Notes

THE HYDROGRAPHER OF THE FUTURE
Reflections on an International Virtual Workshop

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Abstract

The Canadian Hydrographic Service (CHS) expects the skillsets of its multidisciplinary hydrographers to evolve as the field of hydrography undergoes a digital transformation. To characterize these changes, the CHS organized a virtual workshop titled *Hydrographer of the Future,* in which it heard the perspectives of international colleagues in other Hydrographic offices (HO's), industry, and academia. Despite some variations, common themes emerged: the changing technological context, people and culture, and the future role of hydrography. The results of this workshop support the CHS' own internal planning; however, the CHS also hopes to continue learning from its international partners and share its experiences through the International Hydrographic Organization's (IHO) e-learning center.

1. Introduction

The CHS multidisciplinary hydrographers are thoroughly trained and responsible for all aspects of data acquisition, data transformation, tides, currents and water levels, and cartography; however, as the hydrographic organization transitions to data-driven products and services, the type of work performed by its hydrographers is likely to change as well. In anticipation, the CHS is trying to envisage the skillset that its staff will require in a totally digital work environment.

Understanding that many hydrographic offices (HO's) and organizations within the hydrographic community are undergoing similar shifts to a digital workplace, the CHS convened an international advisory group who helped the CHS to develop discussion topics for a workshop on the *Hydrographer of the Future* held April 21, 2022.

The CHS' principal aim for the workshop was to hear our international colleagues' thoughts on the skillsets and training required for hydrographers in a more digital work environment to help define the CHS Hydrographer of the Future. In so doing, the CHS hopes to ensure a successful and enduring digital transformation at CHS. Many of the themes (e.g. Technology; People, Skills, and Organizational Culture) that emerged from the workshop, however, would benefit hydrographic organizations, private enterprises, and academic institutions around the world. The CHS was honoured to have provoked and participated in this international conversation and is grateful to all those who participated in the conversation.

The CHS received overwhelmingly positive feedback after the workshop; participants were engaged and interested in actively participating and contributing to small group discussions by sharing their knowledge, experience and ideas. Many participants expressed an interest in continuing the conversation, and so the CHS is sharing its experiences through a workshop report and by way of the publication of this note. The results of the workshop will also act as input to internal CHS planning and a new human resources and training plan.

2. Workshop Overview

The Workshop was a four-hour virtual event in which, after opening remarks and a short keynote address, participants were divided into seven small discussion groups of one Chair, one Rapporteur and between 10 to 15 contributors, each with a topic to help guide the discussion:

1. How will technology enable hydrographers to solve a problem in the future? (two groups discussed this topic)

2. What is in the toolbox of the hydrographer of the future?

3. Do you think that digital transformation will increase the need for specialization or generalization?

4. How do you see the composition of your workforce changing into the future?

5. What are the evolving hydrographer's skills to work effectively in the Blue Economy?

6. How will future larger hydrographic datasets impact changes in data management?

In total, 98 forward thinking individuals who had a keen interest in being part of the changes in the field of hydrography participated in the workshop (**Figure 1**, see next page). Participants were members of HO's, academia, and industry (**Figure 2**) and represented 24 different countries: Australia, Brazil, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Japan, Kenya, Republic of Korea, Monaco, Norway, New Zealand, Oman, Portugal, Singapore, South Africa, Spain, Sweden, Thailand, the United Kingdom and the United States of America.
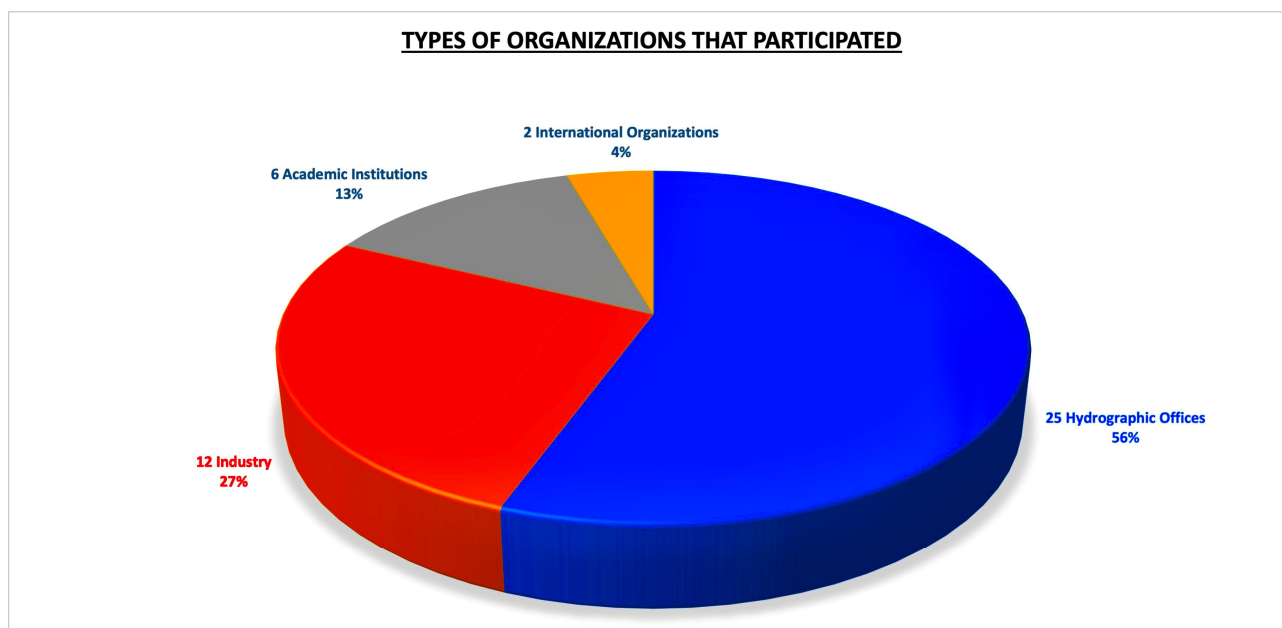

TYPES OF ORGANIZATIONS THAT PARTICIPATED

- 2 International Organizations 4%
- 6 Academic Institutions 13%
- 12 Industry 27%
- 25 Hydrographic Offices 56%

Figure 2. Types of Organizations that participated.

3. Common Themes

Through the many conversations, there was considerable variability in how participants viewed *the Hydrographer of the Future.* This variation contributed to the richness of the discussion and allowed CHS to think more deeply about its own approach to workforce and workplace. Still many common themes emerged that will help guide future conversations and allow CHS to scope out its own internal discussions (**Table 1**). While the focus was primarily on the hydrographer's skill-set, some weight was also given to technical needs and the context in which hydrographers are operating. These themes are discussed below.
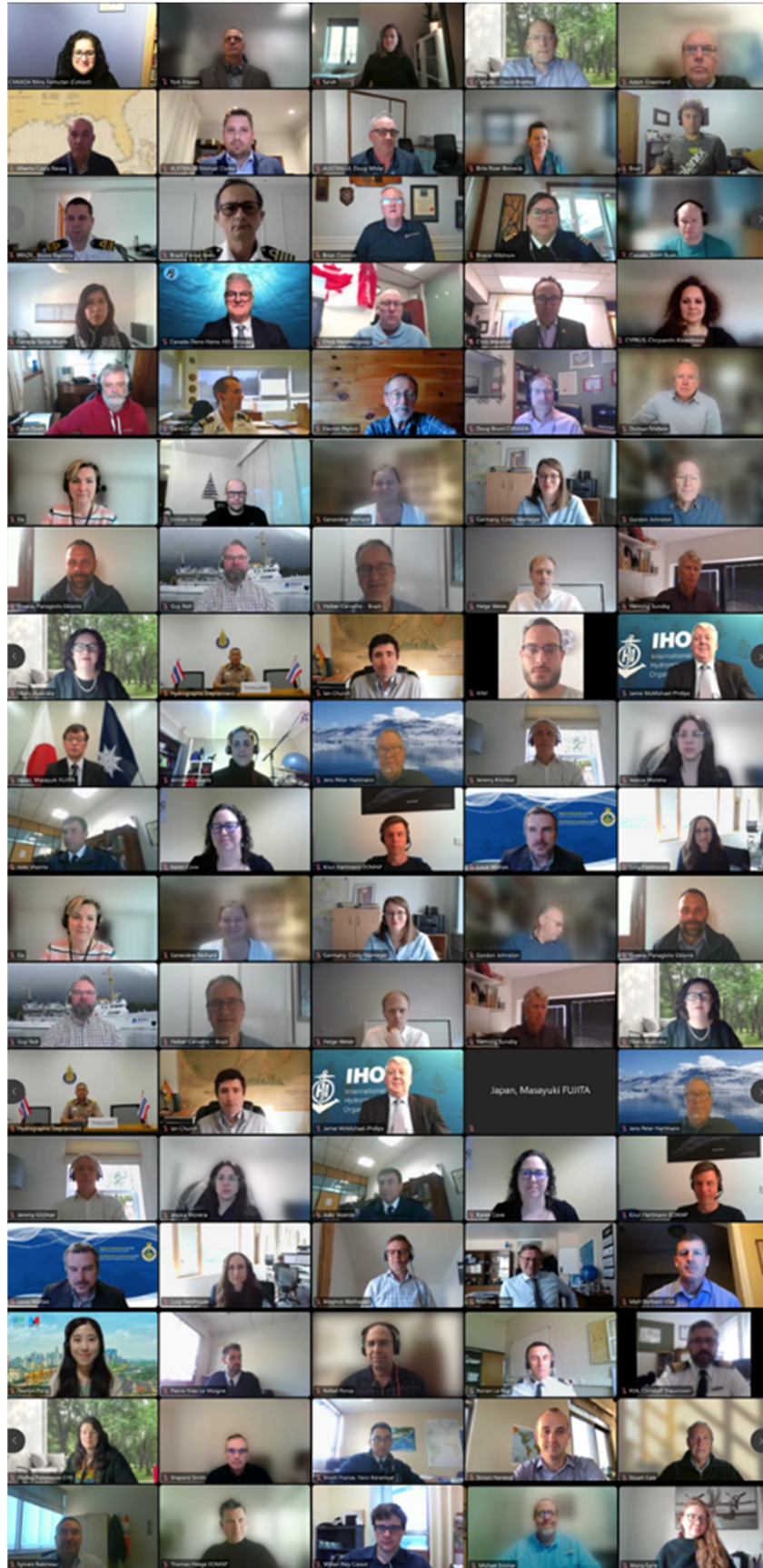
Figure 1. *Photos of participants. Eight participants are absent from the photo.*

3.1 Changing Technological Context

3.1.1 The Evolving Role of the Hydrographic Office

Participants were unanimous in identifying digitalization as the primary driver for change within their respective organizations and many saw an evolving role for their workplaces as the uses and applications for hydrographic data expanded in the context of the Blue Economy (***Table 1***). Despite this commonality, participants' organizations differed in their response to this driver, with their chosen direction determined in part by their national, regional and demographic contexts, as well as their organizational structure.

3.1.2 Technology and Technical Needs

Participants seemed largely to view the role of technology favourably, identifying the possibility that technological advances could fill gaps in data collection, particularly in previously hard-to-reach places or as a force multiplier to increase coverage. The use of uncrewed surface or autonomous vessels came up in many contexts as well as the use of artificial intelligence to support or perform data analysis. Bringing this discussion back to the hydrographer's skillset, some identified the need to contract out for some of these specialized services on an as-needed basis.

3.1.3 Data Management

While technological advances have improved the efficiency of data collection, one large challenge is then dealing with the large volume of data that emerges post-survey. There were many concerns expressed about quality assurance and control of the data, as well as how to store and categorize these data. Defining the authoritative source, as well as thorough metadata and versioning control were identified as important to making fulsome use of the data collected. Storing large volumes of data can be costly and complicated. Organizations will need an underlying system that is properly designed and can handle large datasets. Hydrographic organizations will need to strike a balance between the efficiency gains in data collection and the subsequent burden on the data analysis side.

3.2 People, Skills, and Organizational Culture

3.2.1 The Evolving Role of Humans

In many organizations, the traditional role for staff has been as hydrographer (data collector) or cartographer (chart maker). At CHS, multidisciplinary hydrographers fulfill both roles. Participants were consistent in their view that traditional knowledge, like knowing what makes a good chart, or being able to assess the quality of data collected, will remain important because hydrographers will still need to oversee all aspects of hydrography from data collection to dissemination; however, participants also noted that there will be no single profile of hydrographer in the future. Increasingly HO's will also need hydrographers to be data and project managers. Hydrographers or others within the HO will also need skills in data validation, partnership building and procurement as uses for hydrographic data expand and specialized services are leveraged on an as-needed basis.

3.2.2 The Ideal Hydrographer of the Future – Core Competencies

Recognizing the dynamic environment in which the hydrographic community finds itself, participants predicted that they will need hydrographers with a broad set of skills, though no one hydrographer will need to embody all of the necessary skills the workplace will require. Therefore a team-based approach will be needed to meet the challenges of the future. With that in mind, participants identified the need for individuals who are team oriented, agile and adaptable, problem solvers, innovative, and have a mix of technical and soft skills.

3.2.3 The Hydrographer of the Future – A Generalist or Specialist?

Participants diverged markedly in their approach to recruiting generalists and specialists and even in their definitions of generalists and specialists. Some viewed hydrographers as generalists who then go on to specialize in a sub-hydrographic specialty, like data acquisition, or processing and

others viewing hydrographers themselves as specialists. In addition, though CHS does not distinguish between hydrographers and cartographers, many HO's around the world do, and this is reflected in the separation of the certification at the IHO-level, as CAT A or CAT B. Participants' workplaces also differed in their aims of recruiting generalists and specialists, with some looking to recruit only specialists, particularly in IT, data management, and business. Others were looking only for generalists, and others were looking for a mix of both.

3.2.4 Education and Training

Participants identified that the *Hydrographer of the Future* will need an educational background that provides a base layer of knowledge and then ongoing training to support to help them to adapt to a fast-paced and dynamic work environment, including courses in change management. Participant overall felt that this base level of educations should include courses in mathematics, coding, and geospatial techniques; however, there were differences in whether this base level requirement meant hydrographers or cartographers should have Cat-A or B certification or more unconventional training. Questions arose as to whether the model for capacity building will need to change to be more data-focused, and for the hydrographer to understand uses for hydrographic data beyond navigation. Participants acknowledged the importance of being proactive, to stay on top of change. From several angles, participants narrowed in on the importance of hands-on training to complement the theoretical understanding hydrographers may develop in more traditional course-based programs; e.g. spending time at sea to understand how navigational products are used.

3.2.5 Recruitment, Retention, and Knowledge Transfer

Competition for new hydrographers and IT specialists was a common theme, with participants finding it difficult both to recruit and retain hydrographers. With increasing retirements in some HO's as well as higher staff turnover in general, concerns arose about knowledge retention and transfer. These challenges appear to directly influence the educational requirements set by different workplaces as well as the approaches of these workplaces to ongoing training. With many organizations broadening their educational requirements to meet their staffing needs and others developing training programs tied to promotional opportunities to attract and retain talent. Participants identified the importance of promoting the field of hydrography at educational institutions to attract more talent to the field. Many HO's indicated that talent is preferring the private sector over government agencies and identified the value of secondments or partnerships with the private sector and academia to improve retention. On the issue of diversity, participants noted that gender balance appeared to be improving at the entry level, but there was still work to be done at the managerial/leadership level.

3.3 The Future Role of Hydrography

Participants noted the expanding uses of hydrographic data in the context of the Blue Economy, and the importance of Marine Spatial Data. They noted that HO's now need to focus more on user needs beyond navigation. Participants observed, however, that the importance of standardizing datasets remained both in the hydrographic context under S-100 and for other applications as well, like the Open Geospatial Consortium. As the role of HO's and hydrographic data evolves, participants emphasized the importance of partnerships and defining where the hydrographer fits into the value chain; at what point does the hydrographer handoff the data to a partner? These are all questions that will require engagement and collaboration both internally and between HO's and stakeholders.

Table 1. Common themes.

Common Themes	
Hydrographic Offices are Evolving in an Increasingly Digital World	• Digitalization is acting as a driver for change. • Hydrographic offices vary in the direction they are moving. Some becoming more specialized, others becoming more generalized, or a mix of both. • See an evolving role for hydrographic offices within the context of the Blue Economy and a changing and expanding user base.
Technology & Technical Needs *IT Infrastructure* *Hydrographic Vessels* *Data Collection* *Data Storage*	• Technology can help fill the 'gaps' in data collection in areas that are challenging to survey. Also, e-learning, remote operations support, etc. • A focus on automated or Artificial Intelligence (AI) data analysis techniques and of the vessel itself. • Need to keep up with state of the art when it comes to new vessel acquisition – UAVs. • Contracting out for specialized data services will play a larger role.
Data Management	• Hydrographic organizations need to make it clear which data is the authoritative source when there are large volumes of data being collected and made available • Data storage at large volumes can be costly and complicated. Need underlying systems to be properly designed and maintained to support large datasets-allocate financial and human resources. • When data are stored on the cloud, it then becomes increasingly important to curate those data, provide metadata, versioning, etc. If this is not done, the cloud becomes a "dump" and highly disorganized. • Important to understand strengths/weaknesses of automated QC processes and validate data accordingly before dissemination to clients. • Data ethics/cybersecurity • Efficiency from digitalization offset by volume.
The Evolving Role of Humans	• Data managers and organizers ('cloud engineers'; 'curators of data') • Manage large datasets • Project management • Data validation • Partnership building • Procurement • As we get closer to real-time data availability, the need to communicate error margins in some products such as clearances will become critical as those products become relied upon in the day-to-day operations of clients • Hydrographers are increasingly becoming data managers. Hydrographers need to be knowledgeable on how to incorporate real-time data into their processes. 'Managing data at the speed of knowledge' • The idea of "push button hydrographers" can become problematic as organizations are held accountable for the quality of collected data, and hydrographers need to have the skills and expertise required to ensure that the data collected are "good"; need to understand the how and the why. • In many cases, the hydrographers are "testers" for various hydrographic data collection devices as development is ongoing.

The Ideal Hydrographer (personality traits/background)	• Broad set of skills • Team oriented • No concept of the perfect hydrographer—no one hydrographer can do it all • Mix of technical and soft skills • Problem solver • Agile and adaptable • Innovative • Mix of specialists and generalists • Mix of people skills and knowledge (Technical & Soft) are needed.
General and Specialized Skills required as roles of hydrographers evolve	• Some hydrographic offices still need hydrographers to be a jack of all trades – not specialized in tasks – 'doing it all'; others are increasing specialization, or aiming for a mix of both. With some seeing a need to split the 'hydrographer' into several specialties: acquisition, processing, database, cartography, etc. • Many hydrographic offices separate the role of cartographer and hydrographer, but roles are evolving: Hydrographer still needs to collect the data; cartographer – databases, digital technology, cloud computing. • More requirement for Data Scientists with IT and programming knowledge and GIS are needed--need to know how to manage large datasets collected using remote or autonomous methods, rather than simply collecting the data themselves. More data collected with less effort, but more of an emphasis on management and analysis. • Business specialists, procurement business analytics
Education & Training	• There is no single profile for a Hydrographer; there is a base layer of knowledge (education) that is needed that allows for adaptability • When recruiting new hydrographers – needs are math, coding, geospatial – students in general hydrography programs need additional training in these areas. • Ideally candidates coming in with CAT-A CAT-B certified training are best fit; but also many comments that HOs are hiring staff with educational backgrounds in physical sciences, data science, IT and programming knowledge and GIS. • Education vs Training – education is the core; training builds the skills and helps the hydrographer keep up with rapid advances; • Does the model of capacity building have to change? Should there be a greater focus on developing the expertise in envisioning how data (all types) can be exploited. • Related to the above, concepts of marine spatial data infrastructures must be incorporated into the training of hydrographers. • Important to understand that all hydrographers are not equal and to evaluate and track the training and experience of individuals within an organization. • Training in a classroom or at a smaller scale is important, but also extremely important to apply knowledge in a real-world setting. • Dynamic tech training always reactive to technology most of the time – how can we be proactive (stay on top of change) • Training in Change Management • Balance new competencies with older traditional training. Need to ensure quality of data in addition to our usual products, this will supply stability. • Time at sea – informs understanding of how hydrographic products are used ('voyage optimization').

	Recruitment, Retention and Knowledge Transfer	- Seems to be competition for new hydrographers and their skill sets. - Work to increase knowledge of hydrography as a field in the broader population through outreach to educational institutions, show cool technology. - May have to plan for possibly more dynamic workforce. Retaining staff is critical - exchanges and secondments agreement between HOs and Private Sector is an important possibility to exploit further. - Have to demonstrate that there is a pathway in order to keep younger professionals around. Creative element, long-term investment. Mentorship through career development. Offer clear career goals, experience, & pay expectations throughout. - Employers need to be agile. - Option to seeking new candidates/graduates from relevant university programs/departments. "Get them early" – after a couple years of employment, move to training in-house. - Diversity (gender balance) seems in good shape at the moment with the participants who expressed themselves, however at higher management level there is still work to be done. - Most hydrographic students are going into Industry (Blue Economy) and not HO's. Therefore need to include HO's (HO/Gov, Academia, Industry) in regular conversations to discuss the skills of students joining the workforce (including identified gaps). - Increased international secondments between HOs and with Private Sector is a great tool to tap into global talent.
	Partnerships and the role of hydrographer in these partnerships	- Technology can help process, sort, and manage this volume of data. The one question is where does the hydrographer 'hand off' this information/data. - Develop relationship with manufacturers to ensure that hydrographic staff can access and interact with data acquisition devices in the field rather than relying entirely on manufacturer.
	Expanding uses of hydrographic data – Blue Economy	- Some of information collected in the hydrographic survey process were seen as toss-offs can be valuable information for others. Backscatter, sound velocity profiles, etc. can now be of use in other fields. - Interoperability and standardizing data sets considering not only the S-100 standards but other standards (e.g. OGC). - Marine Spatial Data– should hydrographers be specialists for these environments? - Seeing a need to shift to a focus on user needs.

4. Conclusion and Next Steps

The international discussion fostered by the *Hydrographer of the Future Workshop* is a first step in helping to define the skillset of the *CHS Hydrographer of the Future* and will help the CHS to be more innovative in the way that the organization recruits and builds capacity today. Investment in the CHS' future workforce begins now because the people the CHS hire today will be the organization's *Hydrographers of the Future.* Furthermore, the digital transformation has already begun and so CHS needs to prepare staff to change and evolve as the hydrographic landscape changes. The details of what we heard can be found in the Final Report of the virtual workshop.

As many HO's around the world undergo similar reflections about their own workforces, we at the CHS hope that sharing the results of the workshop will be of benefit to our partners. We hope to build on the energy expressed and momentum gained from the workshop to continue to collaborate and ponder about how we navigate this transformative time. The conversations spurred by the workshop could also be a starting point for joint learning through the International Hydrographic Organization's e-learning project.

5. References

Foroutan, M., Bhatia, S., Béchard, G. (2022). CHS Hydrographer of the Future Workshop Report, April 2022.