Looking Astern to Chart Our Way Forward

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Key words: hydrographers, Cook, history, diversity

SUMMARY

In order to prepare current and future generations of hydrographers, we should reflect on what has come before us. By considering our professional history we can highlight the changes that have occurred and more accurately envisage those that may lie in our future.

A 250 year subset of hydrographic history was studied in Aotearoa New Zealand in 2019 as part of commemorations of dual Māori and European history - since the crew of Cook's *Endeavour* visited the country. For this work, the contemporary experiences of hydrographers in Australasia were compared to those of Cook (Tidey, Jurgens and Morrison, 2019), and a consideration of the evolution of methods and charting outputs was undertaken (Tidey, Morrison and Jurgens, 2019). In these investigations we discovered that some experiences, methods and procedures were relatively constant, even while the technology used evolved rapidly.

By focusing on the responses of the 50 Australasian hydrographers and the past 250 years, this paper shows how long-period comparison provides insights that are useful for the current and future development of 'Smart Surveyors'. The methods and learnings from our research are shared so that others may be able to undertake similar studies and learn from their own professional survey and spatial ancestors. The thoughts of our contemporary hydrographic personnel on the past, current and future of the profession that are presented in Tidey, Jurgens and Morrison (2019) are now analysed in the context of the Smart Surveyor and current hydrography-related projects such as UN Development Goal 14: Life Below Water and The Nippon Foundation-GEBCO Seabed 2030 Project.

Our 2019 discussion also has limitations in its considerations. To strengthen and develop our profession, diverse representation is needed. Our initial work primarily focused on European history and demonstrated the continuation of this legacy in the responses of our modern-day hydrographers. Their answers highlighted the current equity imbalances in hydrography, but we provided little further comment. This paper outlines thoughts on developing more diverse inclusion and representation in our sector of the profession.

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1. INTRODUCTION

Analysis of our past enables reflection on the lineages of current ideas and practices, and provides insights for the future. It can highlight what has worked well and thus should continue to be built upon, but also what has not.

When we consider the future of hydrography, it is useful to reflect on our past and current modes of operation, as well as what may have been lacking in these. In 2019 we had the opportunity to undertake investigation into the recent past and current state of hydrography in Aotearoa New Zealand by hearing from local hydrographers themselves. We also considered developments that had taken place over the 250 years since the extensive survey of the Aotearoa New Zealand coast by Cook in 1769. Two papers from this work were published in a Special Edition of the New Zealand Surveyor journal: *Cook: Our Professional Ancestor* (Tidey, Jurgens and Morrison, 2019) which considers the contemporary experiences of hydrographers in Australasia compared to those of Cook and *Charting Our History* which follows the evolution of methods and charting outputs undertaken over this time period (Tidey, Morrison and Jurgens, 2019).

Here we share the planning and execution of our projects, and the results in terms of 'Smart Surveyors'. Then we consider where, on reflection, we were lacking in our investigations and how the profession might use our findings.

2. TUIA 250 PROJECTS

In 2019 the Ministry for Culture and Heritage in New Zealand ran *Tuia – Encounters 250,* a commemoration marking "250 years since the first onshore encounters between Māori and Pākehā (European) in 1769" (Ministry for Culture and Heritage, 2019). While this date is later than the European 'discovery' of Aotearoa New Zealand by Abel Tasman in 1642, this time period represents the first significant interaction of the native Māori and European explorers, and from a hydrographic perspective – the first significant paper-based charting efforts of nearly the entirety of the country.

At the University of Otago's School of Surveying we wanted to join the commemorations, and the author and a pair of student hydrographers pursued the *Tuia 250 Encounters* theme 'conversations about the past, the present and how we navigate our shared future' for hydrography. We split our focus into people and technology.

2.1 People

Our people focused investigations (Titled 'Cook: Our Professional Ancestor' in NZ Surveyor) comprised two parts and four themes. The first involved analysing Cook's diary and work.

Categorised notes were made of mentions of charting and hydrographic surveying operations, as well as day-to-day life onboard. Secondly we sent a questionnaire out to hydrographers in Australasia, with questions following four main themes of enquiry:

1. Demographics: Who are our participants? Where do they work and their past experiences.
2. Life as hydrographers: What is the lifestyle and the work itself like?
3. Hydrographic work and technology: What they do and how; methods used and technical changes they have experienced.
4. The legacy and future of hydrography: Why do they do their work? Their influences, aspirations and perspectives. Do they consider their work in relation to who went before them? What are their views for the future?

(Tidey, Jurgens & Morrison, 2019, p83)

The questionnaire was available online with a mixture of closed and open-ended questions with both multi-option and free-form responses. 51 people responded, with a significant time involvement from many who provided in-depth commentary in the free-form response boxes. We analysed the responses using statistics for closed-ended questions and word clouds and researcher analysis for open-ended free form responses.

2.2 Technology

Our technology analysis (Titled 'Charting Our History' in NZ Surveyor) considered the developments observable in nautical charts and linked these to technological changes that occurred at the same time. We grouped our work into three time periods:

1. Pre-acoustic
2. Acoustics and Satellite Positioning
3. Today and Tomorrow...?

(Tidey, Morrison & Jurgens, 2019)

We focussed on three areas of interest around New Zealand's coast, each place based on the location of three 1700's era charts donated to the School of Surveying: Firth of Thames, Mercury and Tolaga Bay, Cook Strait and, Dusky Sound and Pickersgill Harbour (the latter being the last data from Cook to remain on a NZ chart – the cartouche was only removed in 2006 (Robbins, 2011)). For each area we obtained all current and archived charts available and analysed the chart features that link to the hydrographic data collection method of that time period.

2.3 Hydrographic investigations in other localities

The commemorations in 2019 in Aotearoa New Zealand provided a useful focus for our investigations, and we think other countries could equally query their hydrographic populations, as well as analysing archived and current hydrographic charts and data to gain an insight into the professional ancestry of hydrography in their area and as a way to start conversations about the future. Surveying institutions often do stocktakes and questionnaires, an example being the

report ‘Future of the profession’ by the UK’s Royal Institution of Chartered Surveyors (RICS) (RICS, 2019), and in our case we have found that this focus on the hydrographic specialisation has provided an interesting and valuable way to consider where we are heading as a profession. We found that the questionnaire alone generated much interest in the local hydrographic community.

However, our initial studies did not consider important aspects such as representation, diversity and inclusion. Due to the nature of the initial 250 year commemoration prompt we primarily focussed on European hydrographic history and through this demonstrated the continuation of this legacy in the responses of our modern-day hydrographers and our analyses. Questionnaire answers highlighted the current equity imbalances in hydrography, but we provided little further comment. This paper outlines thoughts on more diverse inclusion and representation in our sector of the profession.

3. LOOKING ASTERN AND ONBOARD TODAY - Tuia 250 findings

3.1 People

In order to give our work context we first considered hydrography as it is defined, and then the charting activities in Aotearoa New Zealand. We outlined hydrography’s move from the traditional depth, positioning and tide measurements used to create charts for safe navigation, to the wider definition that covers many more activities today: resource exploitation, environmental protection and management, maritime boundary delimitation, national marine spatial data infrastructures, recreational boating, maritime defence and security, tsunami flood and inundation modelling, coastal zone management, tourism and marine science (IHO, 2018).

In Aotearoa New Zealand specifically, we outlined charting developments in several steps; from the initial European maps to the large country-wide efforts on steamships from the 1850’s, progressing to work from the 1940’s by the Royal New Zealand Navy (RNZN), and to today where the national charting responsibilities are managed by government agency Land Information New Zealand (LINZ), who contract acquisition and processing activities to professional hydrographers. (Tidey, Jurgens and Morrison, 2019).

An encouraging finding from our questionnaire to contemporary hydrographers was the enthusiasm they appear to have for their profession and their generosity in sharing this. Our experience - gaining 51 responses when we had hoped for at least 20 - showed many were willing to put in significant time to give us insight into their experiences and thoughts about the future of the profession.

More details are available in Tidey, Jurgens and Morrison (2019) but broadly under our four themes we found:

Demographics:
Respondents were mostly male (84%). We had a bi-modal age distribution around the 31-40 and 61-70 age groups as well as a group of respondents with fewer than 10 years’ experience.

Most of our respondents identified as NZ European, and the majority currently work for private NZ or International companies – although 14 of these had worked for the military at some point in their careers. Our profession is international, reflected in 86% of respondents having taken part in a hydrographic survey overseas. A range of hydrographic surveying is undertaken, with the highest percentage of participation in 'Nautical Charting' and 'Coastal and Engineering Surveys' when using the IHO s5 categories of survey. See Figure 1 for an example of one of the plots created, which shows the range of hydrographic involvement of our participants. In comparison, Cook's work and early hydrography was exclusively focussed on exploration and charting.

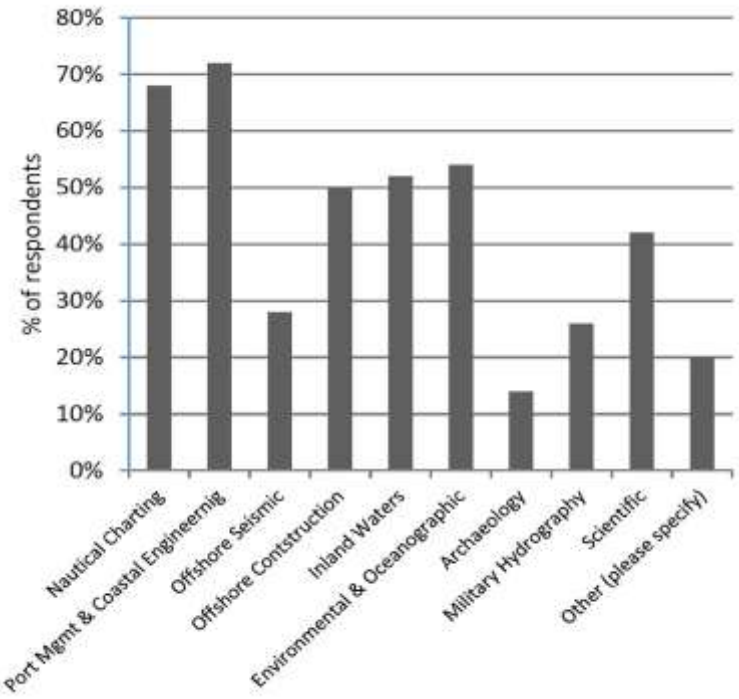

Figure 1 - Q7 results "What types of hydrographic surveying have you been involved with? (Select all that apply)". Other included: as-built pipeline survey, unexploded ordinance (UXO) surveys, as-built gas pipelines and inspections, National Policy Programme and Specification development, cable lay, trenching and ploughing, waste treatment ponds, search and rescue, oceanic cable survey. From: Tidey, Jurgens and Morrison (2019, p86).

Life as a Hydrographer:

Our respondents worked on vessels from <5m to 50m+ in length, with crews mostly of 1-5 or 10-50 personnel. For this theme, a series of word clouds were used to analyse methods communication used when working on a vessel, as well as the best and also the hardest parts of living and working on a boat. The best parts were varied with words like 'sea', 'places', 'seeing', 'commute' (as in, short from bunk to workstation!), 'office' (as in, not traditional), 'money' and 'different' highlighted. The hardest parts were repeated more often with 'away' and 'family' clearly the biggest concerns. Our hydrographers have worked in very poor weather, in politically unstable regions and also been involved in large international crises such

as being at the Deep Water Horizon site, conducting the MH370 missing aircraft search or riding out Hurricane Katrina. Onboard challenges such as relationships and mental-health were also highlighted. (Tidey, Jurgens and Morrison, 2019).

Hydrographic work and technology:
Our Australasian hydrographers usually have freedom to design their measurement and reporting specifications. They use a wide range of technology, but 51% have also used a leadline – the same technology as Cook. 60% have collected data in an "unsurveyed" location, and 29% worked with data from Cook, usually around Fiordland in New Zealand. Many took the time to comment on the visual style of "artistic" or "beautiful" older charts. (Tidey, Jurgens and Morrison, 2019).

The legacy and future of hydrography:
Hydrography was described by our respondents as 'interesting', 'challenging', 'exciting', 'rewarding' and 'adventurous'. They noted their pride in being part of environmental work and "being part of large projects that have the ability to change nations", or a part of large projects in general. The identified challenges faced by hydrographers today were varied (see Figure 2).

Figure 2 - Results from Q31 "What are the three (3) biggest challenges you think hydrography faces today?" where larger text indicates more respondents used these words in their free-form answers. From: Tidey, Jurgens and Morrison (2019, p95)

Respondents were asked if they saw themselves on a continuum from early explorer/surveyors like Cook or Tupaia (the Polynesian navigator who joined Cook's voyage and created a map for him of the relative locations of several Pacific Islands (Robson, 2004)). 37% did, with some stating that the "same thing" is being done, just with newer technology. (Tidey, Jurgens and Morrison, 2019).

3.2 Technology

As we have moved from manual measurement to acoustic, digital, satellite-based and often automated hydrographic surveying operations, we have been able to gather more data at richer densities , increasingly higher accuracies and precisions, and in more environments (deeper or shallower). Our investigations found however, that in terms of charting not much of this multitude of modern data makes it to the traditional nautical chart. The full-seafloor ensonification and multiple data collection options possible with multibeam echosounders, Light Detection and Ranging (LiDAR), satellite and autonomous vessels seem to be currently more use to other hydrographic applications and areas they support, such as scientific research,

environmental protection and engineering, although a combination of uses of hydrographic data is always wise considering the cost of vessel time (See LINZ / MDC partnership mentioned in section 4.1 following).

We also noted a change in emphasis for nautical charting hydrography from exploration to risk-based analyses of the next charting location. However we considered that this did not impact the underlying hydrographic methods as Cook's meticulous work is similar to that required by international and national standards today. As we stated in Tidey, Jurgens and Morrison (2019):

"…many [hydrographers] would surely hope to identify with this description of Cook as:

> "A man who aimed at perfection in all that he undertook, and who established certainties where hitherto there had been doubts" (Snowdon, 1984)."

Through our analysis we anticipated that the growth in autonomous systems will mean "hydrographers will need to adapt their methodologies, possibly spending more of their time onshore monitoring remote unmanned data collection operations, and certainly spending more of their time on planning and quality control than the actual data collection [and processing] itself." (Tidey, Morrison and Jurgens, 2019).

4. CHARTING OUR WAY FORWARD

4.1 Insights for 'Smart Surveyors'

In these investigations we discovered that some experiences, methods and procedures were relatively constant, even while the technology used evolved rapidly and our data points multiply. When considering working with old data our questionnaire respondents pointed out it was necessary to have knowledge of past methods and limitations. Many also noted that they still use leadlines, as Cook would have done, but more for checks of modern acoustic equipment, where the acoustic gear has limitations, or where they don't wish to risk damaging this expensive equipment. Global Navigation Satellite Systems (GNSS) is the main way we position ourselves, having taken over from astronomical observations, but the limitations of range-based accuracy still exist here so further developments here are eagerly awaited.

In our papers, we considered the IHO hydrography categories Port Management and Coastal Engineering, Inland Waters, Environmental and Oceanographic as well as Scientific as those most likely to continue to develop and grow. UN Development Goal 14: Life Below Water highlights international attention on ocean-based measurements and The Nippon Foundation-GEBCO Seabed 2030 Project (Mayer, 2018) gives impetus to consideration of all the often disparate data collection that occurs at sea. We also identified a move in the modern day to link land and sea measurements. This highlights a move from somewhat pure nautical charting to a more holistic understanding of our environment. Vessel mounted laser scanners or airborne LiDAR are tools that can help with this. This work has clear links with national projects, such as LINZ's Joining Land and Sea (JLAS) (Blick, 2018).

While acknowledging the beauty of older charts, one of our respondents noted that the layering of modern electronic charts is beneficial as it provides so much more information than a paper chart. Many respondents noted the increase in data as a challenge for the future. In the instance of electronic charts the hydrographer's data consideration may be – who is collecting all the data in the layers? Can we be doing so on our vessel, considering the time, cost and environmental impacts of vessel time?

Our work with hydrographers also highlighted the developments of unmanned or autonomous surface vessels (USV/ASV) as a logical step from a traditional combination of mothership and smaller survey vessel, such as used by Cook (with the Endeavour and pinnace) to similar approaches today. Now, however, the mothership can be onshore, and not only will the use of autonomous and remote modern technology reduce crew requirements, it also improves safety by taking personnel out of danger zones such as shallow, unpredictable or rough waters. When combined with satellite connectivity for data transfer it may open up opportunities for flexible home-based work (perhaps reducing the concerns our hydrographers identified in being away from family), shift work (for example processing data in a Europe day during an Aotearoa New Zealand night, ready for the next day of field work in Aotearoa New Zealand), as well as expanded work areas – thus supporting far-reaching ocean projects such as The Nippon Foundation-GEBCO Seabed 2030 Project (Mayer, 2018). However, monitoring of staffing developments - particularly the 'at-sea' workforce - during major technology changes such as autonomous vessels or 'smart' operations is necessary, in order that the profession continues to aim for the diversity and inclusion detailed in section 4.2.

The international nature of hydrography is obviously a draw-card for our surveyed hydrographers as well as a requirement due to the " seasonality of some operations, fickle oil and gas markets, limits to national funding for charting and research work, and the growth of large multi-national companies operating in several oceans around the world" (Tidey, Jurgens and Morrison, 2019). This movement of personnel has positive implications in the mixing of ideas, technology and cultures (see section 4.2 following), but equally some negative ones in terms of the environmental costs of travelling and the potential lack of diversity and representation if we are not working alongside or up-skilling local surveyors to undertake hydrographic work in their own regions, as well as taking into account local cultural understandings (see section 4.2 also).

In terms of Smart Surveyors, there are areas for small and large innovations. A small example may be how can we be smart about reporting our daily operations? Cook's detailed diary and the Daily Operations Report (DOR) of today are similar, with weather, survey times, bottom type and other notes, and enabled us to do our analysis. In order to reduce 'office' activities for those managing projects can we automate reporting further through links to weather sensors and processing coverages? Can we work on the isolation and mental health of our surveyors through connectivity, apps or training? A greater consideration of the proliferation of 'smart'

technology and activities is also required. We are seeing increased automation of surveying processing as well as collection with more plug-and-play black-box technology available. Can we ensure our profession keeps up with the changes such that we are still vital personnel on a project? Will we remain 'in charge' of the specifications as our questionnaire correspondents identified? This may well be the largest methodology change we have seen in hydrography for some time.

In our survey our hydrographers highlighted that misunderstandings by the public around operations often occur – for example when seismic operations are undertaken. This made us think that there is need for more public education on hydrographic practises and the standards we work to. We gave the example of the Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (DoC, 2013), but perhaps more general education and exposure would be useful. One way this can be achieved is through campaigns where the end results are widely disseminated, and thus the value of the hydrographic data shown to the general public. An example of this in Aotearoa New Zealand is the LINZ / Marlborough District Council (MDC) partnership which supported a 2016 survey of the Marlborough Sounds which was used for chart updates, but also for understanding of physical and biological features of the seafloor, and other flow-on projects and has been widely shown in public (NIWA, 2018). The Nippon Foundation-GEBCO Seabed 2030 Project (Mayer, 2018) is an international project that also has potential to support this increased awareness and hydrographers world-wide will benefit from participating in, and supporting this initiative.

4.2 Representation considerations

The *Tuia 250 Encounters* celebration in Aotearoa New Zealand in 2019 was conceived differently to past events commemorating Cook's arrival in the country. Where in the past the focus was the English man, his crew and vessel, the emphasis this time was placed on those first shore-based interactions between Māori and European. The concept of '*tuia'* or weaving indicated this approach, encouraging consideration of both threads of our past, their interactions and how we can share the future together well. The commemorations final aim was 'to hold honest conversations about the past, the present and how we navigate our shared future' and in some areas our 2019 research falls short. (Ministry for Culture and Heritage, 2019).

In our 'people' considerations we noted that most of our respondents were NZ Europeans, with many having worked the traditional route of navy to private firm. Further investigation into the ethnicities of our hydrographers (using NZ Census classifications) shows Filipino, French, European, British, South African or Sri Lankan surveyors, with only 1 Māori and 1 Samoan hydrographer. The Māori population of Aotearoa New Zealand in 2018 was 17% (Stats NZ, 2019). In New Zealand, the most recent (2019) portion of Māori and Pasifika students obtaining University Entrance qualifications (during their final year of high school) was 29.4% and 28.8% respectively, with 55% for European students and 60.8% for Asian students (Collins, 2019), while the Māori undergraduate student population at the National School of Surveying ranges

around 5-10% annually. In Aotearoa New Zealand there is a growing acknowledgement of mātauranga Māori - Māori knowledge including Māori world view and perspectives, creativity and cultural practises. This takes into account the considerable past navigation, weather and oceanographic skills and understanding of Polynesian ancestors who settled Aotearoa New Zealand, as well as the concept of kaitiakitanga (”managing human relationships with the environment, not managing the environment” (Hikuroa, 2020)). As hydrography moves to support more diverse work – particularly science, environmental and coastal related projects – the inclusion of this worldview is imperative.

In our questionnaire the ratio of female respondents - at 16% - was slightly higher than statistics of females in the RNZN, Bachelor of Surveying students at the University of Otago, and those listed as certified hydrographers in Australasia (Tidey, Jurgens and Morrison, 2019). Women in Engineering, a group of Engineering New Zealand found in 2015 that the portion of female engineers in tertiary or university study was just under 20%, while those practising as Chartered Professional Engineers was closer to 5% (IPENZ, 2015). This report noted that ways to support diversity in employees were through policies and programmes, flexible working arrangements, mentoring and supporting those on career breaks and returning to work. They saw issues with “recruitment, retention and advancement” including gender pay gaps in the profession. Anecdotally it appears that females employed by hydrographic companies are often assigned data processing and office-based tasks while male co-workers are given more chances to do these tasks in addition to collecting data offshore. A new graduate may not have the confidence or struggle to ask to be given the widest range of experiences, so managers need to ensure they are giving all employees equal opportunities to trial all aspects of a hydrographic career. In doing so the employees will find their area of interest, grow expertise there and likely stay, rather than those pigeon-holed early on based on gender alone.

Diversity Works New Zealand is our national body for workplace diversity and inclusion and has a Workplace Diversity Case Model report demonstrating the value of this to workplaces. Their research highlights social, productivity and prospectivity (preparing for the future) outcomes from increased diversity and inclusion, but also the requirements to properly consider steps for integration, cultural sensitivities and how to move a workplace on from approaches that belong in the past. In the literature review report by Merelo (2019), the value of having a heterogeneous workforce is clearly outlined, with ideas such as increased agility, better problem-solving from a wider range of perspectives and competitive edge mentioned. The report is freely available online and would be useful reading for those involved hydrographic recruitment of students for studies or graduates for employment.

Hydrographic training was considered in our initial work. Collingridge (2002) suggests that Cook began his work during a new era of “scientific navigation”, and the professionalisation of hydrography. Naval training and on-the-job cadetships were common in the 1900’s, but today hydrographers in Aotearoa New Zealand are typically educated by a Navy see (RNZN, 2019) or at a university (such as the University of Otago’s School of Surveying in Aotearoa New Zealand (School of Surveying, 2019)). Our paper highlighted the possible gradual loss of maritime skills by those in the profession. Where in the past the ability to read the water and

navigate safely would have been useful talents to the hydrographer, the training path through universities and training institutions may mean recent graduates have less on-water maritime experience. One way this is recognised is through the additional sea-time requirements of certification for the Australasian Hydrographic Surveyors Certification Panel (AHSCP, 2019). With more automation there is the possibility for this nautical understanding to further diminish – will chart data be collected and processed, or charts themselves be created by those who have never been to sea? In terms of representation, continuing to include nautical skills for those involved charting activities (at the least) is surely necessary.

The main methods of communications identified by our questionnaire respondents when onboard a vessel were cellphone, email, and internet. To attract and retain younger hydrographers who are used to existing in a highly-connected world, consideration should be made of methods to enable them to communicate easily with home. The reducing costs of satellite connections assists this.

Our survey responses demonstrate that hydrographers know the value of their work to themselves, their communities and the planet in general. They appear to generally enjoy the challenges of time on vessels and have either participated in, or are aware of the range of different jobs or projects available within the profession. Mirroring similar comments regarding public education on hydrography in section 4.1 earlier, it seems the profession does not often (or does not clearly) share what a hydrographic surveyor does with the general public. Therefore the school children, university and technical school students who will become future hydrographers remain largely unaware. This lack of publicity (or self-promotion) is shared with the entire surveying profession, which continues to remain little known. Internal research at the University of Otago's School of Surveying indicates that the majority of our students learn about surveying from a relative, neighbour or teacher/advisor who has direct experience with the profession themselves. By increasing the level of publicity for surveying in general, we can make steps to increase overall entry to the profession. Along with this, universities, training institutions and employers alike must ensure that with increased professional publicity they work to model the desired inclusivity and diversity themselves, in their teachers and lecturers as well as in surveying and management positions in hydrographic firms. To do this, individual entities should work to follow proven pathways, such as the outlines suggested in Merelo (2019) and the Women in Engineering reports (IPENZ, 2015).

5. CONCLUSION

In order to prepare current and future generations of hydrographers, we should glance astern and reflect on what we have been through. By considering our professional history we can highlight the changes that have occurred and more accurately envisage those that may lie in our future. Our Tuia 250 investigations were a perfect opportunity for a snapshot of the current hydrographic surveying generation in Australasia, a consideration of the past and a look into the future. This paper has worked to expand the gaze forward over the bow and shown that the continuing technology advancements, combined with a broadening of hydrographic operations,

an increase in diversification and development of greater general public understanding is what is needed for the profession.

When we asked Australasian hydrographers to consider the future of the profession, the main responses highlighted the need to build more public awareness of hydrography, as well as to get more new hydrographers into the profession. This paper agrees, adding that the growth of new hydrographers is a chance to expand and diversify the workforce. There are established methods and considerations to make for both steps, it is up to the profession to take up the challenge.

For those interested in the full text of the Tuia 250 papers referenced here, an online copy of the Special Edition of the New Zealand Surveyor journal is available at: https://www.surveyspatialnz.org/members/Publications/Attachment?Action=Download&Attachment_id=5873

REFERENCES

Australasian Hydrographic Surveyors Certification Panel (AHSCP). (2019). *Certification Levels.* Retrieved from https://sssi.org.au/get-certified/hydrographic-surveyor/certification-process

Blick, G. (2018). *Joining New Zealand Land and Sea Vertical Datums (JLAS)*. Paper presented at the XXVI FIG Congress, Istanbul.

Collingridge, V. (2002). *Captain Cook. Obsession and Betrayal in The New World*. London: Elbury Press, Random House.

Collins, S. (2019) *NCEA pass rates drop slightly and ethnic gaps worsen.* New Zealand Herald. Retrieved from https://www.nzherald.co.nz/nz/ncea-pass-rates-drop-slightly-and-ethnic-gaps-worsen/BVY7RCQEVUSPMNCBR5ACNXMTZE/

Department of Conservation (DoC). (2013). *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations.* In. Wellington: Department of Conservation (DoC).

Hikuroa, D. (2020) Mātauranga Māori and its role in coastal management. *Coastal Systems & Sea Level Rise, What to look for in the future, Special Publication 4* (December), 5-9.

International Hydrographic Organization (IHO). (2018). *Definition & Importance of Hydrography*. Retrieved from https://www.iho.int/srv1/index.php?option=com_content&view=article&id=299&Itemid=289&lang=en

IPENZ (2015) *Women in the Engineering Workplace Snapshot 2015*. Retrieved from https://d2rjvl4n5h2b61.cloudfront.net/media/documents/Women_in_Engineering_Snapshot_2015.pdf

Mayer, L., Jakobsson, M., Allen, G., Dorschel, B., Falconer, R., Ferrini, V., Weatherall, P. (2018). The Nippon Foundation—GEBCO Seabed 2030 Project: The Quest to See the World's Oceans Completely Mapped by 2030. *Geosciences*, 8(2), 63. doi:10.3390/geosciences8020063

Merelo, G. (2019) *Workplace Diversity Case Model*. New Zealand: Diversity Works.

Ministry for Culture and Heritage (2019) *Tuia 250 Encounters*. Retrieved from https://mch.govt.nz/tuia250
NIWA (2018) *New discoveries on Marlborough seafloor*. Retrieved from https://niwa.co.nz/news/new-discoveries-on-marlborough-seafloor
Tidey, E. J., Jurgens, K. M., & Morrison, J-L. B. (2019). Cook: Our Professional Ancestor. *New Zealand Surveyor*, *305*(December), 79-112.
Tidey, E. J., Morrison, J-L. B., & Jurgens, K. M. (2019). Charting Our History. *New Zealand Surveyor*, *305*(December), 131-161.
Royal Institution of Chartered Surveyors (RICS). (2019). *Future of the profession. Consultation response report.* Retrieved from United Kingdom: https://www.rics.org/globalassets/rics-website/media/news/future-of-theprofession-post-consultation-report.pdf
Robbins, L. (2011). James Cook - SNLR. *The Globe*, 68, 20-36.
Robson, J. (2004). *The Captain Cook Encyclopaedia*. Auckland: Random House New Zealand.
Royal New Zealand Navy (RNZN). (2019). *Hydrographic Systems Operator*. Retrieved from https://www.defencecareers.mil.nz/navy/careers/browse-roles/hydrographic-systems-operator/
Royal New Zealand Navy (RNZN). (nd). *Timeline of Women in the RNZN*. Retrieved from http://navymuseum.co.nz/timeline-of-women-in-the-rnzn/
School of Surveying (2019). *Hydrographic Surveying*. Retrieved from https://www.otago.ac.nz/surveying/research/hydrographic/
Stats NZ (2019) *2018 Census population and dwelling counts*. Retrieved from: https://www.stats.govt.nz/information-releases/2018-census-population-and-dwelling-counts
Snowdon, K. J. (1984). Captain Cook as a Hydrographer. *Cook's Log*, 7(4), 290.

BIOGRAPHICAL NOTES

Emily Tidey lectures in hydrography and surveying and is a PhD candidate at the National School of Surveying at the University of Otago in New Zealand. She is a member of the Survey+Spatial New Zealand (S+SNZ - formerly the New Zealand Institute of Surveyors) Hydrography Professional Stream (HPS) leadership team. Emily is the Chair of the Australasian Hydrographic Society Education Panel and a member of the executive of the New Zealand Region of the Australasian Hydrographic Society (AHS). Emily obtained her BSurv (Hons) degree from the University of Otago and her MSc with Distinction (Hydrography) on the FIG/IHO/ICA recognised Category A course at the University of Plymouth, UK. She was a recipient of a Federation of International Surveyors (FIG) Foundation Young Surveyor Fellow Award in 2014.

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