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SYNTHESIS

What's hot and what's not in the aquatic sciences—Understanding and improving news coverage

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Scientific Significance Statement

The frequent appearance of science topics in the news raises public interest, public support for science funding, and support for policies protecting ecosystems. The frequency of news reporting on aquatic science topics is important for assuring research funding, advancing aquatic research, and keeping aquatic ecosystems healthy. An analysis of a major online news database shows that the coverage of different aquatic science topics varies by more than 1000-fold with some growing and some shrinking in press attention. The analysis suggests that more support and interest in the aquatic sciences could be built by encouraging aquatic scientists to more clearly communicate the importance of their research.

Abstract

The frequency of news reporting about scientific topics is positively related to public interest as well as to public support for science funding and public policy change. This correlation can also have positive impacts on individual scientific careers depending on the chosen subject area of research. Analysis of a public news database shows the frequency and trends in news reporting of several popular research areas in the aquatic sciences. The frequency of appearance of topics in the news varies over more than three orders of magnitude. Temporal trends in reporting vary from steeply increasing (+25% per year) to declining (−4% per year). Suggestions are offered concerning the framing of research topics and overall better communication of research findings to journalists and the general public. This understanding may increase news prominence, public interest, science funding, and policy change in aquatic research areas.

Introduction

Scientists often state that their work is important to the solution of problems of public concern. For example, work on harmful algae blooms is sometimes justified based on the concept that harmful algae blooms (e.g., Sukharevich and Polyak 2020; Plaas and Paerl 2021; Kaloudis et al. 2022) and public concern about them (e.g., Vu et al. 2020; Chorus

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et al. 2021; Park et al. 2021; Bhatti et al. 2024) are increasing worldwide. It is important that such suggestions be based on data, so this contribution is an exploration of news and public concern or interest about problems and concepts of the aquatic sciences.

Scientists increasingly see the importance of directly fulfilling societal needs (Fecher and Hebing 2021; Llopis et al. 2022) as do funding agencies (Smit and Hessels 2021), governments, and policy makers (Bornmann 2013). While basic science holds significance, certain research can be so fundamental that its importance is difficult for the general public to recognize (Coan 2022). Many in the aquatic sciences ground their specific research topics on practical values that the media and the public find of interest. Some marine scientists, for example, entered the field due to the societal interest of popular figures like Jacques Cousteau (Zronik 2007; Egerton 2017). Many limnologists entered the field due to the societal importance of clean freshwater (Downing 2014).

Why news coverage of science is important

Journalists exercise their roles as information providers by choosing topics that are new, novel, relatable to the lives of people they write for, visualizable, and lend themselves to a narrative story (Guenther and Ruhrmann 2013). This is part of market-driven journalism (Ferrucci 2018). Journalists rarely write about things people are not interested in unless their purpose is to raise awareness of an emerging topic (e.g., virology and pandemics; Ophir 2019). Some actively avoid topics people have prejudged negatively (Waisbord 2020). A tool designed to track social media searches could even help journalists predict upcoming news stories of public interest (Cucchiarelli et al. 2019).

The public largely pays for scientific research (Price 2019) so there are many reasons to bring aquatic science to public attention. Closest to home, published news about a finding or topic can increase citation rates of scientists' publications (Dumas-Mallet et al. 2020). News stories raise interest in science (King et al. 2017). The more interest the public has in a science topic, the more likely people are to support increased science funding for a research field (e.g., limnology or oceanography; Motta 2018) while specific funding decisions, within a field, may be guided by scientific peers (Bendiscioli 2019). With increased published news about a science topic, the more interest there is in that topic and the more support there is for changes in policies about that area (Caballe and Bardelli 2021). An experimental study (King et al. 2017) showed that published news stories lead to rapid increases in social media conversations about topics and that these discussions move rapidly toward advocacy for policy change. Exposure to science stories on television is a strong predictor of beliefs and policy support (Hwang and Southwell 2009). The effect of frequent news coverage on public beliefs and opinions is a reason for concern about fake (Feldman et al. 2011; Watts et al. 2021) or misleading (Watts et al. 2021) news. Media attention, public concern, and policy changes form a complex, triangular relationship, with each influencing and being influenced by the others in addressing environmental issues (Bakaki et al. 2020).

News stories on marine science and other environmental sciences are chronically under-represented in the news (e.g., Kolandai-Matchett et al. 2021). The purpose of this contribution is to analyze news media stories to find the topics in the aquatic sciences that are published frequently in news outlets ("hot") and which receive less attention ("not"). Further objectives were to examine temporal trends in news attention to aquatic science topics as well as reflect on ways aquatic scientists can raise public interest in aquatic research and news coverage of it.

Methods

A news database (ProQuest™ by Clarivate) was searched for combinations of words that would point to publications treating each topic and news stories were counted and trends in news story appearance were analyzed. ProQuest™ is an easily accessible source of worldwide, English language, publications since 1965 and is available through many university libraries. At the time accessed (May 2023), it consisted of 24,000 newspapers, 7200 wire feeds, 950 blogs–podcasts–websites, and 90 trade journals, among other sources.

This database was searched across all available years (1965–2023) for combinations of terms designed to point to news publications about some common aquatic science topics and the frequency of appearance in each year of was counted. Some concepts and terms of importance to aquatic scientists may have been missed, but the search was based on titles of oral and poster sessions at the 2023 ASLO Mallorca meeting. The various combinations of terms used are listed as Supporting Information Table S1. News articles on climate change across various global environments were compared to the most common aquatic science topics. The methodology may have counted some off-topic publications and failed to include some that should have been counted. Results were spot-checked to assess whether gross errors were being made and searches were altered to make them as accurate as possible. As the late Jon Cole used to quote, it is better to have a slightly inaccurate answer than to have no answer at all. That is, "truth will sooner come out of error than from confusion" (Bacon 1620).

Because news of all kinds has expanded massively since 1965 (Fig. 1), some means of standardization of word usage to account for annual differences in news output was needed. The most common structural words in English (and, for, have, I, on, the, this, that, you) (van Heuven et al. 2014) have stayed relatively constant in frequency and have not changed as much as other trends in vocabulary (Medd and Baysoni 2023). To compare the change in scientific word frequency to overall news output measured by the frequency of common words, the frequency of news mentions of aquatic science topics was compared to the frequency of " the " (space

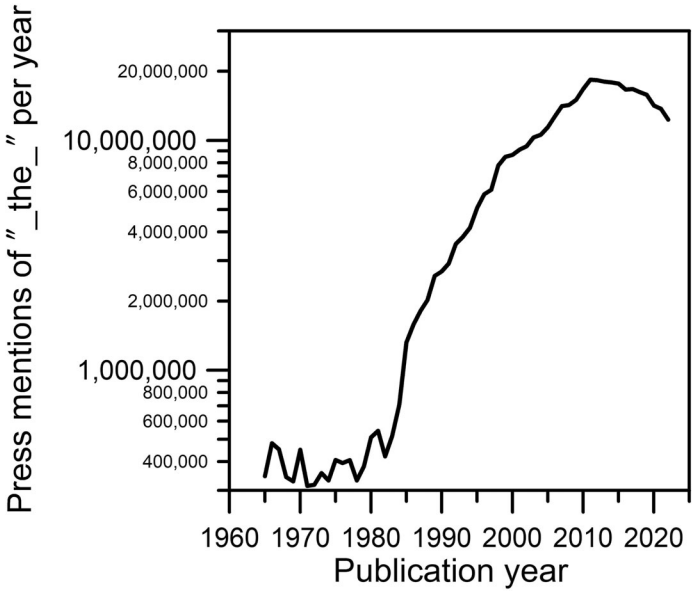

Fig. 1. The Frequency of _the_ in the ProQuest™ database in May 2023.

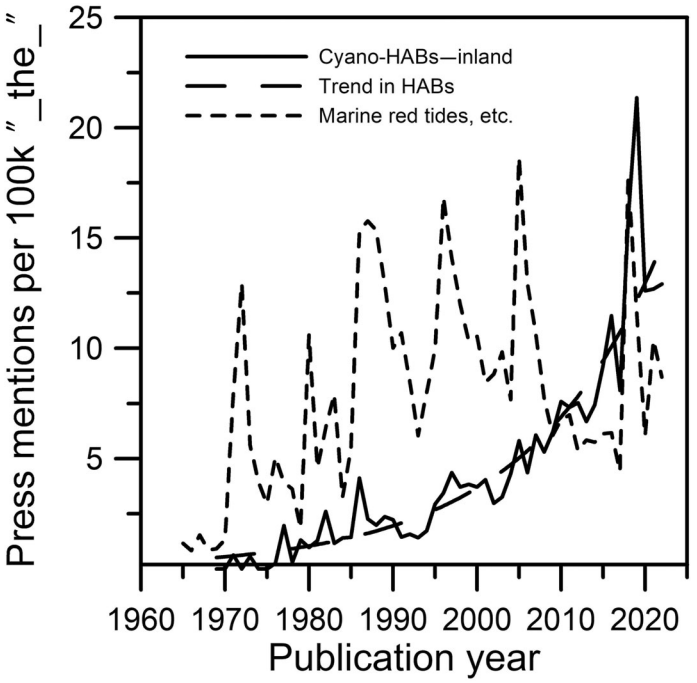

Fig. 2. Temporal trend of news mentions of harmful algae blooms in inland waters and marine systems, normalized to 100,000 mentions of the word _the_. These trends are shown compared to news coverage of climate change and other aquatic science topics in Supporting Information Figs. S1 and S2.

"the" space, hereafter denoted "_the_"). The frequency of the common word _the_ was used as a metric of news output because frequently used words evolve more slowly than those used less often (Pagel et al. 2007) and search engines could search least ambiguously for _the_ than some of the other most common words.

Figure 1 shows the huge growth of news in the ProQuest™ database since 1965. The number of words in the news database increased by over an order of magnitude from 1985 to 2010, with some slight decline from 2010 to 2022, perhaps due to the explosion of news passed through social media (Burggraaff and Trilling 2017; Cucchiarelli et al. 2019).

The frequency of use of aquatic science concepts in the press and trends in use were determined by dividing the number of appearances of terms in each year by the number of appearances of _the_ in the same year. Resulting frequencies and trends are expressed in units of appearances per 100,000 mentions of _the_. Analyses of trends were performed by simple linear regression in JMP Pro, version 16.

Results and discussion

Trends in the news frequency of several common areas of research in marine and inland waters were assessed. As an example, Fig. 2 shows the trend observed for news mentions of harmful algae blooms (CyanoHABs) in inland waters and marine HABs such as marine red tides and other toxic events. News mentions of CyanoHABs have increased very steadily since about 1980 at a compound rate of about 6% increase per year, relative to _the_. Average news mentions of marine toxic events have been about steady with a hint of a cyclical period of 8–10 yr (Fig. 2). This period is quite a bit longer than the period of severe red tides seen in some locations (e.g., Uhlig and Sahling 1990). Since 1965, however, marine toxic events have averaged almost double the frequency of appearance in the news as CyanoHABs (8 vs. 4.5 mentions per 100,000 uses of _the_). The average slope of the trend is, however, much faster for HABs in inland waters than in marine systems, so their frequency in news publications is now about equal.

What's hot—What's not

News mentions of different aquatic science topics vary by more than 1000-fold. By comparison, this is 10 times more variation in frequency than the use of the nouns "time" and "colitis" in the corpus of all written English (Leech et al. 2014). From an historical perspective (i.e., about 58 yr—the length of the database), one can look at long-term trends in news interest in the aquatic sciences (Supporting Information Table S2). Detailed time trends in news coverage are shown in Supporting Information Fig. S1 (hot) and Supporting Information Fig. S2 (not). This spans a period longer than most careers, but gives insight into the kinds of trends occurring over the lifetime of an aquatic scientist. The two top press mentions over the long-term have been inland fisheries and debris in marine and inland water, but both have been declining in news interest from very high rates in the 1970s (Supporting Information Fig. S2). Other hot news interests have been climate

change (accelerating) and pollution (peaking in 1970, 1985, and 2017—perhaps with the appearance of new pollutants). Pharmaceuticals in water, greenhouse gases, and biodiversity have been of high press interest although interest in pharmaceuticals in marine systems has declined over the long-term. The decrease in news coverage regarding pharmaceuticals in marine systems might result from a reduced focus on searching for potential drugs from marine organisms. While lake acidification and eutrophication remain problematic, their coverage in news reporting is declining. Toward the bottom of the news interest scale have been dissolved organic matter, dam removal, and aquatic invasive species in inland waters.

Most germane to current conditions, however, and current careers of aquatic scientists are recent trends in news reporting (Fig. 3). Fifteen years spans the period of early- to mid-career of most scientists, and covers about 3–5 large grant cycles, or 3–5 federal administrations.

What's hot?

Climate change and anything related to it are of hot press interest. This is not surprising as some have called climate change an existential threat to humanity (Ripple et al. 2023). Climate change over the last 15 yr has been mentioned in the press once for every 100 mentions of _the_ (Fig. 3). The aquatic effect of climate change is also increasing steadily in the public eye. About half the mentions of climate change in the press are mentions that include climate change and aquatic systems together (Supporting Information Table S3).

Due to the significant role of greenhouse gases (GHGs) in the narrative of climate change, there has been a high frequency of press coverage on GHGs in both inland and marine waters. Also near the top of hot topics is pollution. Pollutants come in various forms such as nutrients, oil, PFAS, pesticides, estrogen-like compounds, chemotherapy agents, cocaine, and more. Therefore, this frequency does not indicate a specific compound but rather underscores a broader concern about

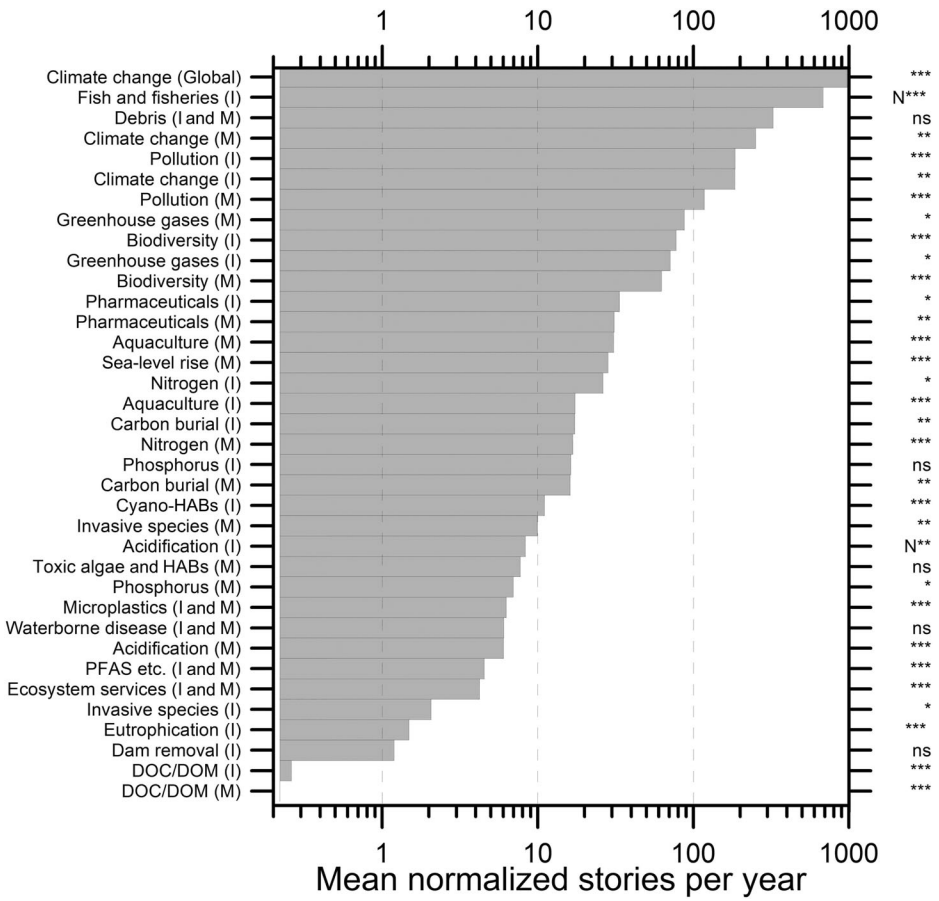

Fig. 3. Trends in news attention to a diversity of aquatic science topics in inland waters and marine systems since 2007. Environments were combined into groups when their separation appeared uncertain or irrelevant. The bars show the average number of mentions compared to _the_ in this news database. Data are mentions per 100,000 _the_. The significance levels show the likelihood of finding an increasing linear trend by chance alone. Asterisks indicate that p values associated with linear regression were ****$p = 0.0001$ or less, ***$p = 0.001$–0.0001, **$p = 0.01$–0.001, *$p = 0.01$–0.1, while ns means $p > 0.1$. All trends are positive except when marked "ns," meaning no significant trend or with an upper case "N," indicating that news interest is declining significantly. Environment is denoted as I and M: I, inland waters; M, marine.

contaminating both marine and inland waters. Likewise, debris in aquatic systems has been a frequent subject of press reports although the concept has covered topics from litter to microplastics.

Aquatic biodiversity is also a hot news topic. It is a frequent press topic and rising in frequency. Scientifically, this makes sense because climate change, pollution, habitat destruction, and invasive species all combine to impact biodiversity. People have a nostalgic, sense of longing for how things used to be (Lowenthal 1975) and people are deeply interested in wildlife (United States Fish and Wildlife Service 2018).

What's not so hot?

Press publications about dissolved organic matter in aquatic systems (Fig. 3) are among the rarest aquatic science topics in the news. DOC/DOM sessions at ASLO meetings have, however, more submissions than many. DOM is really interesting to aquatic scientists but the press does not report much on it. The apparent contradiction may stem from public support for broad topics (Motta 2018) vs. specific funding decisions being made by peers (Bendiscioli 2019).

Some topics that journalists and the public fail to engage are potentially some of the future's most important. For example, depending on population growth, inland waters' eutrophication is likely to grow by 40–200% by 2050 and 100–400% by 2100 (Beaulieu et al. 2019). Yet, there is infrequent mention of it in the news. Both limnologists and oceanographers have indicated that eutrophication is and will be one of the planet's most important water problems (Downing 2014). The paucity of news on the topic may simply be because the term is unclear to people. Acidification (inland and marine) has not captured much press attention, although attention to acidification is growing for marine systems and declining about inland waters (Fig. 3). The impacts of invasive species on marine and freshwater systems are rarely covered in the news, despite their ability to fundamentally alter ecosystem function. Toxic blooms, although increasing in press attention (Fig. 2), are relatively low in news frequency.

Warming trends? Cooling trends?

Virtually all nutrients and nutrient effects are of little frequency in press reports (Fig. 3), although growing (Table 1). The aquatic science community may not have made a tight enough connection between nutrients and their social impacts for them to be newsworthy. People have difficulty grasping multiple causative agents like nitrogen and phosphorus causing algae growth (Nisbett and Ross 1980) or they may appear in the news as generic terms like "fertilizer." Making connections clearer to journalists and the public may bring nutrients into the public eye.

The average statistical rate of growth of press coverage of aquatic science topics (Table 1) suggests that few aquatic science topics are declining in journalistic coverage and this may portend a growing public interest in water resources. Both inland fish and fisheries and acidification are significantly declining in prominence while others are not significantly increasing or decreasing. Several aquatic fields, although not as commonly mentioned, are increasing faster than the rate of increase in attention to global climate change in the news. These are PFAS and its derivatives, microplastics, aquatic ecosystem services, carbon sequestration in marine and inland waters, and sea-level rise. DOC/DOM in marine and inland waters is also rising rapidly in press attention, albeit at an average rate that is an order of magnitude lower than other fields growing fastest in press attention.

Several fields are not significantly increasing or decreasing in press attention. In inland waters, these include nitrogen, phosphorus, and invasive species. These may have become victims of the journalistic issue-attention cycle (Djerf-Pierre 2012). Phosphorus and nitrogen are among the greatest threats to safe and clean water supplies. Invasive species are still spreading rapidly among lakes, completely altering ecosystem function with large societal costs. In marine systems, toxic blooms still severely impair recreation and food supplies. A diversity of waterborne diseases still kill many people worldwide so perhaps were not discovered using a generic search term. News stories on these are few and not increasing in relative frequency.

Raising the profile of aquatic science

Press attention to scientific fields can alter funding streams, changes in policies and the careers of aquatic scientists. There is sometimes a substantial mismatch between aquatic scientists' attention to topics and the frequency these topics appear in the news. This is important not only to the public vision of the aquatic sciences but also to the advancement of the careers of individual aquatic scientists. If one is working in an important area that gets little public attention, scientific- and media-attention can be realigned. Two ways to do this are to (1) more actively connect aquatic research with areas of public and social interest and (2) work toward improving the communication of aquatic science with the public and the press.

Aligning research with public interest

Philosophers and sociologists of science suggest that vital sciences generally support a restricted number of key paradigms (Rigler and Peters 1995; Kuhn 2012). Some suggest that ecology does not receive as much funding and public support as some other fields (e.g., astrophysics) because ecological paradigms are diffuse, making public attention difficult (Peters 1991). It could also be because astrophysics may provide more tangible products or has better captured public attention and imagination.

One way to bring aquatic science topics into greater news focus and attain stronger public support is to connect research with areas of large and growing interest to the press, people, and funding agencies. These research areas can be found at the top of Fig. 3 and Table 1. Working in research areas where relevance to larger problem areas is clearer and citation networks are broader (sensu deSolla Price 1965; Radicchi

Table 1. The frequency of appearance of topics selected for this study in press reports relative to _the_. Shown are the average frequency as well as the linear rate of change in press reports over the same time period. The shaded cells have trends with significance levels > 0.01 so are essentially statistically flat without statistically significant negative or positive change in rates of appearance. Topics are listed from highest to lowest increasing rate of change.

Topic	Average relative press mentions, last 15 yr	% Change per year
PFAS etc. (I and M)	4.52	25.2
Microplastics (I and M)	6.26	22.7
Ecosystem services (I and M)	4.22	15.0
Carbon burial (M)	16.12	13.0
DOC/DOM (I)	0.26	11.9
DOC/DOM (M)	0.22	11.4
Sea level rise (M)	28.23	11.1
Carbon burial (I)	17.28	10.8
Climate change (global)	973.9	10.2
Biodiversity (M)	62.26	8.1
Eutrophication (I)	1.48	7.8
Cyano-HABS (I)	11.04	7.5
Climate change (I)	184.99	7.3
Climate change (M)	251.32	7.1
Pollution (M)	117.44	6.4
Aquaculture (M)	30.72	6.3
Biodiversity (I)	77.49	6.2
Greenhouse gases (M)	87.14	5.5
Acidification (M)	6.01	5.3
Pharmaceuticals (M)	30.97	4.3
Pollution (I)	185.41	4.2
Toxic algae and HABs (M)	7.71	3.8
Greenhouse gases (I)	70.76	3.7
Invasive species (M)	9.93	3.5
Pharmaceuticals (I)	33.49	3.3
Phosphorus (M)	6.94	3.3
Nitrogen (M)	16.78	3.2
Aquaculture (I)	17.34	3.1
Waterborne disease (I)	6.05	2.2
Invasive species (I)	2.06	1.1
Nitrogen (I)	26.23	1.0
Debris (I and M)	324.88	0.7
Dam removal (I)	1.19	0.7
Phosphorus (I)	16.28	0.3
Fish and fisheries (I)	680.31	−3.0
Acidification (I)	8.29	−3.6

et al. 2012) may also result in more peers being aware of the importance of the specific research area.

Like other scientists (Wei et al. 2013), aquatic scientists work on topics they feel are among the most important areas of scientific advancement. The development of both limnology and oceanography derived through relevance to keeping aquatic systems healthy (Downing 2014), although the relevance of specialized research to broader aquatic science concerns sometimes becomes distant (Casadevall and Fang Ferric 2014). Working toward making those connections clearer can bring research closer to addressing the interests of the press, the public and the priorities of funding agencies.

For research interests near the bottom of Fig. 3, one way to have a stronger impact is to accentuate its interface with one of the topics at the top of Fig. 3. Science could seek, for example, the interaction of DOM with climate change, the effect of dam removal on fish and fisheries, the interaction between eutrophication and marine debris or other pollutants or how species invasions change with climate change. Making such connections might augment the societal relevance for some topics that the public and the press may have found obscure.

Improving communication with the public and the press

Choice of research area and research topic are among the most important career decisions scientists make (Chakraborty et al. 2015). Increased press and public attention to chosen research areas may be enhanced by clearly and frequently expressing the research's importance to people, agencies, and journalists. Clearer public interest in the aquatic sciences could be attained by improving communication of the importance of research to people, policy makers, and funders.

Positive publicity matters to universities, laboratories, agencies, and others who employ scientists. Their communications staffs seek to express why people should care about the importance of their organizations (but *see* Fecher and Hebing 2021). Scientists and science communicators can seek out public relations opportunities and find ways to better interface with people and the press.

Better communication with people and the press can result from using a diversity of approaches to communication (Suldovsky 2017). The most usual and least successful approach is assuming that interest in or support for scientific and technological advances and concepts can be enhanced by just giving people information (e.g., Simis et al. 2016). This is called the knowledge deficit model. Other communication models might better communicate the value and interest of the aquatic sciences to the press and society. Some approaches to use to increase the uptake of science by the public might include integrating the audience's background, culture and emotional contexts (contextual model, Mitchell et al. 1989); communicating via discussions among scientists and lay people (dialogue model, Turney 2007); acknowledging local knowledge and expertise (lay expertise model, Brossard and Lewenstein 2009); involving the public directly in inquiry or application (public engagement model, Miah 2017); or choosing where and when to communicate science for the best social benefit (upstream–downstream model, McMahon 2022).

The knowledge deficit model is the most common and there have been decades of arguments in the literature that it should not be (Seethaler et al. 2019) because it is a "…repetition of emotionless objectively sterile information to increase understanding" (Jones and Anderson Crow 2017). All the above communication models could, however, work under some circumstances. Books on science communication (e.g., Laszlo 2006) often combine these ideas in recommending how to communicate well. Some science communicators have advocated that science communication training should be mandatory for undergraduate science majors (Brownell et al. 2013).

A few things to consider when communicating science to the general public (after Laszlo 2006). (1) *The story*. People need to know why they might care. Stories that consider the audience, relate to their experiences, and conclude with a relatable message are memorable. (2) *The format*. Chronological narratives detailing the process of the work, its challenges, and outcomes (i.e., manuscript translations) tend to be ineffective. Technical terms or acronyms kill communication (*see* also Falkenberg et al. 2024). (3) *The tone*. The story is important, not the methodological elegance or the brilliance of scientists. (4) *The feel*. Irony, humor, and enthusiasm are compelling. Surprises and unexpected twists in the plot are interesting. Telling people what to do, think, or how to act can hinder their interest and understanding.

Given the importance of marine and freshwater science worldwide, informing the public about the aquatic sciences can be beneficial. Good science communication can improve the prospects for aquatic resources as well as scientists' careers. One of the principal correlates of whether science stories are picked up by the press is whether they appear on EurekAlert! (https://www.eurekalert.org/; MacLaughlin et al. 2018). Appearing on that and similar science aggregation sites will also increase the citation rate of the research by other scientists, enhancing networking for greater effectiveness.

Diverse aquatic research areas receive very different degrees of attention from the press, the public and policy makers. Press attention to many areas of aquatic science is increasing or constant compared to the overall body of news. News coverage increases public interest that is associated with support for funding and policy changes. Regardless of the rates of news coverage of diverse fields of the aquatic sciences, increased quality and intensity of communication with the public can increase interest. Aquatic scientists need to solve environmental problems and we need to take on the biggest problems we can solve (Rigler and Peters 1995). As we do this, attention to press coverage and good public communication can have a synergistic effect, enhancing the aquatic sciences' ability to understand and create solutions.

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Conflict of Interest

None declared.

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