacity building, education and training was not so much about whether such activities were important – it was very clear they were – but about where the support for such actions should sit in the structure; section 1.3 posited that such functionality might be best treated as a set of services provided to the ocean observing system rather than as a bespoke capacity building function of OceanObs itself. The logic behind this was that it was more efficient to have this need met by specialists who can tailor responses across the broader needs rather than focused on the ocean observing system in isolation. The optimum arrangement should be considered within

governance discussions and at high-level forums such as the JCB and governing bodies of IOC and WMO. If the architecture posed by section 1.3 is adopted, then the primary task for the supporting structure is to coordinate and identify requirements and seek external sponsors of the activities.

The clarity of feedback around metrics was not aided by the way the question was posed, since it was not clear to some correspondents whether this was intended to include sensitivity and impact studies and the sort of functionality provided by JCOMMOPS/OceanOPS. The interviews provided an opportunity for clarification, and as a result some of the interview feedback provided a higher rating (not included with the table). Such an opportunity was not available to written correspondents. Analysis of the interview feedback suggested this functionality would have rated more highly if clarification were available from the outset.

The questions around mobilizing of resources drew the most uneven responses, partly because of different interpretations of what was being asked, but also because people/groups had genuinely different positions on whether support capacity should be drawn into the support structure. This might seem paradoxical given that the responses provided for section 2.1 (and section 2.4) were dominated by issues around adequate resourcing and effective levels of support. One explanation is that actors at Level 2 and 3 believed core support should be argued for and mobilized mainly at the highest level, to avoid multiple smaller players trying individually to arrange support for their piece of the system; they thought it was important, but not as part of their own activities. We found there was substance to that point of view: resourcing and investment should be managed in a more strategic way, with emphasis on the core and long-term sustainability.

Mobilising resources in support of the asset classes (as depicted in Figure 2) also drew a wide variety of responses. Some were firmly of the view that support for networks and assets was the function of national agencies and others with capacity to implement and maintain the assets. However, for those heavily committed to projects around asset builds for the System, or from developing countries, much greater emphasis was placed on facilitating and coordinating potential investment. Argo was often used as an exemplar. Both arguments have validity. Correspondents familiar with Argo noted it seemed unhelpful to include the effort of proposal writing as part of the OceanObs System support structure. Similarly, for efforts such as IMOS, business and new policy development probably should not be regarded as part of the OceanObs System support structure.

All correspondents were asked to identify additional functionality that should be added. A compilation of these suggestions is included in Attachment 7. As one might expect, when read in conjunction with Table 3, it resembles a Xmas wish list more than a set of strategic priorities. Attachment 8 attempts to consolidate this information and map it into the initial outline given by Table 3, leading to six pillars of support structure action and change:

1: Planning and design
2: Coordination
3: Tracking progress and impact
4: Developing, setting, and maintaining standards and best practice
5: Resources and Investment
6: Engagement and communication

These can be thought of as the strategic goals of support. Attachment 8 also uses the tiered level structure proposed in section 1.3 to provide a sense of the priorities at different levels; priorities differed among networks and capabilities.

2.2.2. Findings

Finding 9. *Structure. Stakeholders found the existing support structure complex and lacking transparency. A strategy should be developed that clarifies the architecture and primary goals of the support arrangements.*

Candidate goals (pillars) were provided above and are shown schematically in Figure 4; section 1.3

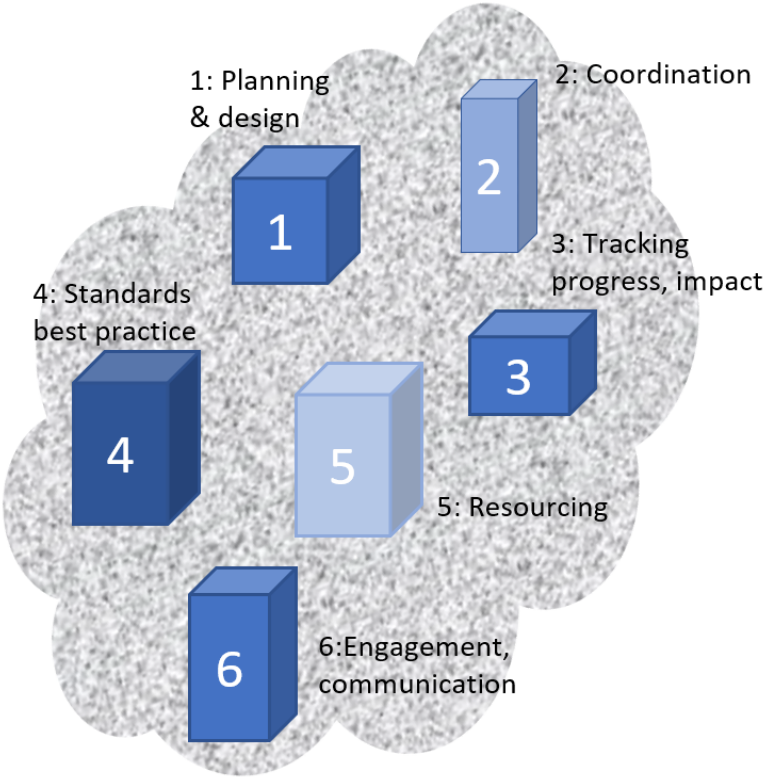


Figure 4. Schematic showing the six pillars (strategic goals) for a possible future ocean observing system support structure. They operate as a "cloud" of support, adjusted to the different Levels of the system (Figure 2).

explained how the different levels and domains of support action might be arranged.

Finding 10. *Priorities. This study found that (i) planning and coordination, (ii) vision and strategy, (iii) creation and maintenance of standards, and (iv) coordination and support for activities were ranked highest among potential activity areas for support.*

It should be stressed that other proposed areas, and areas nominated by correspondents, also drew significant support.

Finding 11. *Capability and capacity. Capacity building, education and training were identified as important for the ocean observing system, and thus prioritised for support. This study suggested that needs should be determined by OceanObs but met by external providers rather than building a bespoke programme into the ocean observing system.*

Clearly support will need to be mobilised behind such an arrangement.

Finding 12. *Mobilising support. The mobilization of resources and investment for support should be managed in a more strategic way, with greater focus on the whole, rather than on the many different individual actions spread over Levels 1, 2 and 3 activities. The mobilisation should be supported by a strategic plan, with agreement on priorities (also see Finding 20).*

Many of the efforts listed in Table 1 were small and not sustainable without devoting a significant proportion of the available effort to fund raising. We should seek consolidation, at least in a logical sense, so that agreed core activities were supported adequately.

Finding 13. *Mobilising resources for major assets. In general, the business cases/proposals for assets that comprise the core of the ocean observing system (observations, data management and modelling/production) should be developed and argued at the national and regional level, not by the OceanObs system support structure. The latter should focus on coordination and facilitation within the scope of the overall aims.*

2.3. Form

2.3.1. The present form

The current structure was characterised as a hub and spoke model[34], with one hub arranged around GOOS governance (e.g., the GOOS SC and its Panels) and the GOOS Office, and peripheral centres of action, a subset of which may also be regarded as hubs, some tightly connected to the GOOS hub, but many with loose or unspecified links. The existence of multiple hubs without a full understanding of the interrelationships led to a level of confusion. The global form and intergovernmental sponsorship meant all UN States were in theory engaged through the GOOS hub and, potentially, advanced GOOS relevance to global goals such as the SDG.

GOOS recognized the potential efficiency gains from regional nodes of support and the potential benefits to developing countries who have less capacity to support their own infrastructure or limited skills in data manipulation and analysis. The feedback from consultation suggested the future support structure should maintain regional nodes irrespective of the long-term fate of the Global Regional Alliance approach, for improved relevance, engagement and efficiency. The current structure had several such regional nodes that were regarded as benchmarks/models for the future.

[34] E.g., https://www.westernsydney.edu.au/__data/assets/pdf_file/0005/894434/Hub_and_Spoke_v2.pdf. We use the term hub for a centre with many connections (spokes) and node for a centre with a smaller number of connections.

The current form had multiple hubs and spokes of uneven quality and value. There were many networks and ocean observing (sub-)systems – some correspondents estimated more than 100 – but not all of those had support outside that provided to build the network/system.

The governing bodies of GOOS set out with good intent but were hampered by lack of community pull and immaturity from the user side, on the one hand, and the lack of resources to support an ambitious build on the other. Cracks began to emerge around the five year mark as several initiatives were spun up with only loose ties to central governance (e.g., Argo, CoML and GODAE/Ocean Predict)[35]; at the same time the lead for implementation was spun-off into JCOMM. All were successful spin-offs, but the quasi-independence from GOOS contributed to a fragmented and uneven support structure, diminished authority and accountability at the core and encouraged further fractionation. The presented form seemed to actively enable bottom-up and bespoke solutions– multiple hubs, disconnected networks, etc.

Correspondents did not identify any viable alternative form of support, but they characterised the present arrangement as broken and in need of serious repair. Tested on this at interview, most agreed the hub-and-spoke model was appropriate but that the main hub must be renovated and rejuvenated and made fit to fulfil its central[36] role. Correspondents also argued that a future system should seek rationalisation and consolidation, in concert with the strengthened hub[37]. The form needed to have an authoritative and respected (and agreed) over-lead (cf. controlling role) so that the system acted as one. The concept of subsidiarity was key – all elements stayed connected but understood their role and were accountable to each other and to external stakeholders. Beyond the present consultations, other models have been discussed, including collective impact discussions, where backbone support was highlighted, serving as the backbone for the entire initiative and coordinating participating organizations and agencies[38].

2.3.2. Drivers of change

As discussed, the diminution of central authority and leadership must be addressed. Presently, individual component parts flourished and grew consistent with their mission, irrespective of outcomes for the OceanObs system. Individual assets, or even asset classes sometimes grew in the absence of demonstrated user pull, and the mutually supporting ideals of the system were severely tested.

Many correspondents yearned for centralised authority such as present in WMO, but none provided optimism that IOC, or IOC acting with WMO, could deliver such a structure, at least not for the whole. There were also many, mainly from research, who valued the freedom and dynamism that a less authoritarian structure provided: 'Please not a model like a controlling GOOS '. Change must

[35] The author should declare a conflict of interest since this was a mode that he championed and used.

[36] Unless stated otherwise, central should be viewed as a logical construct, not a physical or organisational construct.

[37] Note that the overall architecture may include several hubs.

[38] E.g., S Turner et al (2012): "Understanding the Value of Backbone Organizations in Collective Impact". Available from https://ssir.org/.

seek an appropriate middle ground. A form that was good for research – flexible, agile self-determining – may not be optimum for operational applications and users[39], and vice versa. These differences were mostly at the extremes – OceanObs infrastructure that supported applications/users almost always contributed to research.

The lack of overarching institutional structure or a firmly managed distributed system created issues also at the national level, and even for multi-lateral groups such as the G7. It was seen to inhibit engagement and investment. Governance arrangements were also relevant. The form must be investible.

Several commented about the role of IOC, some emphasised the strength it brings to the support structure, but others sought to distance or even remove the supporting structure from IOC. The latter stance appeared counter-productive given the clear value IOC brings, as identified in section 2.1. The alternative favoured (or at least implied) by many was to adopt a form that fully takes advantage of both IOC and WMO, but in which a central authority had broad buy in and support across the OceanObs system and steered a balance between the dynamism favoured by research stakeholders and the steady, dependable and accountable structure favoured by operational users. Governance discussions were of course relevant to such decisions (see section 0) but it appeared there was common ground available in terms of the principles underpinning a successful support structure and those of the different governance models.

One consequence of such an arrangement was that ownership would irrevocably be vested in the hands of shareholders/stakeholders – all contributors would own and benefit from the support structure, but would also have responsibilities to determine strategy and priorities, and be willing to park self-interest for the greater good. The current IOC and WMO involvement should remain strong, drawing on their intergovernmental strengths, but operate alongside and with other contributors.

The discussion in section 1.3 highlighted that the future form needed to improve clarity and transparency, specifically around roles, responsibilities and accountability. For example, an actor at Level 2 must know what other actors at that level were responsible for and ensure harmonious and constructive partnerships. Level 1 must focus on high level enabling, not control, of activities at Level 2.

The changed form needed to favour certainty and sharing of the load. Building coherence and connectedness was also important if it was to be a true system.

Other drivers for rationalisation and consolidation were identified in the responses. Examples included:

- Some countries having up to 4 regional support entities
- Numerous players around the carbon cycle with overlapping mandates

[39] For our purposes, operational means the performance of practical work or of something involving the practical application of principles or processes derived from the ocean observing system (ref. https://www.merriam-webster.com/dictionary/operations). It is inextricably linked to services and use beyond research.

- Multiple centres of action for data and information portals, only loosely coordinated at times (at least for the purposes of GOOS).
- The form for global, regional to national engagement was broken

Some correspondents pointed to significant gaps in support for implementation, formerly coordinated through JCOMM, and now through the JCB. These mechanisms were established for the physical and climate networks and included data management and model/production systems, but networks beyond that scope were now maturing and seeking implementation support, either within the current structures, or through a sister structure. This would include technical support – the change in name for JCOMMOPS to OceanOPS implied this was under consideration, but there was no evidence of planning or resourcing for such a change.

2.3.3. Findings

Finding 14. *The present form can be likened to a hub-and-spoke model, with one hub arranged around GOOS, and secondary hubs and other centres of action (nodes) sitting on the spokes. The weakness of the spokes and the lack of clarity around the relative responsibilities of hubs and node blunted the effectiveness of the model.*

Finding 15. *No viable alternative to the hub-and-spoke model emerged through consultations though we were aware of interest in so-called Backbone Organisation constructs.*

Finding 16. *The present structure has not fulfilled the requirements of the community and appeared unsustainable. It lacked authority, clarity and transparency, and its effectiveness and efficiency were unsatisfactory for many stakeholders. For some it was not investible.*

Finding 17. *While several of the values brought to the structure by the intergovernmental partners were highly valued, many believed the ocean observing system cannot prosper and be sustained if it remained wholly within the current intergovernmental GOOS support structure. A hybrid hub-and-spoke model was the favoured alternative, with improved clarity and transparency around different roles, responsibility, and accountability.*

Finding 18. *Several gaps were identified though some were better considered as governance issues. In terms of support, the following were in need of urgent attention:*
** Support for data management assets as part of the system;*
** Support for implementation beyond the scope of the former JCOMM;*
** Technical support similar to that provided by OceanOPS for emerging areas; and*
** More effective regional centres of support.*

Figure 5 is a schematic of how the hub and scope scheme might be arranged within the cloud of OceanObs support.

2.4. Resourcing and investment

2.4.1. Results

Several correspondents did not agree that resourcing of support functions was poor, but rather suggested that poor engagement and communication led to misalignment between available resources and requirements. Those views notwithstanding, most correspondents thought there was

a mis-match between the mission and expectations of the current GOOS and resourcing and investment, and that this was replicated throughout the OceanObs System (see section 2.1). The choice before the OceanObs community then was to either rationalise and prioritise among the many activities that were in need of support, or to raise the level of resources and/or make the current resources work more effectively. These issues appeared to be exacerbated by the distributed structure.

Present resourcing of support functions was typically short-term and lacked security; there was not a core hub (or backbone if you prefer) with stable and secure staffing and with sufficient operating funds to undertake core work and fulfil core responsibilities. There were examples of securely resourced entities within the OceanObs System, but these appeared to be the exception. Of the agencies actively invested in support, most believed they were getting good return on their investment, but with the caveat that they targeted investment where it was most likely to return value.

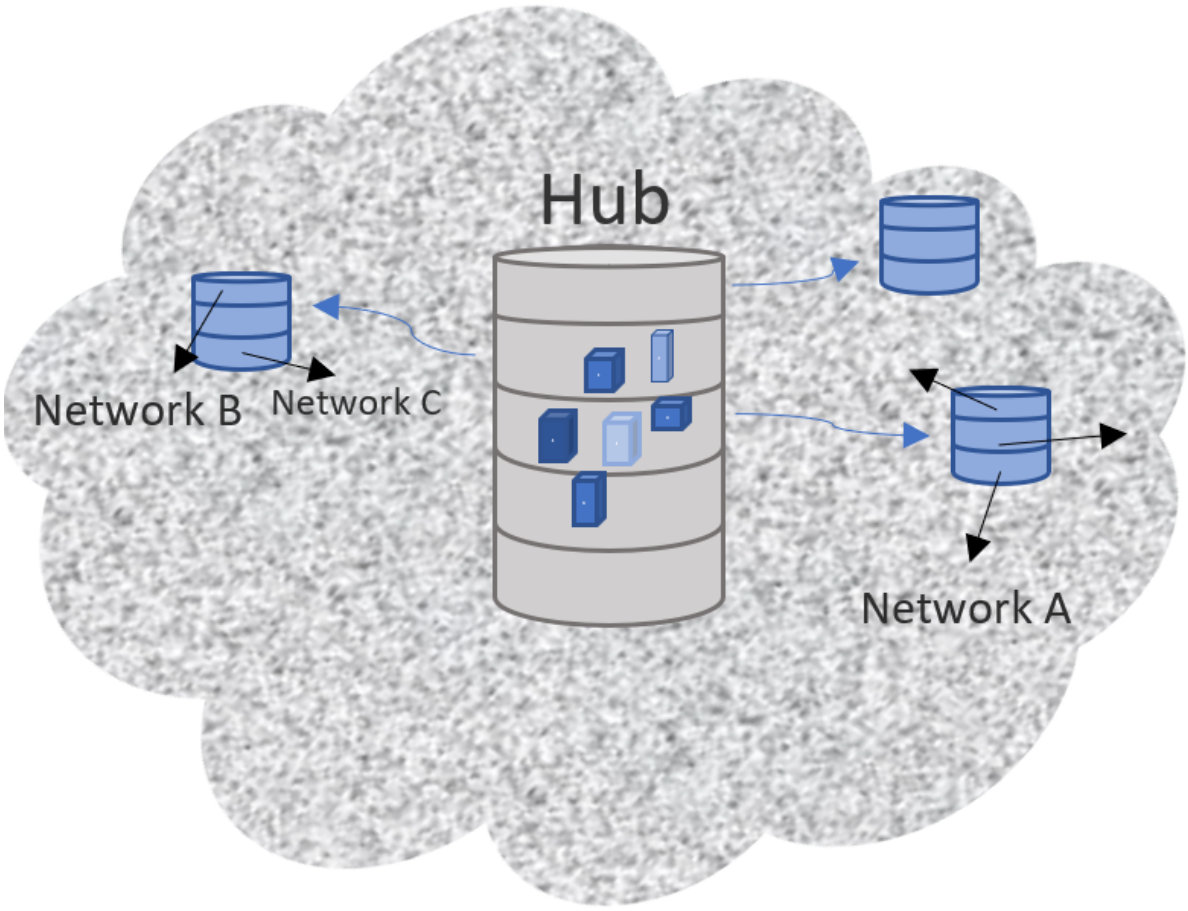


Figure 5. Schematic of the central hub and spokes to other hubs and nodes. The central hub follows the strategic pillars, as do all elements of the support cloud. There may be several satellite hubs and nodes, for example for a region or asset class. These in turn may have spokes to networks. Some Level 3 actors may link directly to the central hub.

Several correspondents noted the need to broaden the base of support. Some resources flow through intergovernmental mechanisms, but the majority was drawn from a narrow base and a small group of agencies. For example, the US continued to provide around half of the observational assets and around the same proportion of the extra-budgetary support resources. Recently, at the G7 Working Group for the future of the Oceans and Seas, the party states agreed to support the launch of a G7 Ocean Coordinating Centre to support global ocean observing.

While improved financial arrangements would improve support, the structural failings discussed in the previous section will continue to destroy value if they are not addressed. Several correspondents noted the mechanics of contributing resources were difficult.

Correspondents noted we were not always able to articulate why you would get "good return for your investment" in the OceanObs system support structure; they missed a persuasive narrative. Others argued that OceanObs had not done a good job to inform users and the funding authorities (legislatures, agencies) of the importance of these systems and of the need for long-term stewardship of data; we needed to awaken users of this information to realize where it comes from, and how much better we could serve their needs with more resources.

Many emphasised that investment principally occurs at the national level; there were few investment options at regional or global/UN levels. Establishing and communicating the value argument for resourcing support structure was therefore critical, and the evidence from these consultations was that this was not done well. We do not regularly communicate to nations what the support structure was delivering on their behalf.

Several correspondents noted that for many of the countries with access to the ocean there was little evidence the case for ocean observing had been made successfully. Very few countries had a decent ocean observing system and/or relevant policies in place. Most countries relied on information collected by others. GOOS encouragement and/or IOC endorsement had done little to change this situation.

The previous section found that regional networks, aggregated around common interests, could and should play a major role in future support arrangements. EuroGOOS was often raised as an example. It was sometimes easier to resource such entities because they were more relevant for coastal and other local issues and mapped more readily into national arrangements.

At the national level it was not unusual to have several ministries deal with ocean matters. Of relevance to this discussion was the fact research and operational[39] activities were almost always separated, and often not coordinated with respect to OceanObs System needs. National focal points were in a variety of ministries. For OceanObs system support, science agencies were less likely to be interested in supporting long-term needs, but conversely were often willing to support project-based activities.

Bilateral and occasionally multilateral arrangements have been used to good effect on occasions, particularly around partnering with developing country agencies. It was an effective way to broaden the base of engagement in the ocean observing system, even if it did not lead directly to increased resources.

POGO, IOOS, EuroGOOS, IMOS and others have been active in attempting to make the case for support of the ocean observing system. Correspondents saw advantages in joined up support for this work. The proposed functional line around sensitivity and impact studies (section 2.2.1, pillar 3) is important for making such cases.

Both UNESCO/IOC and WMO have significant funding derived from assessed contributions; in the case of WMO assessed contributions comprise around 75-80% of the total budget of US$90M. The IOC typically receives around US$3m annually via UNESCO assessed contributions, roughly matched by extra-budgetary contributions. In the context of the discussions here, it was interesting to observe that IPCC was funded through voluntary contributions from a subset of its Members and affiliates (some core staff were funded via WMO); its procedures do not define (assess) any fixed level of annual financial contribution, yet IPCC has been able to sustain support at the required levels over a long period of time. In addition, for each assessment cycle (of around 7 years) additional resources were committed to Working Group Report secretariats in the range US$5M annually. The key to unlocking such commitment was, first, the high visibility and global importance of climate change, and second an unwavering commitment to deliver regular high-quality independent assessments according to schedule.

Several correspondents noted opportunities around private sector and philanthropic engagement, both through investment in assets and through supported infrastructure. Both POGO and the Census of Marine Life benefitted from significant strategic investments by the Sloane Foundation[40]. While private sector and philanthropic engagement were unlikely underpin and secure the long-term future of the OceanObs system support structure, they could play a role in accelerating development in specific areas.

It was difficult to generate guidance on the quantum of the gap in support. One correspondent noted that around 10% their budget for OceanObs was devoted to support (for meetings, coordination, etc.). In another case, around 5% of the total investment in observations was dedicated to support arrangements. It was almost impossible to quantify the overall in-kind/volunteer contributions though some agencies have tried.

2.4.2. Findings

Finding 19. *The current arrangements for resourcing and investing in support for the ocean observing system were problematic. There were issues of prioritisation and misalignment; mismatches between the mission and ambition and available resources; insecurity among the people; and resources spread too thinly over the distributed system.*

Finding 20. *Resourcing and investment should be managed in a more strategic way, with emphasis on the core and long-term sustainability (also see Finding 12).*

Finding 21. *The community has not developed a persuasive case and narrative to support investment in the support structure.*

[40] See the short article by Jesse Ausubel at https://pogo-ocean.org/history/

Finding 22. *Current investors/partners generally believed they were getting good value, but several identified difficulties with the mechanics of making contributions.*

Finding 23. *The community must improve regional engagement and support and enable more productive and purposeful engagement into the national level.*

Finding 24. *Support from the regular budgets of IOC and WMO was likely to be flat in real terms, at best, so other avenues must be explored.*

Finding 25. *The gap in support cannot be quantified at this time. It will be important to use the framework developed in previous sections to develop a budget outline.*

3. Discussion and Conclusions

This study consulted extensively, and we wish to acknowledge and express our appreciation of the willingness of people to volunteer time to contribute to this study. The number of consultations exceeded targets, and all were informative. The instances of misunderstandings were minor and did not compromise the conclusions.

The literature base (both published and grey) was skinnier than expected. IOC historical documents were a valuable resource for following the trail from GOOS inception to the present, but less useful for understanding the requirements and optimal form for support going forward.

The interest and engagement in the OceanObs system has grown enormously since GOOS was formed. The OceanObs conferences, at the 6, 16- and 26-year marks grew by a factor of 2 each time, and the huge capability of the present system bears little resemblance to the prototype launched in the early 1990's.

3.1. Historical legacies

With the power of hindsight, initial steps toward a sustained observing system were misguided and overly influenced by the success of WMO and its culture (operational systems, institutional power, ….). The available intergovernmental powers on the ocean side (mainly IOC of UNESCO) were never likely to be capable of replicating that success, particularly within the constraints of UNESCO and in the absence of a binding convention[41]. Growing new initiatives from scratch within intergovernmental systems was always challenging, but never more so than today when several nations were disengaging. This should be recognized as one of the mitigating factors in the present malaise.

Section 1.2 “Governance frameworks of ocean observing activities” discussed some of the history of GOOS and alluded to some of the issues arising as the OceanObs community extended well beyond the official intergovernmental GOOS. The name GOOS also caused problems because it was used in various ways, even within the official community. The study adopted the name OceanObs[15] to get around that, but that does not address the fundamental problem in the long-term. First, we

[41] Holland and Pugh (2010) discuseds the issues at length (Troubled Water, Cambridge University Press)

observed that WMO recognized three component parts, WIGOS, WIS and the (WMO) GDPFS, and did not have the awkward problem of explaining how a global ocean observing system also included a data system and a modelling/processing/forecasting system. Second, we noted that IOC was often equivalenced to WMO in discussions such as this, which was appropriate, but was awkward when we discussed GOOS since, in theory at least, it was holding the functionality equivalent to WIGOS, WIS and the GDPFS. This awkwardness mapped into the supporting structure in many places. We recognize this matter might be considered beyond the scope of this study, however we judged it important enough to include as a recommendation for consideration of the sponsor. In essence, we considered the following structure (Table 4) would serve the OceanObs community better and remove at least one of the points of confusion for the community (the titles are illustrative only).

Highest level:	World Ocean System, Ocean Partnership, or similar name
Component parts: Observation Data Management Production Application	1. Global Ocean Observing System (observational assets only) 2. Global Ocean Information System (D&IM, including parts or of IODE) 3. Global Ocean Processing, Modelling, and Forecasting System 4. [Applications and services]

Table 4. Possible changed structure for OceanObs.

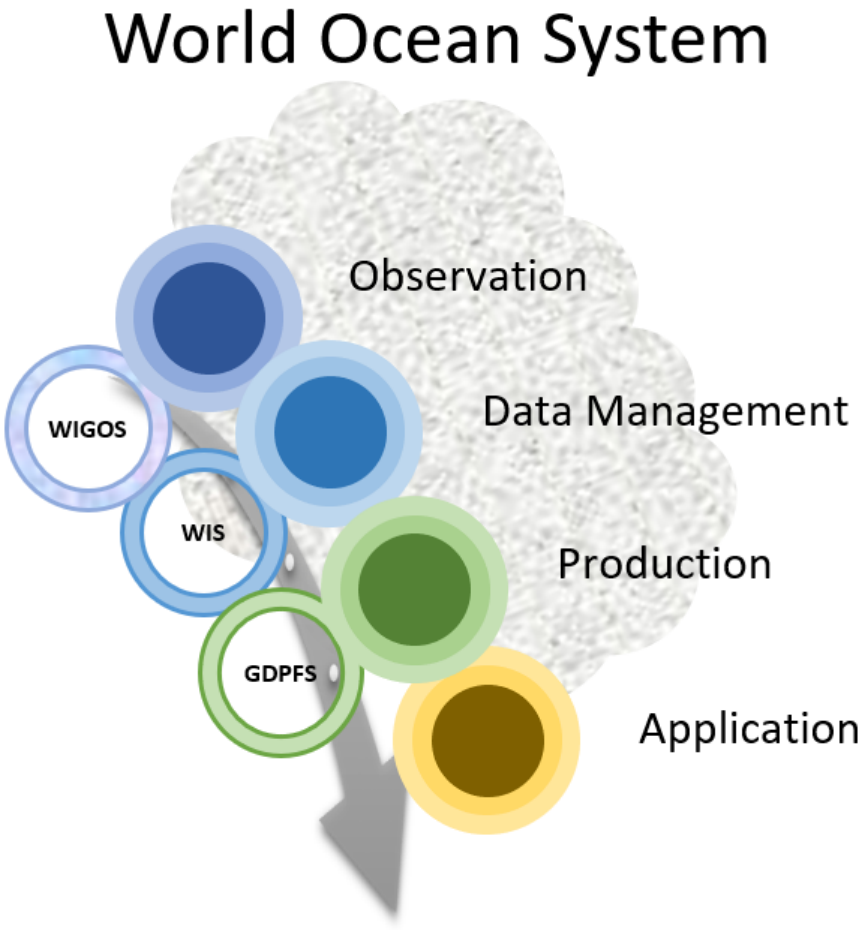


Figure 6. Schematic showing connection and alignment between WMO and a 'World Ocean System'.

Figure 6 presents this schematically; it mimics the WMO structure, not because there was a requirement to do so, but rather because it was a logical construct that could work for operational ocean and ocean research purposes alike and would reduce some of the confusion around the name GOOS. The 3 parts will intersect and have overlaps, just as we see with WIGOS, WIS and the GDPFS, but these can be managed. We also anticipate that in all 3 components there would be overlap with the WMO counterparts, including managing and incorporating activities that were led on the WMO side.

Recommendation 1 *The GOOS community should reconsider its structure within the governance discussions, aligning GOOS uniquely with ocean observation activities, and recognizing a Global Ocean Information System and a Global Ocean Processing, Modelling and Forecasting System as the two other elements of a world ocean system.*

3.2. Synopsis and conclusions from findings

From the published literature and from inputs provided to this study, there was little doubt that the current system was failing. There were pockets of excellence, and irrefutable evidence from the growth of the observation networks that we have made great progress over the last thirty years, yet the system that was supposed to be user driven, integrated, methodical and organised (systematic) fell well short of its objectives, and system support was thin and with limited capacity.

The support structure grew organically while at the same time the core organised around GOOS was unable to scale up to the mission it assigned itself. The result was a distributed architecture that sometimes coped locally but was unable to act as a coherent, single system.

The terms of reference for this study (Attachment 1) focused on support functions and excluded the broader concerns of governance (see section 0). However, the findings summarized in Attachment 9 and the recommendation above inevitably encroach into governance; we could not find a way of fully responding to our charge without doing so. Our conclusions hopefully are relevant to governance policy development but not prescriptive.

3.2.1. National engagement

While national focal points were part of the GOOS architecture almost since inception, the evidence from consultations was that the system of focal points were failing to deliver. Moreover, the OceanObs community failed to engage and communicate clearly with nations or to have the influence and impact on national policy settings envisioned in its ambition. This lack of upward impact was replicated elsewhere.

Recommendation 2 *A plan for rejuvenating national engagement should be developed, including for communicating progress with all parts of the support structure. Communiques should be issued immediately upon the conclusion of any major activity (e.g., Committee or Panel meetings) to inform stakeholders of areas of discussion and decisions to create a sense of timely action. Such activity was at best only partly resourced as part of the present support structure.*

3.2.2. Regional engagement

We found strong support among correspondents for retaining regional support structures, but the feedback also echoed the Moltmann et al (2019) paper [31] which concluded the role of GOOS Regional Alliances remained an outstanding issue. Given both IOOS and IMOS were in effect national alliances, only EuroGOOS can be put forward as a strong and successful model for regional collaboration and coordination of support, despite significant efforts elsewhere.

We concluded regional networks should be recognized as an element of the architecture when and where it was clear they provided advantage and value in terms of the six pillars (objectives) of the support structure (section 2.2 and Figure 4). There were two clear cases where such advantage and value might prevail.

The first was in situations where the region (or basin) brought unique phenomenological considerations into play, directly influencing design, requirements, and optimal solutions (the Figure 7a model). TPOS 2020, IndOOS and SOOS were three such examples. TPOS 2020 was a stakeholder intervention whose objectives were to redesign and reset the TPOS. It cut across domains (physical, climate and biogeochemistry) and covered the end-to-end system (observation, data management, and modelling and prediction), including full consideration of user requirements and their implications for the system. TPOS 2020 worked in the same space as the domain Panels and provided support aligned with all six pillars. The project was now evolving to the implementation phase, thus intersecting more directly with the activities of the Ocean Coordination Group.

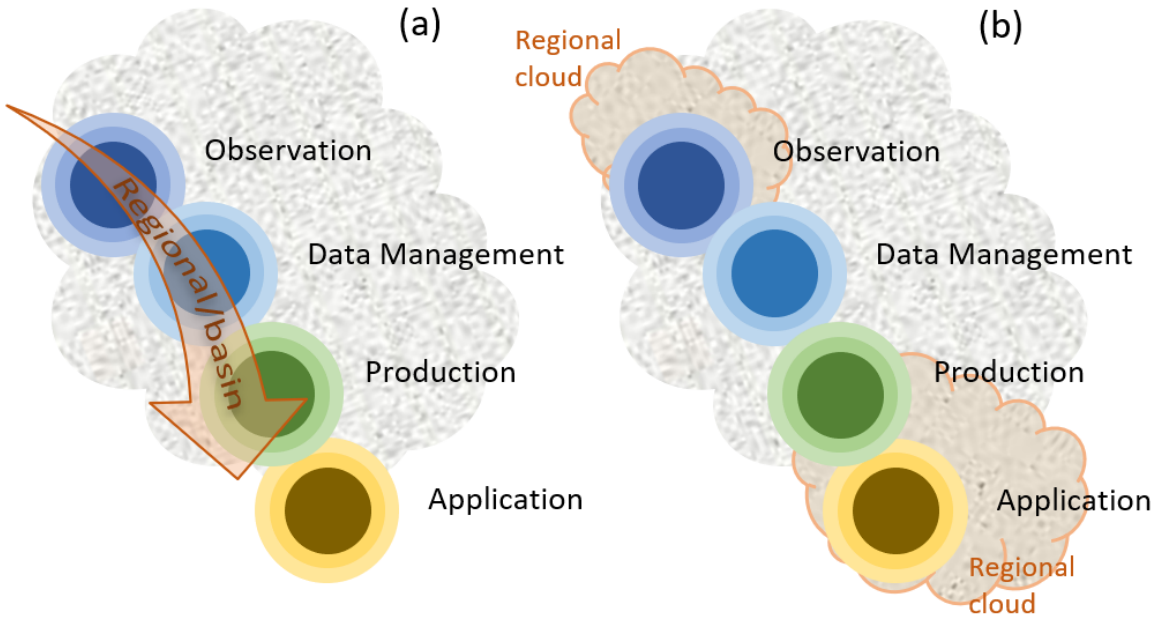


Figure 7. Two examples of regional support. (a) the support cuts across the system and focuses on a basin for scientific reasons; (b) regional networks formed for geopolitical reasons with strong interfaces to users.

The second situation, and the one most referred to in consultation, was where a regional network was acting at and effective at the regional user/societal interface, enhancing engagement and

uptake (Figure 7b). They were often based on geopolitical considerations; EuroGOOS and PI-GOOS were two such examples. Their value was at the edges/interfaces of the 'cloud of support' and were not necessarily strong across all the pillars and aspects of the support structure. Some regional networks also rendered advantage through capacity building and training actions. The GRAs were typically of this type, but as Moltmann et al (2019) noted, questions remained around the advantage and value of individual GRAs.

Recommendation 3 *Regional networks should be recognized as part of the support structure when and where they offered advantage and value for implementing the six pillars of the support strategy and for regional user/societal engagement.*

3.2.3. The role of research and associated support

The research community and scientists were variously categorized as the saviours and lifeblood of the system (strength comes from bottom-up), or as existential threats to an orderly, planned, integrated system for societal benefit (too much bottom-up influence). Several correspondents presented examples where the research community has contributed valuable support (for example, the CLIVAR Office support for IndOOS) and presented models for effective partnerships that we might adopt. As noted earlier, the roots of GOOS can be traced to the world experiments of the 1980's and 1990's and so it should come as no surprise that the research community remained strongly engaged in governance discussions and the future of ocean observing. We concluded that a harmonious balanced approach was needed, with the need for research infrastructure recognized alongside operational users on the output side, and research- and operationally supported elements on the input side. For the latter we do not consider coordination of research activities as in scope but acknowledge that experimental and ad hoc research output (input for the OceanObs system; see section 1.3) was useful, particularly for testing, validation, and design.

Recommendation 4 *Experimental and ad hoc research contributions to observations, data and information management and modelling and forecasting should be recognized, but not necessarily coordinated through the support structure. Research use of products and system services should be captured in the user and uptake strategy.*

3.2.4. User engagement and uptake

Engagement and dialogue with users remained a work in progress, despite the emphasis in the FOO and in the GOOS Strategy. There were instances where the end-to-end chain was managed well (for example, CMEMS and EuroGOOS in Europe; IMOS in Australia; IOOS in the USA) but the ocean observing community lacked an effective overall strategy for user engagement. This engagement should build from instances where it was managed well using, for example, real case studies and testimony from existing users. In keeping with the overarching role of research use as a major route to impact, these case studies should include examples where the system has been used in the form of research infrastructure, for example for assessing the rates of climate change. Consideration should be given to developing a champions or reference group to foster user engagement and uptake.

Recommendation 5 *A plan for show casing user uptake and energising the dialogue and engagement with the user community more generally should be developed. Such an activity was presently not resourced as part of the support structure.*

3.2.5. Capacity building, education, and training

We provided an outline of a possible future architecture for the support system (Figures 2 through 5). The innovations compared with the present structure included (i) a clear demarcation of the scope and principal asset classes of the system (Figure 2b), designated as Level 1 support, (ii) an illustrative architecture for Level 2, using Observation assets by way of example (Figure 3), (iii) delineation of the primary functionality required of the support system (Figure 4), and (iv) illustration of how the present hub-and-spoke model may be transformed (Figure 5).

We have suggested that capacity building education and training requirements should be identified, but that a bespoke capability should not be built into the architecture of the OceanObs system. However, its absence amongst the pillars (for example, Figure 4) was likely to be a concern for some. Sources of such capability included POGO, IOC, WMO and specific bilateral arrangements. Many correspondents stressed its importance but were less clear on how it should be resourced or organised. That said, it was implicit that the support structure must provide leadership to mobilize resources behind such activities.

Recommendation 6 *A small study group should be formed from the major supporters of capacity building, education, and training to provide guidance on how activities should be identified, prioritised and executed within the framework of support.*

3.2.6. System structure and architecture

Further development of the architecture was beyond the scope of this study but should be undertaken as a matter of priority. An issue that needed to be addressed was the place of applications and value-added services. The outline presented here suggested they were beyond the system, as they were, for example, in CMEMS and IMOS. Recommendation 5 above emphasised the importance of user engagement and involvement in the system but did not explicitly recommend coordination of such activities; rather it implied that the user interface should be managed jointly by users and the observation/information/production systems.

Recommendation 7 *A high-level description of the architecture of the ocean system should be developed and put out for public comment and feedback. The architecture should include clearly delineated observation, information and data management, and production and forecasting elements and a virtual 'cloud of support' that ensured it operated effectively as a system, with effective connectivity internally and externally.*

3.3. Options for future support structures

Based on the findings and the Recommendations above, we outline three options for the future.

(Option 1) Business as usual but reinforced.

This option causes the least disruption with the current governance staying in place, and the support structure persisting in its current form. Recommendation 2, Recommendation 4 and Recommendation 5 should be implemented. Aspects of Recommendation 6 should also be considered.

It would assist stakeholders if the function and form of the current system was better explained and more transparent (the current study provides some guidance), including some simple organograms to explain how the primary parts work together (see Recommendation 7). The Level structure introduced in section 1.3 (A framework for support) might also assist. A dialogue might also be established between GOOS and other leading players to develop a better understanding of relative roles.

Another simple step might be to form a virtual support coordination group among those with higher-level permanent roles. These need not be long sessions (say, 2 hours every 6 months) but would help foster a sense of acting as a single system.

(Option 2) An unknown structure arising from other governance discussions

This retained the status quo while the governance debates ran their course. The backbone organisation model seems to have the greatest potential. If appropriate, some of the actions listed under Option 1 could be taken up. The other action would be to prioritise the governance debate.

(Option 3) A renovated and rejuvenated hub-and-spoke model

The elements of this model have been introduced above and it is the recommended option. To be successful, information sessions and engagement would need to precede any change. A small group could be charged with developing and refining the outline of the support system architecture presented here.

In parallel, a strategy for support should be worked through the community using this study as a basis. Some refinements and improvements of the over-arching structure (Recommendation 1) and Levels and primary pillars (Recommendation 7) might emerge. For each pillar, a set of primary actions should be agreed. These actions should focus on the change, not business as usual. An indicative timeline might accompany the actions list. To guide the actions, the Principles developed by Tanhua et al[1] might be used as a backdrop. That is the changes should be aimed at making the support system more responsive; more purposeful; achieve greater clarity around objectives; more transparent; achieve greater efficiency and effect/impact; more adaptable; improve sustainability; support authoritative processes; and/or improve performance and accountability.

Recommendation 8 *The framework for support should be further developed, along with a 5-10-year strategy based on the guidance provided in this Report.*

Strategic planning is not about taking on more responsibility (scope creep) but improving the overall system. This work must be done prior to any collective approach for increased support; in our view, support will begin to flow once the "house" is in order and is investible.

An additional consideration that might be useful (but beyond the current study) is to attempt to cost and quantify the needs for support. We need to understand what the real ask is now, and what it might be in the future. One step might be to use the 6 pillars to interrogate some of the nodes and networks to (a) understand what they can achieve with present resources; (b) what they might achieve with a modest improvement in resourcing, say 20%; and (c) what ideal resourcing would look like and achieve (some provided indicative numbers through the interviews). With this work we might be better placed to guide stakeholders on the shortfall.

For strategy it is always useful to have a long-term goal and vision, in part to motivate and guide change, but also to provide stakeholders a vision of where the support enterprise is headed. The Decade does provide such an opportunity and it might not be unreasonable to target a complete transformation by 2025.

Recommendation 9 *The community supporting relevant ocean activities should be engaged to renovate and rejuvenate the current hub-and-spoke arrangement, consistent with whatever changes in governance that might be agreed elsewhere and following the other Recommendations and Findings of this Report. The change should be in place by 2025 and follow the roadmap outlined in this study.*

<u>Roadmap Outline</u>

Step 1. Socialize the Executive Summary of this Report among the stakeholders listed in Attachment 6 (and others as appropriate).
Step 2. Form a small virtual steering team from among the stakeholders to guide the initial steps in the process of change.
Step 3. Develop an initial strategic plan for support (Recommendation 8), identifying early actions (those not requiring a major uplift in resourcing) and medium- and longer-term actions and targets.
Step 4. Initiate early actions for Recommendation 2 and Recommendation 5, including communiques on the support structure change.
Step 5. Seek feedback on the proposition at Recommendation 1 and proceed to develop a description of the desired architecture (Recommendation 7), as appropriate.
Step 6. Socialize the outcomes from Steps 1-5. Achievable by Q3 2021.
Step 7. Convene an initial Heads of Support Council to manage the transformation (Q3 2021). This group should be small (around eight members) and be representative of the major stakeholders providing support.
    a. It should provide the outward looking face of the system.
    b. It should not be intergovernmental and should be able to convene for short periods, remotely.
    c. It should have a role and responsibilities like a Board for a major Project or Programme.

d. It should follow the Principles listed earlier: Responsive; Purposeful; Clarity; Transparency; Efficiency and Effectiveness; Adaptive; Sustainability; Authoritative; and Performance Accountability.
e. It should own the high-level strategy and oversee its implementation.
f. IOC and WMO would be ex-officio members and it would have an independent Chair in addition to the members.
g. There should be an open call for the 6 seats at large, with voting rights at least partly, if not wholly proportional to the weight of investment in the support structure.

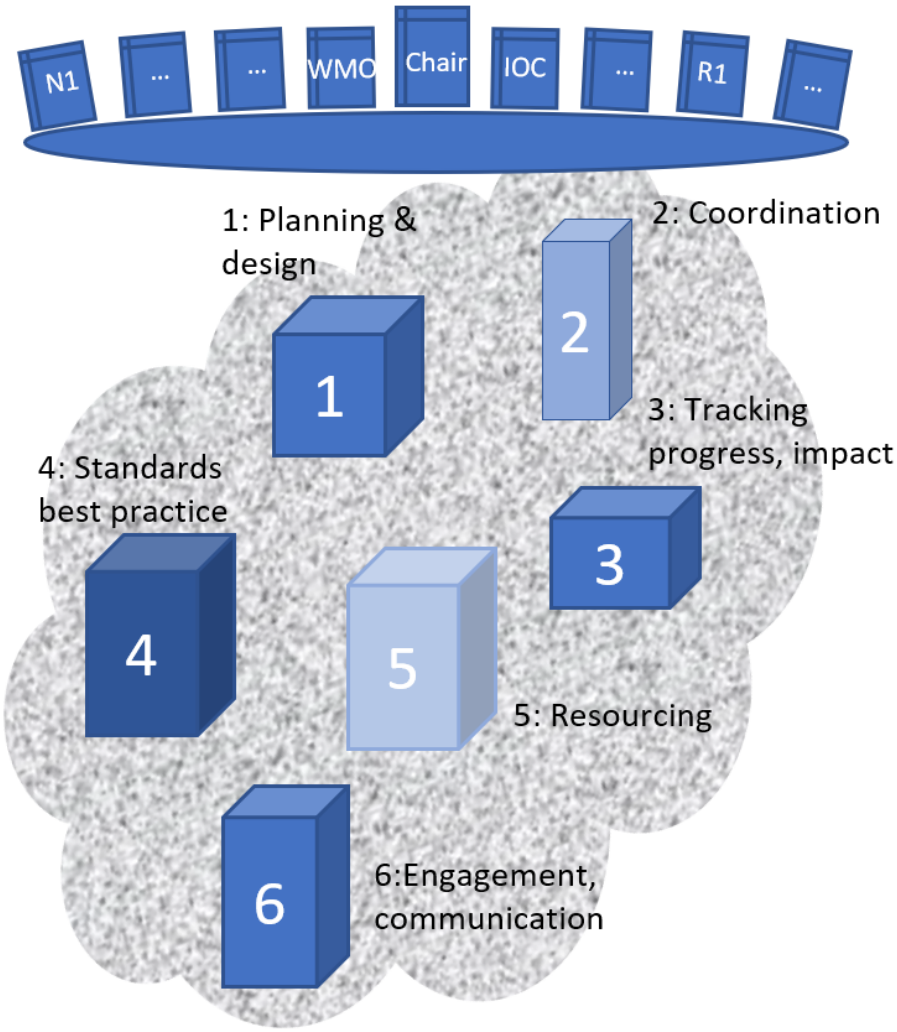


Figure 8. Schematic of the conceptual Heads of Support Council set against the strategic pillars. Members might be drawn from regional or national stakeholders.

Step 8. Develop costings for the support structure. On the basis of consultations, we expect it to be around 5% of the total cost of the system.

4. Closing remarks

This study has yielded insights into the evolution of the support structure from its early days connected to GOOS, to now where there are multiple hubs and the connection to GOOS is fractured. We recommend a path forward that recognizes the realities of the circumstances and broader context of ocean observing activities; this path necessarily steers us away from a central intergovernmental structure to one where all partners are recognized and engaged in supporting the endeavour. IOC and WMO remain central and play key roles, but they are joined by others in a structure that is more agile and flexible but also authoritative and accountable.

Reform and transformation will not be easy, but the prize will be a support structure that is fit for purpose, right sized and appropriately resourced. Efficiency will be important to make and sustain an investible structure. The risks of not acting are significant. The weaknesses, fragmentation and loss of authority and credibility are trending in the wrong direction, despite major advances in the observing system itself. This study found no evidence that the issues would be self-correcting, or that the various governance discussions would necessarily deliver a solution. The importance of the ocean, and ocean observing, are trending in the right direction and we in the ocean community have a responsibility to act now while we can and while there was a unique opportunity for reform.

Attachment 1 Terms of Reference for Study

Aim: To study the form and function of support provided to global and regional ocean observing activities and provide options for future transformation.

SCOPE

The consultant will conduct consultations (through interviews or by e-mail) with key support function stakeholders, with a list and general questions to be agreed with the GOOS Office.

The consultations will address:

Form and function of support

- Requirements
- The strengths and weaknesses of current arrangements, including:
    - Effectiveness
    - Efficiency
    - Relevance/fitness for purpose
    - Size (under- or over-serviced)
    - Level (intergovernmental, non-governmental, global, regional)
- Gap analysis and case for change as appropriate
- Conclusions/recommendations for form and functions

An interim report with the findings of these consultations will be shared with the GOOS Office.

The final report will include the following elements:

a) Background on the governance frameworks of ocean observing activities
    a. Existing frameworks and strategies relevant to the form and function of support
    b. Governance arrangements: published studies and a summary of work underway
    c. A brief overview of existing support arrangements, including investment

b) Form and function of support (as above)

c) Strategic change
    a. Assumptions
        i. Implications of possible governance arrangements
        ii. Scope
        iii. Included functionality
    b. The case for change
        i. Objectives and goals of a Change project

        ii. Key actions
    c. Recommendations for a change project

d) Roadmap and implementation plan
    a. Consider opportunities arise from the Decade
    b. Aligning investment and delivery
    c. Key milestones
    d. Supporting transformation of governance, as appropriate

DELIVERABLES

1. Agreed list of stakeholders and questions
2. Results from consultation with key support function stakeholders (following b) in scope).
3. Report from the study described above

Attachment 2 GOOS Office Terms of Reference

[Extracted from the Annex to the 1998 Memorandum of Understanding on the co-sponsorship of the GOOS Steering Committee.]

6. GOOS SECRETARIAT

6.1 The GOOS Secretariat located at the IOC Secretariat shall assist in the promotion, planning, coordination and implementation of GOOS, provide staff support to GOOS Committees and Officers, consistent with resources, and facilitate co-ordination between the GSC and the I-GOOS and with the Secretariats of GCOS and GTOS.

6.2 A Director of the GOOS Secretariat shall be appointed in consultation with the sponsoring organizations.

6.3 The Director and staff of the GOOS Secretariat shall not be assigned duties outside the objectives of GOOS without the specific approval of the sponsoring organizations.

6.4 The Director will be responsible to the Officers of the GOOS Steering Committee and I-GOOS, acting on behalf of the sponsoring organizations.

6.5 The terms of reference of the GOOS Secretariat shall be to assist the GOOS Committees in:

a. The promotion, coordination, implementation and management of GOOS;

b. Identifying the resources needed for GOOS and the means for obtaining them;

c. Developing and updating plans for initiating implementation stages and monitoring the progress of GOOS;

d. Liaising with related research projects and other observing system bodies as appropriate;

e. Conducting public and information activities to promote GOOS.

6.6 Bearing this in mind, the GOOS Secretariat staff, under the responsibility of the Director, shall be charged with:

a. assisting the GOOS Steering Committee in preparing scientifically and technically-based plans for the development of GOOS,

b. providing staff support to the GOOS Steering Committee and its Officers and to the subsidiary bodies established by the Committee,

c. maintaining liaison with the sponsoring organizations and other relevant bodies,

d. maintaining liaison with the I-GOOS and its officers,

e. making arrangements for scientifically and technically-based planning and related co-ordination activities,

f. the preparation of annual budgets for the GOOS Steering Committee activities for approval by the Officers of the GOOS Steering Committee and the sponsoring organizations and for regular reporting on the use of funds made available to the GOOS Steering Committee in accordance with the provisions of section 7 of this Annex.

6.7 The continuity of these arrangements and of the necessary financial support for the GOOS Secretariat staff and planning activities shall be reviewed periodically by the sponsoring organizations and the Officers of the GOOS Steering Committee.

Attachment 3 Excerpt from the 1998 GOOS Prospectus

…

5.7.5 Provision of structural support and expertise

A certain level of structural support and expertise is essential to facilitate the implementation of the GOOS and its two major Themes. As demonstrated in chapters 3 and 4, already substantial, widespread material and intellectual investment has been made in the foundations, planning, design and prototypical elements of the GOOS. These will not be brought together and enhanced to create an effective and efficient operational system without such support and expertise

The tasks can be characterised as:

a. the conduct of international planning and coordination that promotes and enables collective investment, particularly where there are cross-cutting issues to be resolved such as those of data management and the development of a consensus over space-data requirements;

b. ensuring the creation, maintenance and promotion of internationally acceptable operational procedures and practices;

c. facilitating training and other forms of capacity building, noting that this is not an optional add-on but a fundamental objective of the GOOS and essential in a global system being conducted under the terms of the UNCLOS and the UNCED.

…

Whilst it is reasonable to expect the funding of operational activities to be provided through appropriate agency budgets and for science programmes through national science foundations, the funding of support function is less direct. In effect, tasks (a) and (b) are overheads on the operational and research functions that they help to sustain, justified on the basis of the economies of scale and cost sharing, and hence cost saving, that they enable. Task (c) is likely to be funded through national and international development aid organisations, including the World Bank and the Global Environmental Facility (GEF).

Attachment 4 Survey Form

[1] STATE OF SUPPORT ARRANGEMENTS (General observations and perspectives)
Several recent papers suggest OceanObs has (to quote one) "sub-optimal financial and management support levels for many of the [GOOS] efforts".

Do you agree with these views, or have other perspectives on the current state of support arrangements?

[2] ADEQUACY AND EFFECTIVENESS

Delving a little deeper into the responses at [1] (strengths, weaknesses, opportunities, drivers).

- What/where are the strengths and weaknesses of the current arrangements from your perspective?

[3] REQUIREMENTS

We wish to understand the collective requirements for support across OceanObs – the needed functions. They may be specific to global, regional, or local actions, or to networks. The requirements usually take the form of actions and/or functions that span across and are common to participants.

- Based on your experience and knowledge of support requirements, can you indicate which of the following are the primary requirements of support arrangements? [Use the drop-down options. "Yes" if it is a primary requirement; rank, 10 is highest]

(a)	International planning and coordination	**priority**	**rank**
(b)	guiding the vision and strategy	**priority**	**rank**
(c)	coordination and support for the activities	**priority**	**rank**
(d)	tracking metrics	**priority**	**rank**
(e)	creation and maintenance of standards	**priority**	**rank**
(f)	capacity enhancement and training	**priority**	**rank**
(g)	promotion, communication, engagement	**priority**	**rank**
(h)	mobilizing funding to sustain support	**priority**	**rank**
(i)	mobilizing funding for OceanObs	**priority**	**rank**

- Are there other functions/actions that you believe should be included?
- The interface from global activity to national requirements has been a troubled one for GOOS and it poses interesting questions for governance.

  Do you have any views on how the national interface and national requirements should be handled with respect to support?

[4] FORM

Support for OceanObs is currently distributed, coming through multiple centres, generally small.

- Is this form an appropriate and effective response to the requirements? Are there other forms that may bring more integrated arrangements (federated in form, but not necessarily co-located) with improved lines of accountability?

[5] RESOURCING

The community seems to agree that resourcing for support activities for OceanObs is woefully inadequate. We wish to understand the reasons for this.

- Do you agree that resourcing of support functions is poor and, if so, can you provide insights into why this is so and how we may improve the situation?

[6] INVESTMENT

Lines of support require a compelling argument based on need or, if you prefer, a strong business case for investment. Some lines entail greater risk; in other cases, there may be doubts around the return from investment. The complexity of OceanObs and/or its international nature may also pose potential barriers for investment.

- Do you believe a persuasive case for investing in support functions has been made? Where are the risks and barriers to investment?

ANY OTHER COMMENTS

Attachment 5 Interview Questions

[1] STATE OF SUPPORT ARRANGEMENTS (General observations and perspectives)
Several recent papers suggest OceanObs has (to quote one) "sub-optimal financial and management support levels for many of the [GOOS] efforts".

Do you agree with these views, or have other perspectives on the current state of support arrangements?

Type response here

[2] ADEQUACY AND EFFECTIVENESS

Delving a little deeper into the responses at [1] (strengths, weaknesses, opportunities, drivers).

- What/where are the strengths of the current arrangements from your perspective?

  Type response here

- Where are the weaknesses and failures?

  Type response here

- Follow-up if appropriate: To what extent is the quality, extent and effectiveness of support simply driven by the level of financial support? If we could triple investment in support would it all be OK?

  Type response here

- Are there missed opportunities to implement and/or strengthen support within the current OceanObs governance arrangements?

  Type response here

[3] REQUIREMENTS

We wish to understand the collective requirements for support across OceanObs – the needed functions. They may be specific to global, regional, or local actions, or to networks. The requirements usually take the form of actions and/or functions that span across and are common to participants. The requirements of individual nations are out of scope, but we do wish to ask a question around the OceanObs-national interface.

- Based on your experience and knowledge of support requirements, can you indicate which of the following are the primary requirements of support arrangements?

[Use drop downs. "Yes" if it is a primary requirement; rank, 10 is highest]

(a)	International planning and coordination	**priority**	**rank**
(b)	guiding the vision and strategy	**priority**	**rank**
(c)	coordination and support for the activities	**priority**	**rank**
(d)	tracking metrics	**priority**	**rank**
(e)	creation and maintenance of standards	**priority**	**rank**
(f)	capacity enhancement and training	**priority**	**rank**
(g)	promotion, communication, engagement	**priority**	**rank**
(h)	mobilizing funding to sustain support	**priority**	**rank**
(i)	mobilizing funding for OceanObs	**priority**	**rank**

- Are there other functions/actions that you believe should be included?

  Type response here

- The interface to national requirements has been a troubled one for GOOS and it poses interesting questions for all the governance models being considered at present.

  - Do you have any views on how the national interface should be handled with respect to support?

    Type response here

  - What function/sub-functions should be added? [For example, establishing and maintaining best practice guidelines for national organisation].

    Type response here

[4] FORM

Support for OceanObs is currently distributed, coming through multiple centres, generally small.

We wish to discuss whether this is an appropriate response to the requirements and whether there are options for more integrated arrangements (federated in form, but not necessarily co-located) with improved lines of accountability.

- Is the current distributed model effective and efficient?

  Type response here

- Do you believe integration across the distributed efforts is adequate?

  Type response here

- Is this form a natural consequence of minimalist and/or ad hoc (short-term) financial arrangements?

Type response here

FORM OF ACCOUNTABILITY: The distributed nature leads to mixed lines of accountability. For support that is part of the IOC or WMO secretariat there is a clear line of accountability through the Executive Secretary and Secretary General, respectively, and they in turn are accountable to their respective governing bodies. The influence of Member States/Members is in a collective sense, irrespective of the contributions. For support sitting outside the Secretariats, the lines of accountability are quite different. Other models might be possible.

- Are the current lines of accountability clear and effective and, if not, what steps should be taken to improve them?

  Type response here

- [If appropriate] Is there an alternative form that we should consider?

  Type response here

[5] RESOURCING

The community seems to agree that resourcing for support activities for OceanObs is inadequate. We wish to understand the reasons for this.

- Do you agree that resourcing of support functions is poor and, if so, can you provide insights into why this is the case?

  Type response here

- From your perspective what is needed to improve resourcing for collective community support? [e.g. roadblocks, barriers]

  Type response here

[6] INVESTMENT

Lines of support require a compelling argument based on need or, if you prefer, a strong business case for investment. Some lines of investment entail greater risk; in other cases, there may be doubts around the return from investment. The complexity of OceanObs and/or its international nature may also pose potential barriers for investment.

- Do you believe a persuasive case for investing in support functions has been made? Are there risks and barriers to investment?

  Type response here

- If you (or your agency/nation) are investing in support, do you feel you are getting a good return on your investment and, if so, what is the message you would convey to others to encourage them to join?

  Type response here

- Possible follow-up: Are you likely to increase or decrease your support over the next decade? What are the primary reasons?

  Type response here

[7] OPTIONAL

Several alternative governance models are currently being discussed including the Collective Impact model (Ocean Partnership for Sustained Observations, Weller et al (2019)) and the polycentric multi-level model (Tanhua et al); both were discussed and debated at Ocean'19 along with the current governance arrangements (which might be characterised as a loosely coupled hybrid of top-down and bottom up arrangements).

Do you support any of these new models for OceanObs/GOOS governance, or have an alternative? Note this information is only for this support function discussion.

Type response here

Attachment 6 List of correspondents

Name	Position	Institution/Group	Role
David Legler	Director	NOAA	Interview 1
Tim Moltmann	Ex Chair GRAs		Interview 2
Dr. Sophie Seeyave	Chief Executive Officer	POGO	Interview 3 and survey 3
Michelle Heupal	Director	IMOS, Australia	Interview 4 and survey 5
John Gunn	Past Chair GSC	IMOS Chair	Interview 5
Toste Tanhua	Co-Chair	GOOS SC	Interview 6 and survey 1
Masao Ishii	Co-Chair	BGC/IOCCP Panel	Interview 7
Kim Currie	Co-Chair	BGC/IOCCP	Interview 7 and Survey 14
Maciej Telszewski	Head	BGC/IOCCP Panel Office	Interview 7 and survey 8
Sabrina Speich	Co-Chair	OOPC	Interview 8 and survey 11
Dr Weidong Yu	Co-Chair	OOPC	Interview 8 and survey 10
Eric Lindstrom	Research Scientist	Saildrone	Interview 9
Pierre-Yves Le Traon	Research Director	CMEMS/Mercator Ocean	Interview 10 and survey 12
Takeshi Kawano	Director-General	RIGC, Japan	Interview (written)
Lisa Beal	Co-Chair	IndOOS/IORP	Interview 11
Gabrielle Canonico	Co-Chair	Biology/Ecosystem Panel	Interview 12
Nic Bax	Co-Chair	Biology/Ecosystem Panel	Interview 12
George Petihakis	Chair EuroGOOS Board	EuroGOOS/HCMR,Greece	Interview 13 and Survey 22
John Siddorn		Met Office	Interview 14 and survey 19
Ed Hill	Director	NOC, UK	Interview 14 and survey 19
Matt Palmer	UK National GOOS	NOC, UK	Interview 14 and survey 19
Katy Hill	Marine Science Co-ordinator	NOC, UK	Interview 14 and survey 19

Patricia Miloslavich	Director	SCOR	Interview 15 and Survey 27
Susan Wijffels	Co-Chair	Argo	Interview 16
Craig McLean	Assistant Administrator	NOAA	Interview 17 and survey 29
Prof. Dwikorita Karnawati	Director	BMKG	Interview 18
Nelly Florida		BMKG	Interview 18
Anthony Rea	Director, Infrastructure Division	WMO	Interview 19
Ghada El Safrey	Member Champion Group, CMEMS	Delft	Interview 20
Anja Waite	Co-Chair	GOOS SC	Interview 21
Carl Gouldman	Director	US IOOS	Interview 22
Vladimir Ryabinin	ES	IOC/UNESCO	Interview xx and survey 26
Feng Jun (Jeffery)	Deputy Director	MNR, China	Survey 32
Dr. WANG Dakui		Nmefc/MNR	Survey 32
Rick Lumpkin	AOML GDP management	AOML, Miami USA	Survey 15
Johannes Karstensen	Project Coordinator	Atlantos	Survey 7
Brad de Young	Project Coordinator	Atlantos	Survey 6
Boris de Witte		CLIVAR	Survey 24
Andrea McCurdy	ex support staff	DOOS	Survey 28
Patricia de Rosnay	Scientist	ECMWF	Survey 13
Iain SHEPHERD	DG-MARE	EOOS/H2020 EuroSea	Survey 3
Emily Smail	Blue Planet	GEO	Survey 25
Martin Visbeck	Chair OceanObs'19; member ISC Board	GEOMAR	Survey 4
Ann O'Carrol	Chair	GHRSST Project Office	Survey 9
Jorge Manuel Paz Acosta	Chair	GRASP	Survey 21
Monika Breuch-Moritz	Vice-Chair region I	IOC	Survey 20
Kirsten Wilmer-Becker	Manager	Ocean Predict Office	Survey 23
Nick D'Adamo	Head	Perth Programme Office	Survey 16
Brett Moloney	Scientist & IOGOOS officer	CSIRO	Survey 18

Jon Turton	Marine Obs	Met Office	Survey 19
Penny Holiday		NOC	Survey 19
Maria Hood	Consultant	GOOS Office	Survey 17 Part 3 only
Ray Schmidt	Principal	Collective Impact initiative	Comments
Dr Louise Newman	SOOS Executive Officer	SOOS	Survey 30
Jim Baker	Principal	Collective Impact initiative	Comments
Sylvie Pouliquen	Head In Situ TAC, Coriolis	IFREMER	Comments
Breck Owens	Director	Argo Support Office	Point of contact
Inga Lips	Secretary General	EuroGOOS	Point of contact
Katsia Paulavets		Int. Council of Science	Point of contact
Mike Sparrow	a/Director and research	WCRP	Point of contact
Kerry Sawyer	CEOS Executive Officer	CEOS	Potential survey
Patrick Heimbach	Co-Chair	DOOS	Potential survey
Nadia Pinardi	Individual	Ex JCOMM; modelling	Potential survey
Muthalagu Ravichandran	Head	Indian Ocean GOOS	Potential survey
Mika Odido	IOC Coordinator in Africa	IOC	Potential survey
Ariel Troisi	Chairperson	IOC	Potential survey
Alexander Frolov	Vice-Chair region II	IOC	Potential survey
Cesar Toro	Head	IOCARIBE, IOC	Potential survey
Mathieu Belbeoch	Lead/Argo tech Coordinator	OceanOPS	Survey 31
Wenxi Zhu	Head	WESTPAC Office, IOC	Potential survey
Alban Lazar	scientist Africa, Latin America		Potential survey

Attachment 7 Additional requirements/functions

This list is generated from interviews and feedback in the surveys. Some editing and rationalisation has been applied. All should be interpreted within the context of support arrangements. For example, a(iv) should be read as "Support for sensitivity and impact testing and evaluation".

a) Support system design, evaluation, sensitivity and impact studies
    i) Expansion of information services which shows the value of investment. [would rank this as the top priority]
    ii) Promote and encourage a transparent/traceable ocean observing that ultimately allows to exactly determine which observational data point contributed to an observing product
    iii) Coordination on assessments of benefits of ocean observations (economic value, impact)
    iv) Sensitivity and impact testing and evaluation
    v) Commitment to the rigor of the scientific method: supporting science that improves the effectiveness, efficiency and impact of the observing system
b) National engagement (two-way)
    i) Science – national Policy interface
    ii) System: national interactions: national focal points
    iii) National engagement; national comporting more with regional
        (1) E.g. PANELS SHOULD AGREE A COMMUNIQUE AT THE END OF THEIR MEETINGS TO SUMMARISE WHAT THEY HAVE ACHIEVED
        (2) Could provide models for national action; best practices; guides
        (3) Must reach into users
        (4) Have the GRAs helped?
c) Intergovernmental relationships
    i) Science - Policy interface
d) The user interface
    i) Building interactions with users
    ii) Manage the data systems to yield societal benefit
    iii) Improving the interface with the user. If the data is only used for scientist to make more papers rather that to solve specific societal needs, the support from governments may fall
e) Data exchange
    i) Dissemination on the GTS
    ii) Data, adequate guidance and appropriate data management structures
    iii) Interoperability, quality and data flow
    iv) Data, adequate guidance and appropriate data management structures.
    v) Extending JCOMM OPS to Ocean OPS: missing non-physical networks
        (1) Importance of the Information Centre concept at Level 3
    vi) Support for transforming the data systems – FAIR and improved data exchange, and coordination to enable more efficient access to all data: standardisation
f) Innovation
    i) Developing and formalizing linkages/interfaces to existing infrastructure and expertise (DOOS)

ii) Innovation, support and coordination - having specs that are fit for GOOS purpose.
iii) Support/framework for emerging networks and/or technology: MBON, DOOS, …
    (1) The SCOR WG methodology might be a way to prioritise
    (2) Many developing countries are "emerging" also
iv) Taking advantage of innovation to reduce call on human resources, e.g. far more remote conferencing/meetings.
v) Innovation, support and coordination

g) OTHER
i) Regional foci
ii) Logistics, eg of volunteer ships
iii) Need for a support strategy
iv) Briefing/induction to manage the high turnover of personnel and volunteers.
v) advocacy and identifying gaps. Moving activities away from science to sustained groups;

Attachment 8 Required functionality of a future support structure

(a) Planning and design

- Includes vision and strategy, and understanding of user requirements
- Mainly global or regional; can be for scientific themes or specific assets.
- Informed by sensitivity and impact studies, cost benefit studies, research
- For Level 1 the focus is on strategy and should include specific targets; also responsible for overall architecture (form) of the OceanObs System
- For Level 2 the focus shifts toward detailed design and implementation: identifying requirements for Observations; agreeing strategy and implementation plans for response; working with the research community will be vital.

(b) Coordination

- Level 1 includes intergovernmental actions; managing the science policy interface; national interface (high-level, and regional); coordination of players acting at Level 1; liaison with the user community wrt requirements; liaison with and providing requirements to CB&T and education centres of excellence; managing high-level risks and issues.
- At Level 2 the focus shifts to coordination and support of activities, within Asset Classes and across asset classes and with Level 1 activities; national interface (more technical); working with the research community will be vital; interoperability, QC/QA and FAIR; CB&ET needs communicated and consolidated upwards; issues and risks managed and elevated as appropriate
- Innovation: Develop pathways and support frameworks for innovation, emerging networks and/or technology; provide feedback on readiness;

(c) Tracking progress and impact

- At Level 1, following progress relative to the strategic plan; Building interactions with users; consolidating high-level feedback from the user community; review of Asset Class progress and progress relative to thematic plans;
- At Level 2, promoting impact studies (products user impact; effectiveness of data management; observation impacts for products and users); tracking progress of implementation (technical – OceanOPS - and relative to strategy);
- Establishment of user forums and/or reference groups (all Levels)

(d) Developing, setting and maintaining standards and best practice;

- Standard operating procedures, validation, quality control and verification
- An organised library of documentation and references.
- Models for services, user interaction
- At Level 1, documented and agreed plans with both user and bottom-up endorsement/buy-in; FOO; support framework; agreed cycles for planning, review etc.; intergovernmental endorsement as appropriate;
- At Level 2, sets of documentation on standards and best practice within sub-systems/Classes with buy-in from asset managers; etc. (NB: each Asset Class will have specific needs); working with the research community will be vital.

(e) Resources and Investment

- Aim for a single OceanObs System plan, or tightly coupled and consistent plans;

- Level 1: Take the lead on managing the overall resources for core support activities and subsidiary actions; maintain a resource and investment strategy and annual and longer-term plans for support, including costed requirements.
- Level 2: Contribute to Level 1 plans wrt sub-systems; coordinate and facilitate resources and investment in specific assets (capital expenses; maintenance and operation) and experimental projects (working with the research community will be vital).

(f) Engagement and communication

- Manage engagement and communication that enables (a) – (e) above.
- Introduce innovation to reduce THE call on human resources, e.g. far more remote conferencing/meetings.
- Briefings/induction to manage the risk from high turnover of personnel and volunteers
- Level 1: responsible for all high-level interactions (upward and downward)
- Level 2: manage with provides and users of the capability/asset and more specifically with relevant R&D and innovation groups

<u>By Level</u>:

Each level delivers support across 6 different areas: (1) Planning and design; (2) Coordination; (3) Tracking progress and impact; (4) Developing, setting and maintaining standards and best practice; (5) Resources and Investment; and (6) Engagement and communication

Level 1

- Focus is on strategy and should include specific targets; also responsible for overall architecture (form) of the OceeanObs System
- Coordination of intergovernmental actions; managing the science policy interface; coordination of players acting at Level 1; liaison with the user community wrt requirements; liaison with and providing requirements to CB&T and education centres of excellence; managing high-level risks and issues.
- Following progress relative to the strategic plan; consolidating high-level feedback from the user community; review of Asset Class progress and progress relative to thematic plans;
- Establishment of user forums and/or reference groups (all Levels)
- An organised OceanObs System of documentation and references.
- Documented and agreed plans with both user and bottom-up endorsement/buy-in; an OceanObs FOO; agreed cycles for planning, review etc.; intergovernmental endorsement as appropriate;
- Take the lead on managing the overall resources for core support activities and subsidiary actions; maintain a resource and investment strategy and annual and longer-term plans for support, including costed requirements.
- Manage engagement and communication that enable the above.; responsible for all high-level engagement and communication (upward and downward)

Level 2

- Implementation: identifying requirements for Observations; agreeing strategy and implementation plans for response
- Focus shifts to coordination and support of activities, within Asset Classes and across asset classes and with Level 1 activities; interoperability, QC/QA and FAIR; CB&ET needs communicated and consolidated upwards; issues and risks managed and elevated as appropriate
- Promoting and coordinating impact studies (products user impact; effectiveness of data management; observation impacts for products and users); tracking progress of implementation (technical and relative to strategy);
- Establishment of user forums and/or reference groups
- Documentation on standards and best practice within sub-systems/Classes with buy-in from asset managers; etc. (NB: each Asset Class will have specific needs).
- Contribute to Level 1 plans wrt sub-systems; coordinate and facilitate resources and investment in specific assets (capital expenses; maintenance and operation) and experimental projects;
- Manage engagement and communication with providers and users of the capability/asset

Attachment 9 Summary of findings

Finding 1. General health of support structures: The survey and interviews revealed pockets where the support structure was seen to be working well and serving requirements within a specific area of operation. Elsewhere, performance and achievement were less satisfactory and uneven, in part through lack of resourcing, but also in part because of the nature of the support (e.g., fractionated, disconnected, complex).

Finding 2. People: Consultations revealed a strong appreciation of the effort of individuals within the support structure, and of the agencies contributing resources and effort. However, it also revealed significant pressures arising from an unreasonably heavy workload, short-term outlooks, and unreasonable expectations in terms of delivery.

Finding 3. Effectiveness: The current support structure was effective in some areas but in general was not meeting expectation for the vision and mission of GOOS, or for the OceanObs community more generally.

Finding 4. Efficiency: The efficiency of the support structure was compromised by the fragmented approach and insecure lines of support, particularly in core areas where small resources were being spread thinly over many different tasks.

Finding 5. Relevance and functionality: The response to support requirements was patchy, with some aspects served well, and others not. There were clear gaps in parts of the cycle, specifically around data systems and model/production systems. The interface to national activities and users was also poorly served.

Finding 6. Extent: The present effort was estimated to include around 53 FTE, but this was poorly documented with no record of operational expenditure or volunteer/in-kind efforts. Unmet requirements were often partially picked up by volunteers, partially masking the extent of the gap for core priority functions.

Finding 7. Architecture of the support system: The support structure was built in an ad hoc bottom-up manner and there was no master plan or agreed priorities across GOOS, or the OceanObs community more generally. This led to confusion around roles, responsibility, accountability, leadership, and cross-support system engagements and coordination. There were also important functional gaps across the end-to-end system and across networks.

Finding 8. Impact and national connections: The survey found upward impact, into UN conventions and related fora and into national policy and decision-making arenas to be poor. The system of national GOOS focal points appeared dysfunctional.

Finding 9. Structure. Stakeholders found the existing support structure complex and lacking transparency. A strategy should be developed that clarifies the architecture and primary goals of the support arrangements.

Finding 10. Priorities. This study found that (i) planning and coordination, (ii) vision and strategy, (iii) creation and maintenance of standards, and (iv) coordination and support for activities were ranked highest among potential activity areas for support.

Finding 11. Capability and capacity. Capacity building, education and training were identified as important for the ocean observing system, and thus prioritised for support. This study suggested that needs should be determined by OceanObs but met by external providers rather than building a bespoke programme into the ocean observing system.

Finding 12. Mobilising support. The mobilization of resources and investment for support should be managed in a more strategic way, with greater focus on the whole, rather than on the many different individual actions spread over Levels 1, 2 and 3 activities. The mobilisation should be supported by a strategic plan, with agreement on priorities (also see Finding 20).

Finding 13. Mobilising resources for major assets. In general, the business cases/proposals for assets that comprise the core of the ocean observing system (observations, data management and modelling/production) should be developed and argued at the national and regional level, not by the OceanObs system support structure. The latter should focus on coordination and facilitation within the scope of the overall aims.

Finding 14. The present form can be likened to a hub-and-spoke model, with one hub arranged around GOOS, and secondary hubs and other centres of action (nodes) sitting on the spokes. The weakness of the spokes and the lack of clarity around the relative responsibilities of hubs and node blunted the effectiveness of the model.

Finding 15. No viable alternative to the hub-and-spoke model emerged through consultations though we were aware of interest in so-called Backbone Organisation constructs.

Finding 16. The present structure has not fulfilled the requirements of the community and appeared unsustainable. It lacked authority, clarity and transparency, and its effectiveness and efficiency were unsatisfactory for many stakeholders. For some it was not investible.

Finding 17. While several of the values brought to the structure by the intergovernmental partners were highly valued, many believed the ocean observing system cannot prosper and be sustained if it remained wholly within the current intergovernmental GOOS support structure. A hybrid hub-and-spoke model was the favoured alternative, with improved clarity and transparency around different roles, responsibility, and accountability.

Finding 18. Several gaps were identified though some were better considered as governance issues. In terms of support, the following were in need of urgent attention:
* Support for data management assets as part of the system;
* Support for implementation beyond the scope of the former JCOMM;
* Technical support similar to that provided by OceanOPS for emerging areas; and
* More effective regional centres of support.

Finding 19. The current arrangements for resourcing and investing in support for the ocean observing system were problematic. There were issues of prioritisation and misalignment; mismatches between the mission and ambition and available resources; insecurity among the people; and resources spread too thinly over the distributed system.

Finding 20. Resourcing and investment should be managed in a more strategic way, with emphasis on the core and long-term sustainability (also see Finding 12).

Finding 21. The community has not developed a persuasive case and narrative to support investment in the support structure.

Finding 22. Current investors/partners generally believed they were getting good value, but several identified difficulties with the mechanics of making contributions.

Finding 23. The community must improve regional engagement and support and enable more productive and purposeful engagement into the national level.

Finding 24. Support from the regular budgets of IOC and WMO was likely to be flat in real terms, at best, so other avenues must be explored.

Finding 25. The gap in support cannot be quantified at this time. It will be important to use the framework developed in previous sections to develop a budget outline.

Attachment 10 Acronyms

AOML	(NOAA) Atlantic Oceanographic and Meteorological Laboratory
BGC	Biogeochemistry/biogeochemical
BMKG	Badan Meteorologi, Klimatologi, dan Geofisika (Meteorology, Climatology, and Geophysical Agency), Indonesia
CB	Capacity Building
CEOS	Committee on Earth Observation Satellites
CLIVAR	Climate and Ocean: Variability, Predictability and Change
CMEMS	Copernicus Programme. Copernicus Marine Service
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DOOS	Deep Ocean Observing Strategy
ECMWF	European Centre for Medium-Range Weather Forecasts
EOOS	European Ocean Observing System
FAIR	Findable, Accessible, Interoperable, Reusable
FGGE	First GARP Global Experiment
FOO	Framework for Ocean Observing
FTE	Full-Time Equivalent
GARP	Global Atmospheric Research Program
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GDPFS	Global Data-processing and Forecasting Systems
GEF	Global Environmental Facility
GEO	Group on Earth Observations
GEOMAR	Helmholtz Centre for Ocean Research Kiel
GEOSS	Global Earth Observation System of Systems
GHRSST	Group on High Resolution Sea Surface Temperature
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GRA	GOOS Regional Alliance
GRASP	GOOS Regional Alliance for the Southeast Pacific
GSC	GOOS Steering Committee
GTOS	Global Terrestrial Observation System
GTS	Global Telecommunication System
HCMR	Hellenic Centre for Marine Research, Athens
HOTO	Health Of The Oceans
ICES	International Council for the Exploration of the Sea
ICS	International Council for Science
ICSU	International Council of Scientific Unions
IFREMER	Institut Français de Recherché pour l'Exploitation de la Mer
IMOS	Integrated Marine Observing System (Australia)
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Sub-Commission for the Caribbean
IOCCP	International Ocean Carbon Coordination Project
IODE	International Oceanographic Data and Information Exchange
IOGOOS	Indian Ocean Global Ocean Observing System Regional Alliance
IOOS	Integrated Ocean Observing System (USA)
IORP	CLIVAR/IOC-GOOS Indian Ocean Region Panel

IPCC	Intergovernmental Panel on Climate Change
ISC	International Science Council
JCB	Joint WMO-IOC Collaborative Board
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JCOMMOPS	Joint Technical Commission for Marine Meteorology in situ Observations Programme Support - now OceanOPS
JGOFS	Joint Global Ocean Flux Study
LMR	Living Marine Resources
MBON	Marine Biodiversity Observation Network
MNR	Ministry of Natural Resources, China
NEARGOOS	Northeast Asian Global Ocean Observing System of WESTPAC
NGO	Nongovernmental Organizations
NOAA	National Oceanic and Atmospheric Administration
NOC	National Oceanographic Centre, UK
OCG	Observation Coordination Group
OOPC	Physics and Climate Panel (formerly the Ocean Observations Panel for Climate)
OOS	Ocean Observing Systems
PI	Principal investigator
POGO	Partnership for the Observation of the Global Ocean
QA	Quality Assurance
QC	Quality Control
RIGC	Research Institute for Global Change JAMSTEC
SC	TPOS 2020 Steering Committee
SCOR	Scientific Committee on Oceanic Research
SDG	Sustainable Development Goals
SEAGOOS	Southeast Asian Global Ocean Observing System of WESTPAC
SOOS	Southern Ocean Observing System
TAC	Thematic Assembly Center
TOGA	Tropical Ocean-Global Atmosphere (programme)
TPOS	Tropical Pacific Observing System
TPOS 2020	Tropical Pacific Observing System 2020 Project
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USA	United States of America
WCRP	World Climate Research Programme
WESTPAC	IOC Sub-Commission for the Western Pacific
WG	Working Group
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment