A One Health Approach to Marine Health

Juli Seth, Public Health Program (BSPH), Virginia Tech
Emma Fralin, Public Health Program (BSPH), Virginia Tech

Abstract

Background: Climate change, plastics, and overfishing are major threats to marine health. The scientific and public health communities will be front and center in dealing with these threats. A One Health approach, where the integration of various disciplines together promote the protection and preservation of people, animals, and the environment, represents a sound model to address marine health problems.

Purpose: The purpose of this paper is to show how a One Health approach can be applied to marine health in order to protect and preserve marine ecosystems. A literature review was conducted on Google Scholar using the keywords "climate change", "overfishing" and "plastics," with inclusion criteria of publication date as 2005-present.

Conclusions: A One Health model was formatted based on this review to target the marine threats of climate change, plastic pollution, and overfishing. This One Health model was found to benefit the health of marine individuals, populations, and ecosystems, as well as human health. Establishing One Health teams is an appropriate way to handle the addressed marine threats that require cross-disciplinary skills.

Recommendations: The complex threats marine ecosystems face demand international cooperation and cross-disciplinary knowledge. Based on the findings of this review, a One Health approach is strongly recommended to best promote the health of marine life.

Background

Humanity is at a critical turning point of redirecting global industrialization to favor the planet's health. Global industrialization has led to massive consequences that need to be acknowledged and accounted for. The most neglected, largest sink of pollution, and worldwide connector, is the planet's oceans. Earth's oceans have an estimated volume of 1.3324×10^9 km^3 and could hold up to 1 million more species than the 226,000 eukaryotic species currently described (Charette & Smith, 2010; Appeltans et al., 2012). Marine health is a broad term that covers everything from the health of fish and ocean mammals, tourism and fishing industries, water temperatures and rising sea levels, transportation and research, and human waste in every part of the blue planet. A major threat to marine health is climate change. The evidence of climate change affecting the global oceans is far too vast to list here, so the overall subject and its negative implications on marine health will be discussed here. One of the most obvious effects of warming global temperatures is the melting of ice. Lack of ice directly reduces wildlife habitat, which directly reduces traditional food available to indigenous peoples (Gadamus, 2013). Melting ice also decreases seawater salinity, which has been shown to negatively affect phytoplankton growth and subsequently disrupt the food chain (Mintenbeck, et al., 2012).

Ocean acidification, caused by the increase of CO_2 levels resulting in a lower pH, is another issue for marine health. The ocean absorbs about one third of atmospheric CO_2 emitted from human actions, and since carbon emissions have exponentially increased in the past century, the ocean's acidity has also increased (Mintenbeck, et al., 2012). Both temperature increase and ocean acidification are significant stressors of coral reefs, leading to bleaching and slowed growth (Hoegh-Guldberg, Poloczanska, Skirving, & Dove, 2017). Decreasing oceanic pH has also been shown to decrease olfactory sense in fish larvae that allow them to find suitable habitat, which would reduce respective populations (Munday, et al., 2009).

Eutrophication is another problem for marine health, and has been documented as an environmental stressor, harming both animal and human populations. Eutrophication and climate change work in additive fashion to essentially make an aquatic habitat uninhabitable, whether by creating dead zones, increasing competition among microorganisms, or producing toxic phytoplankton (Suikkanen, et al., 2013). In addition to these concerns, climate change has also been shown to increase disease transmission between organisms, as higher temperatures allow for vector and parasitic range expansions (Ostfeld, 2009).

Plastic pollution is a major threat to marine health that plagues many spots in our ocean's geography. Plastics that consumers and industries use do not biodegrade, but form microplastics that congregate and mix in our oceans. When disposed, these plastics can end up in any of the five major oceanic gyres; two of which are located in the Pacific Ocean, one in the Indian Ocean, and two in the Atlantic Ocean. About 280 million tons of plastic is produced each year that ends up in one of these gyres (Sigler, 2014). In order to better understand the effects of plastics, it is critical to understand what constitutes these plastics, where how they end up in the ocean, how they affect marine health, and how they ultimately come back to affect human health.

Many additives are mixed in with natural polymers of plastic. Of concern are phthalates and bisphenol A (BPA). These chemicals can be toxic and have a negative effect on marine and human health. Phthalates are used in PVC (polyvinyl chloride) plastics while BPA is used as a monomer in production of polycarbonate plastics and PVC (Thompson, Moore, vom Saal & Swan, 2009). The main concern lies in the fact that phthalates are not chemically bound in plastics and can leach out of the material, which can negatively affect life in the ocean. BPA and phthalates have been found to affect the life cycle and reproduction of many aquatic-inhabiting animals such as amphibians, crustaceans, and even insects. Another problem with plastics is that they attract harmful pollutants such as polychlorinated biphenyls (PCBs). PCBs have been found to cause cancers in marine animals and greatly affect the immune, nervous, endocrine, and reproductive systems. Through consumption and the nature of the ecosystem these harmful pollutants can end up back in humans and ultimately cause cancer or other harmful conditions within humans (Sigler, 2014).

Plastics can settle in the oceans in multiple different ways. Most oceanic plastics result from accumulation in landfills. There is also much accumulation of plastic that ends up on ocean shores. There have been reports of more than 100,000 items per square meter on some shorelines (Thompson, et al., 2009). Other avenues are through the contamination of sewage, fragments of plastic contaminating compost of municipal solid waste, and plastic traveling from streams, rivers, lakes and the sea ultimately ending up in the ocean (Thompson, et al., 2009). Once plastics reach the ocean, they can travel throughout its depths from the surface to the ocean floor, affecting all marine life in between. Plastics that have not degraded to microplastics pose a major threat of entanglement for marine animals such as cetaceans and sea turtles. Within the last decade, at least seven endangered humpback whales (*Megaptera novangliae*) have been spotted towing mass amounts of tangled nylon rope and items such as crayfish pots or buoys (Sigler, 2014).

Plastics can fragment due to UV, mechanical, and microbial degradation (Wright, Thompson, & Galloway, 2013). Once plastics become microplastics, they become difficult to distinguish between phytoplankton for fish and cetaceans and therefore, become consumed. Naturally these microplastics start to sink down to the ocean floor by biofouling which is the accumulation of microorganisms, plants, and algae on surfaces and in this case microplastics. This causes the plastic to lose its buoyancy and chemical characteristics to where it no longer can stay on the surface of the water and sinks (Wright, et al., 2013). By this process, many new organisms are exposed and can accidently consume the plastic. These microplastics can then be brought back up to the ocean's surface by defouling, where animals feed on the biofilm accumulated on the plastics causing them to rise back up and affecting more animals on the way back up (Wright, et al., 2013). Once these microplastics are ingested, accumulation and blockage within the digestive tract can occur causing major blockages leading to death or affecting the health of the marine animals due to the chemical composition of these plastics. (Sigler, 2014).

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Another major contributor to marine health is an unbalanced ecosystem of organisms. With a rise in global human population and thus demand of fish, a dramatic drop in fish numbers has been measured. Besides the obvious implications of reduced fish numbers including susceptibility to disease and extinction, the indirect effects promote even higher points of concern. In the Caribbean, overfishing of reef fish that consume sponges leads to coral reefs being overtaken by sponges (Loh, Mcmurray, Henkel, Vicente, & Pawlik, 2015). Such competition has the probability of driving off remaining fish, and more significantly, preventing the reestablishment of corals, which would further the chances of the ecosystem collapsing (Brandt, Olinger & Chaves-Fonnegra et al., 2019). Another effect of overfishing is the disruption of the food chain. Removing predatory fish populations has been shown to prevent the transfer of nutrients up the food chain, and has led to sustaining harmful algal blooms (Vasas, Lancelot, Rousseau, & Jordán, 2007). Overfishing also has drastic consequences for human health in the fishing industry. Because fish populations have declined, industrial fishing boats have resorted to fishing in more dangerous waters, and without the ability to increase fishermen wages, they lose employees. Boats are then forced to seek more dangerous waters, and cannot increase fishermen wages, so resort to recruiting workers coercively or by trafficking. It is estimated that over 100,000 are recruited by these means (Marschke & Vandergeest, 2016).

As public health addresses the important topic of marine health, it is also important that a good model be used in proposing solutions. One Health can provide such a model. One Health is the integration of human, animal, and environmental medicine and research, so that collective decisions of prevention and protection can be made from teams of all disciplines (Destoumieux-Garzón et al., 2018). One Health has been acknowledged for decades, but is only recently gaining traction in research and health practices. The benefits of One Health are numerous, including but not limited to the promotion of global wellbeing through the interconnectedness of nations, the perspective shift of acknowledging that the health of the planet promotes the health of human and animal inhabitants, and the ever-increasing idea that interdisciplinary groups can advance problem solving far better than individual ones. The purpose of this paper is to apply a One Health approach to marine health in order to better protect and preserve the global marine ecosystems.

Methodology

This literature review was conducted using Google Scholar with inclusion criteria of journal articles from 2005-present and keywords of "climate change", "overfishing" or "plastics" within the title. This produced about 12,900 articles which demonstrated numerous approaches and recommendations for promoting marine wildlife, ecosystem, and human health. From this, articles were chosen that operationalized One Health in order to develop a framework (Figure 1), which required evaluating individual, population, and ecosystem health. For the purpose of this paper, these components were defined as a cycle induced by human action that subsequently affects marine health on the individual, population, and ecosystem levels. Such effects then come back to impact human health as demonstrated in the One Health Framework below (Figure 1).

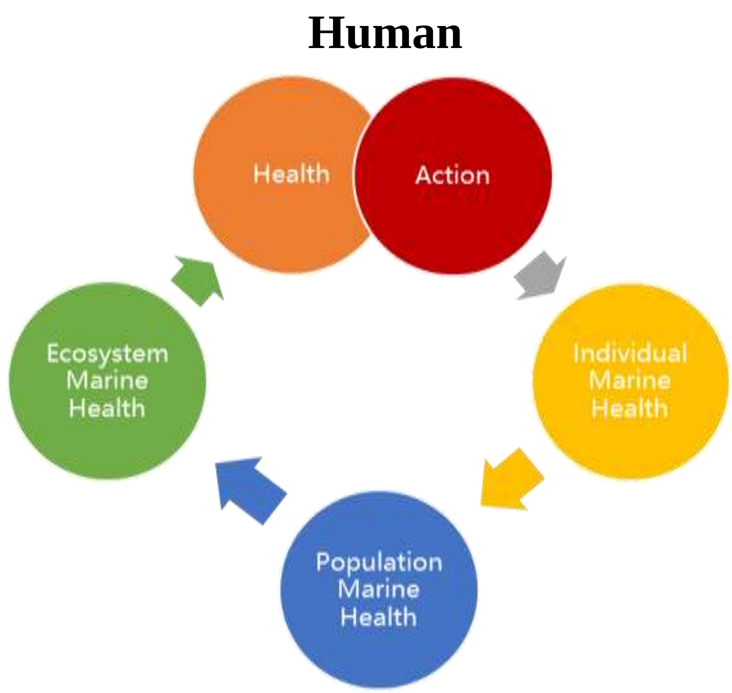


Figure 1.
The One Health Framework

Current Public Health Solutions

Melting ice has serious consequences for terrestrial and aquatic life as well as humans. It has been recommended that a Marine Mammal Health Map be incorporated into the Global Ocean Observing System, which would help link data on climate change while surveilling marine mammal health and indigenous people's needs (Moore & Gulland, 2014). A growing concern with melting ice is the interest industries have gained in opportunistic trade routes and drilling. It has been estimated that the Northern Sea Route would barely impact global trade, but drilling would be more beneficial, and therefore poses a greater risk (Bensassi, Stroeve, Martínez-Zarzoso, & Barrett, 2016). Russian drilling advances were stopped by the United States when Russia was sanctioned for its actions against Ukraine. This shows that political decisions have greater impacts than environmental concerns, and so it seems only necessary that a One Health Team for marine health include policy makers and governmental committee members

(Bensassi, Stroeve, Martínez-Zarzoso, & Barrett, 2016). Currently, combating plastic pollution involves tracking, collection and destruction strategies. Tracking trash uses radio frequency identification (RFID) tags and cellular transmitters (Sigler, 2014). This has allowed researchers to follow where trash has been, how long it has been moving before being deposited, and where the trash finally accumulates. This helps target where plastic pollution campaigns should be held, as well as target where more efforts should be put in plastic cleanup. Drones have been suggested in plastic collection as well as a major cleanup project called the Ocean Cleanup Array (Sigler, 2014). This project poses a solution by anchoring a platform to the ocean floor where plastics accumulate on top and marine life underneath remain unharmed. A projection of 7.25 million tons of plastic can be collected and removed in this way (Sigler, 2014). Finally, a destruction method called thermal degradation poses a solution to destroy plastics into liquid hydrocarbon fuel (Sigler, 2014). This way plastics no longer have to be accumulated through landfills and can have a direct route to be converted into fuel.An additive effect on top of these issues is overfishing. By further draining already stressed populations, humans are perfecting the stage for the possibility of even more extinctions. A study conducted by Herrera, Moeller, & Neubert, 2016) suggested that closing high seas to fishing will actually benefit self-interested states that are overexploiting fish resources. Creating a model that suggests convincing states to agree to such a closure was also found to be more attainable than one would think (Herrera et al, 2016). Marine reserves where fishing is not prohibited are economically beneficial even under non-cooperative systems (Herrera et al, 2016).

Conclusions

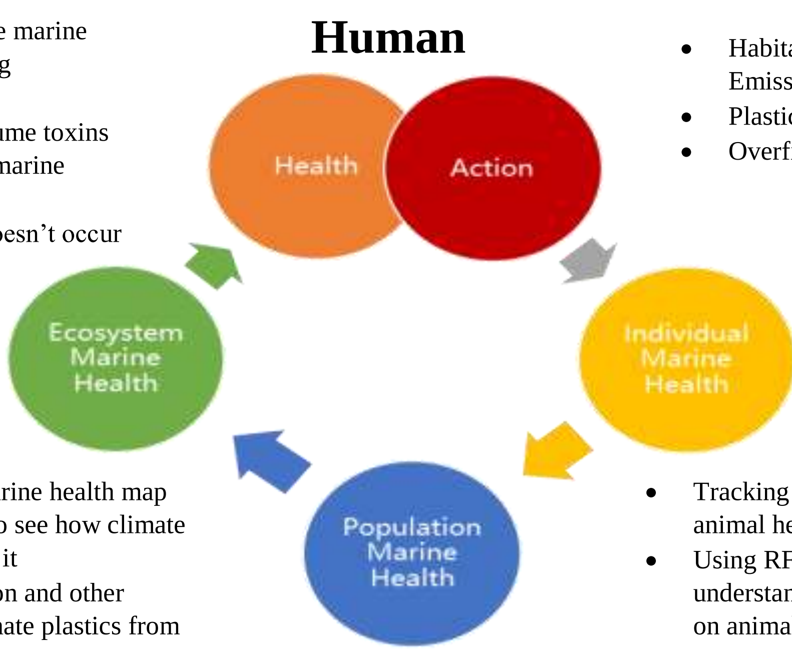
A One Health approach to marine health would benefit the environment, animals, and humans across the globe. The authors recommend that global surveillance be increased and maintained, and stress that indigenous groups must be accounted for and listened to. A One Health team for marine health would be better able to implement policies to mitigate and manage the effects of climate change. The One Health team would also help to transition society towards a massive cultural shift in decreased waste production and sustainability, among other attributes.

A One Health approach would provide information on the overall health of the blue planet from perspectives of specialists in oceanography, wildlife medicine, ecology, public health, policy, and so many more. This disciplinary integration will better address and manage the effects humans have imposed on the natural world by increasing global surveillance of marine ecosystems. By utilizing the One Health approach, future generations will have data on the effects of climate change, plastic pollution, and overfishing on marine and human health and a comprehensive outlook on possible solutions.

Recommendations

The interconnectedness of the planet should be embraced and respected. Figure 2 shows an application of recently discussed issues and their consequences.

- Humans can consume marine life without disrupting ecosystems
- Humans do not consume toxins and phthalates from marine consumption
- Human trafficking doesn't occur



- Habitat destruction, Carbon Emissions → Climate Change
- Plastic pollution
- Overfishing

- Tracking individual marine animal health with tags
- Using RFID tags on plastics to understand location and effects on animals
- Closing high seas fishing

- Population health of species can be obtained with tags etc.
- Better collection being placed on species that are affected by plastics

- Comprehensive marine health map can be developed to see how climate change is affecting it
- Thermal degradation and other methods can eliminate plastics from ecosystem
- Opening marine reserves can let ecosystems thrive

Figure 2.

Applied One Health Solutions for Marine Health

In order to apply a One Health approach to marine health, teams can be formed to help shift society towards a more sustainable way of living. A One Health team addressing climate change would not only stress global surveillance and collaboration, but would also focus on applying scientific suggestions to public policies. There has been a disconnect between science and policy action, and having scientists and policy makers work together as a part of a One Health team would allow both parties to better understand each other's needs and how to enact solutions (Lemos & Rood, 2010). This communication will also benefit the prevention of disease transmission and outbreaks by increasing the preparedness of nations, overall global surveillance, and production of much needed vaccines and treatments.

Currently when combating plastic pollution, there are no talks on how to solve the issues of inadvertent marine consumption of plastics. Tracking, collection and destruction are all strategies being taken into account, which will eventually lead to less consumption; however, the flow of biofouling and defouling of microplastics and how it affects marine animals is not taken into account in collection strategies. Based on this, it is the researcher's suggestion to incorporate the expertise of ecologists and wildlife veterinarians to help reduce the number of marine life consuming plastics and detect those who have. In addition, medical doctors must understand how phthalates and toxins from consumed marine life affect human health. Therefore, a One Health team comprised of wildlife veterinarians, ecologists, doctors, marine scientists and public health officials needs to be formed when coming up with solutions to plastic pollution.

A humanitarian concern with overfishing is the 100,000 or more workers recruited coercively or by trafficking (Marschke & Vandergeest, 2016). In order to prevent such cases, global surveillance must be increased. This added surveillance will directly benefit human rights enforcers and illegal fishing prevention to establish a better understanding of fish populations and their needs. A One Health approach would therefore benefit the health of marine populations as well as international human health. With the help of humanitarian and public health workers, a One Health team would utilize population health specialists to determine the health of marine systems and the least destructive areas and quotas for global fishing industries. This would prevent marine areas from being drained of resources and increase the resiliency of populations. Other parts of this team could include wildlife biologists and veterinarians to recognize and mitigate disease outbreaks that could further harm marine populations. Policy makers and economists would utilize their skills to advise trading and demand of resources in order to best determine trade effects and necessary laws (Zhou, Smith, & Knudsen, 2014). This integration of a One Health approach would be a catalyst in shifting societal attitudes and industry choices towards a more sustainable way of living, promoting the health of both marine ecosystems and human populations.

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