ENSTU 300: Critical Thinking & Communication in Environmental Studies

The Impacts of Seawater Desalination on Marine Life in Monterey County

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Abstract

This report studies the impacts of seawater desalination on ecological habitats and marine organisms in Monterey Bay, California. A variety of perspectives from various stakeholders on the environmental topic are considered and explored. Stakeholders include policymakers, environmentalists, local residents, fishers, and commissioners. This paper analyzes different alternatives using a specific set of criteria valued by stakeholders involved. Social, environmental, and economic factors are weighed using the costs and benefits of other alternative solutions for freshwater production and conservation. The report uses cost-benefit analysis to determine whether new policy should be created to mitigate the effects of current technology used in ocean desalination facilities. The success of California's current desalination policy will be assessed, and additional policies to incentivize the prospected facilities in Monterey County will be reviewed.

Introduction

Only within the moment of time represented by the present century has one species–man–acquired significant power to alter the nature of the world (Carson, 1962). Human involvement is prevalent amongst the majority of environmental cases, but because humans are part of the problem, they can also be part of the solution as stewards of the earth. In Monterey, the ebb and flow of this human action–just like waves in the ocean–determines the bay's ecological health.

Freshwater is increasing in value for all of California due to prolonged drought, an increasing population, and a future of uncertain climate change. An alternative to mitigate this problem is increasing production of freshwater. For coastal regions like Monterey Bay the development of seawater desalination facilities is an option that is being delegated. Stakeholders for both current and prospective ocean desalination facilities include residents of Monterey County, the California Coastal Commission, the California Department of Water Resources, owners and operators of the desalination facilities, nonprofit organizations who promote the conservation of ecological habitats, and various fisheries in Monterey Bay. All stakeholders have either economic or environmental incentives for involvement, if not both. If the general public chooses not to respond, then new desalination facilities will be constructed without change in policy or monitoring of technology used.

Seawater desalination is the process used to extract salts and minerals from saltwater to make freshwater that can be used for human consumption and irrigation (Kumar et. al. 2016). The current technologies utilized in desalination processes across the coast of California are open water intakes. The primary effect of these screened open ocean intake pipes is mortality of larval fish, fish eggs, and numerous types of plankton (Szeptycki et. al., 2016). Plankton serve as the foundation of the food chain for all marine life, and the overall impact from such mortality would hinder the health and diversity of Monterey Bay. Seawater desalination facilities have the ability to potentially harm marine biota further with the discharge of brine disposal into the bay. Brine is a salt solution heavier than seawater so its discharge is deadly to life in the ocean since it settles on top of communities of benthic organisms as well as their habitats. The brine acts similar to syrup that is poured into water; it settles at the bottom and is very difficult to mix (Reeb, 2017).

Alternatives should be explored so that the negative impacts that seawater desalination plants have on marine biota is reduced as much as possible. The conservation of marine life is important for the balance of entire ecosystems. Marine life specifically benefits people in Monterey Bay by creating jobs, serving as food on menus, and creating diversity for the ecotourism industry. Understanding the role that marine life plays in the Monterey region will help the general public manage human involvement and the role that desalination eco-footprints have. Most of the current policy involving seawater desalination pertains to regulating the disposal of saline into the environment at the discharge point, so there is much room for improvement in the policy of desalination (Szeptycki et. al., 2016). Alternatives include increasing water conservation, improving desalination technology, and using a different water source for the facilities. The largest challenge for seawater desalination is reducing environmental impacts from both brine discharge and intake technology while meeting projected water demands for the local communities.

Background

History

California has been in a drought for the past couple decades and faces the challenge of maintaining and conserving a freshwater supply. Since the drought has continued throughout the state, various alternatives have and are still being explored to help conserve the state's existing water supply. In 2014, Governor Jerry Brown acknowledged the water shortage problem by declaring a state of emergency. The Governor installed various executive orders to mitigate the effects of prolonged drought–increased water conservation, recycled water use, and production of freshwater (Brown Jr., 2014). Some of these alternatives, like the production of freshwater using reverse osmosis otherwise known as desalination, diversify the state's water portfolio but also come with risks that can be evaluated using a specific set of criteria (Szeptycki et. al., 2016). California is faced with the challenge to maintain a water supply that meets the needs of its growing population and addresses the uncertainties of a changing climate (California Natural Resources Agency et. al., 2016); therefore, the proposal of seawater desalination plants to relieve the stress on California's freshwater supply is becoming more of a viable option.

Methods of desalination have been utilized for centuries since it is characterized as the basic removal of salts and other contaminants from water. Saudi Arabia was the first to successfully build a seawater desalination plant in the late 1930s. The United States and other nations followed in pursuit of desalination research during World War II to help relieve stress on regions with low availability of safe drinking water (Cooley et. al., 2006). The first technologies that developed were distillation-based and then filtration membranes emerged in later years–the current technology used in Monterey Bay's desalination facilities. The membrane technology uses reverse osmosis to separate contaminants from the water being processed. Distillation-based technologies are being replaced by more-efficient reverse osmosis facilities; however, despite these improvements, reverse osmosis desalination also consists of energy-intensive processes and is faced with the challenge of sustainability (Kumar et. al., 2016). In order to propose this method as a viable solution to ensure long-term water sustainability for California and other regions around the world, this technology has room to be further developed and improved through scientific innovation.

Scientific Background

There are ten ocean seawater desalination facilities that currently exist in the state of California (*Figure 1.1*), and eleven potential sites are being prospected along the state's coastline (*Figure 1.2*). These facilities may help relieve stress from California's current water usage and future projections of water shortages (Pacific Institute, 2016). There are certain challenges presented for marine biota along the coast of California. The water intake and discharge processes may threaten a variety of species. Furthermore, methods for which seawater is drawn and deposited must be considered for environmental impact.

Open ocean intake is a technology used for seawater desalination and has two specific risks on marine biota–impingement and entrainment. Impingement refers to the trapping of small fish on the intake screens. Entrainment is the capture of organisms that are pulled in by the current or inflow of water (Mackey et. al. 2011). In other words, some small fish and larvae are incapable of swimming against high intake velocities, resulting in higher mortality rates for these organisms. To mitigate the impingement of fish and other marine organisms, the State Water Resources Control Board established a regulation of no more than 0.76 millimeters wide for the openings of the holes on intake screens; however, there are tremendous amounts of plankton and fish larvae that are smaller than this proposed size (Williams, 2017). The impingement and entrainment of marine life is the most significant threat associated with seawater desalination (Cooley et. al., 2006). The current facilities located in the Monterey region utilize some type of beach well or slant well (Pacific Institute, 2016). The intake velocity is minimized using sub-surface wells so this technology reduces the risk of entrainment for marine biota (Mackey et. al., 2011). However, stakeholders in Monterey County have much to debate since only one out of the three prospected sites, shown in *Figure 1.2* below, has proposed using sub-surface technology.

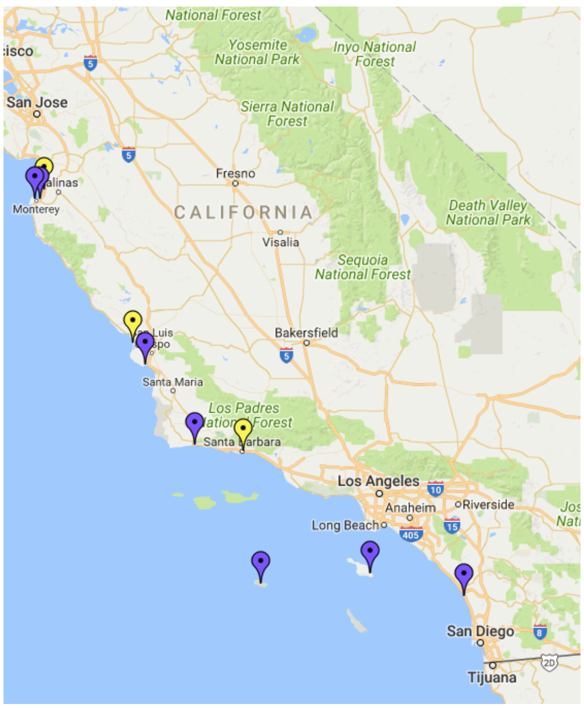

Figure 1.1 (Map showing existing locations of seawater desalination facilities)

Source: Pacific Institute, 2016

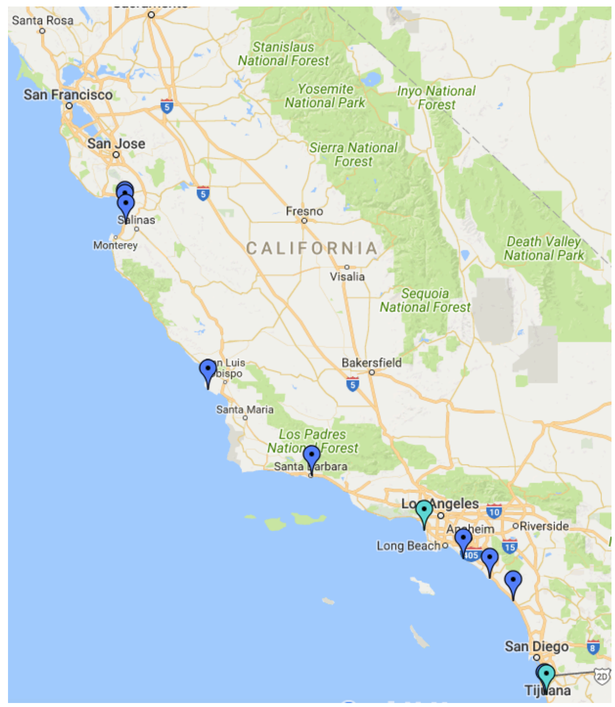

Figure 1.2 (Map showing proposed locations for new seawater desalination facilities)

Source: Pacific Institute, 2016

Today, three desalination facilities exist in Monterey County and three more potential sites are being prospected in this region. DeepWater Desal Project, The People's Moss Landing Water Desal Project, and Monterey Peninsula Water Supply Project are in the process of development (Pacific Institute, 2016). As discussed prior, intake technology must be taken into consideration for each facility's environmental impact. Monterey Peninsula Water Supply Project is the only plant proposed to operate using subsurface intake wells. These subsurface wells use sand as a natural filtration and have the ability to reduce or eliminate impingement and entrainment of marine biota (Mackey et. al., 2011). Furthermore, Monterey Peninsula Water Supply Project will only operate at half the capacity of the other two proposed projects in the Monterey region (Pacific Institute, 2016). The capacity at which each facility takes in water is also accounted for since this affects the total volume of marine biota negatively affected per unit of water.

The volume of brine deposited into the ocean is another cause of concern for certain stakeholders in the development of new desalination plants. Ocean discharge is the least expensive and most common method for disposal of waste from coastal desalination sites (Cooley et. al., 2006). Therefore, economic and public health benefits must outweigh the environmental costs that result from the brine waste. California's new policy on the discharge of brine into the environment focuses mainly on water quality near the discharge point. The new standard is for all waters within one hundred meters of the discharge point not to exceed more than two parts per thousand (Szeptycki, 2016). The average salinity level of seawater generally ranges from thirty-three to thirty-eight parts per thousand (University of Hawaii, 2017). Data was recorded from Point Cabrillo in Monterey by Hopkins Marine Station scientists from 1919 until 1964 that showed a consistent mean salinity level range of approximately thirty-three parts per thousand (Stanford University, 1964). This shows that coastal conditions are relatively constant and new variables such as increased saline have the ability to disturb ecosystems in a manner not yet studied. The chemical components as well as the physical behavior of brine pose a threat to all marine biota in the surrounding regions where it is disposed. Despite the supposed sustainability of current standards, field and laboratory data for the long-term effects of elevated saline concentrate on California marine biota is limited, often not peer-reviewed, or contain flaws in the study design. According to the California Water Resources Control Board, additional research is needed on the chronic effects of increased saline to local, relevant species, particularly emphasizing sensitive benthic species (Jenkins et. al., 2012). The accumulation of higher salinity levels in water depressions and the seabed has yet to be studied and monitored though, so there is much room for improvement in the development of new policy.

Location for the permitting of new seawater desalination facilities along the coast of California is a factor that may determine ecological effects on the surrounding environments. The state has a numerous amount of law and policy mitigating the potential effects of disposal of pollution into various waterways that will be discussed later in this report. The proposed projects for the Monterey Bay region are located within a federal national marine sanctuary and have additional policy to address in regards to preservation of habitat and species diversity. Additionally, agricultural waste run-off from the Salinas and Pajaro rivers into the Monterey Bay may affect future concentrate levels of brine discharge. Since there is no existing data or research on how this brine would interact with run-off contaminant concentrations, federal and state regulators may or may not evaluate these uncertain circumstances and take them into account for protection of local environments when developing new policy.

As mentioned in the introduction, California has turned to production of freshwater from seawater using desalination processes to help mitigate California's water shortage. This alternative is just one of many proposed by California's governor, Jerry Brown. In order to successfully determine whether seawater desalination is a viable option, one must compare the costs and benefits of each alternative. Energy is the largest single variable for operating ocean desalination plants. This alternative also requires the most energy in comparison to Governor Brown's other options–water conservation and water recycling practices (Cooley et. al., 2004). Currently, the average Monterey Peninsula resident uses sixty gallons of water daily, while other parts of the world, such as some regions in Australia, have a higher rate of water recycling and conservation efforts and use only thirty gallons of water per person daily (Potter, 2015). Furthermore, the proposed desalination sites would only create 1.2 percent of additional freshwater supply (Reeb, 2017). When there is a steady increase of seven percent annually of water demand across the state due to population growth, policymakers may have to address the costs that this option withholds (Cooley et. al., 2017). Lastly, with the value of freshwater increasing due to scarce resources available, it is relatively impossible to predict the cost of what seawater desalination will be in the future, but *Figure 2* on the following page shows the average percentages of where money is invested for operational and construction costs. Though there is much uncertainty for economic cost analysis of desalination, one factor is certain and that is the effort to make seawater desalination facilities more energy-efficient and sustainable will help reduce the overall costs of operation.

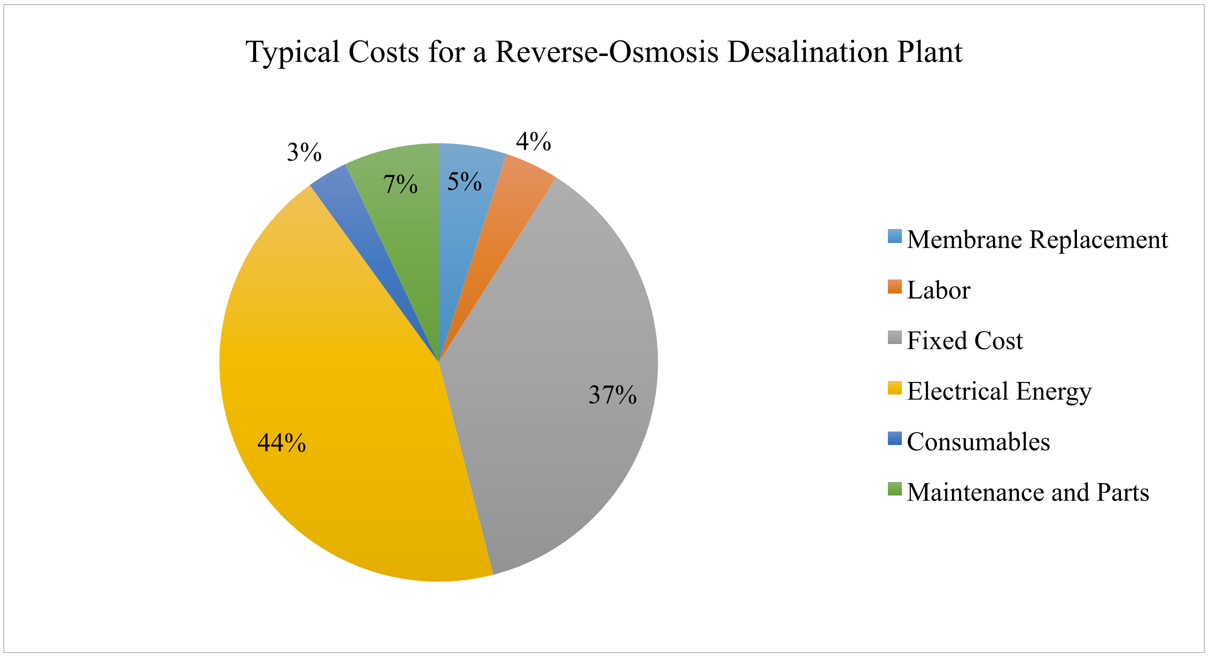

Figure 2 (Pie graph showing total costs for construction and operation of seawater desalination plants)

Source: U.S. Bureau of Reclamation and Sandia National Laboratories, 2003

Policy Context

Policy is advantageous for mitigating negative effects of any environmental issue, even the impacts of seawater desalination operations on marine life. Some questions that need to be considered when addressing seawater desalination projects are: How can the effects of brine discharge be minimized through adverse disposal strategies? What cumulative effects occur due to location chosen for the desalination site? What are appropriate monitoring procedures for waste discharge? What intake technology should be implemented to ensure success rates of species diversity?

The United States Environmental Protection Agency established the Clean Water Act to regulate the discharge of pollutants into the rivers, lakes, and ocean waters of the U.S., specifically measuring the quality of all surface waters. Under the Clean Water Act, the federal government has implemented pollution control programs like the Environmental Protection Agency's National Pollutant Discharge Elimination System for setting standards for wastewater disposal. Section 316(b) of the Clean Water Act also requires that the location, design, and capacity of intake structures minimize environmental impacts by installing meshed wire screens on the intake pipes and not exceed a velocity intake of more than 0.5 feet per second. This helps to mitigate entrainment and enmeshment of marine organisms. The State or Regional Water Quality Control Board and California State Lands Commission are in charge of regulating these standards put forth (Cooley et. al., 2006). This environmental policy does not include regulations for brine discharge that settles at the bottom of the ocean floor and is not included in ocean surface waters.

The United States Environmental Protection Agency installed the Pollution Prevention Act that implements pollution should be prevented or reduced at the source whenever feasible and should be treated in an environmentally safe manner whenever plausible before releasing back into the environment. The act also implements disposal or release of pollutants should be last resort to other available alternatives whenever feasible. The environmental policy may or may not clearly define if brine discharge from desalination plants is environmentally safe and may be reduced at its source because of other water conservation alternatives; however, there are regulations put in place to ensure that salinity levels within one hundred meters of the discharge point do not exceed more than two parts per thousand (Szeptycki, 2016). Therefore, there is room for improving evaluation of whether new water-quality regulations farther than one hundred meters are needed to protect local environments.

Every existing and newly constructed seawater desalination facility is also required to conduct an Environmental Impact Assessment and Environmental Impact Report in accordance with the National Environmental Policy Act and the California Environmental Quality Act. These are typically submitted as one document and describe the facility's impact on fish and wildlife resources, water supply, and water quality. This could be helpful in mitigating the long-term effects of increased salinity on fish development and habitat, like kelp forests in the Monterey Bay. Both the California State Lands Commission and the California Coastal Commission are in charge of enforcing and regulating these reports.

Two policies that also may influence proposed future desalination sites for the Monterey Peninsula are the Endangered Species Act and the Marine Mammal Protection Act. An Endangered Species Act consultation is required for all seawater desalination facilities by the U.S. Fish and Wildlife Service and the California Department of Fish and Game (Cooley et. al., 2006). This consultation specifically assesses the habitat needed for endangered or threatened species, both local and migratory, and requires the facility to comply with accordance to preserving them. The state's Department of Fish and Game is in charge of managing marine and estuarine endangered, exotic, and threatened species. Some marine animals in the Monterey region protected by these policies are Guadalupe fur seals, Southern sea otters, California Brown Pelicans, and California Clapper Rails (NOAA, 1999). Marine mammals and various whales may be affected if populations of their prey start to deplete due to ecological effects from brine and intake technology. Policymakers have yet to create policy to mitigate the mortality of plankton and larvae stages of fish because a long-term analysis of the protection of these marine mammals' prey populations is needed.

When national marine sanctuaries are proposed, policy is reformed for the preservation and conservation of marine life within the designated sanctuaries. The National Oceanic and Atmospheric Administration created guidelines for the construction and operation of seawater desalination plants in accordance with the Monterey Bay National Marine Sanctuary's regulations. The first guideline regulation involves a prohibition of disposing of any material into the boundaries of the sanctuary, unless granted authorization through the Regional Water Quality Control Board permits. This also includes monitoring of waste discharged outside the sanctuary's boundaries since waste is able to travel into the sanctuary through ocean currents; however, this may be permitted through the Regional Water Quality Control Board as well. Lastly, the installation of intake and outfall pipes on or below the seafloor that may disturb the seabed would require Coastal Development Permits and Sanctuary authorization by the California Coastal Commission (MBNMS and National Marine Fisheries Service, 2010). Although there are permits for regulating waste and intake pipelines within the Monterey Bay National Marine Sanctuary, disturbance of certain benthic communities and mortality rates of plankton and small fish by desalination plants are still uncertain in regards to long-term analyses.

Stakeholder Perspectives

The majority of people residing in the regions of the Monterey Peninsula hold a stake for the operation and construction of seawater desalination plants, since safe, drinking water is a necessity, and fisheries provide jobs and revenue for the municipal economy. Some of the largest stakeholders are residents in Monterey County, California Department of Water Resources, the owner and operator at each seawater desalination facility, and various fisheries. The owners and operators of the desalination plants vary, but the main organizations include Monterey Peninsula Water Management District, California American Water, DeepWater Desal, and Monterey Peninsula Regional Water Authority (Pacific Institute, 2016). The major stakeholders mentioned above are evaluated by a specific set of criteria in *Table 1* below. The criteria are as follows: how much the stakeholder will be affected, their values, their contributions, and their concerns about the proposed seawater desalination projects in the Monterey Peninsula.

Stakeholder Group and Representatives	Impact	What does the stakeholder(s) value about the project?	How can the stakeholder(s) contribute to the project?	What are the concerns of the stakeholder(s)?
Residents	medium-high	increased freshwater supply; lower utility bills	policy	public safety; freshwater production; higher utility bills
California Department of Water Resources	low	increased freshwater supply	funding	expenses; restrictions
Owner/Operator	low-medium	increased freshwater supply	funding; choice of technology installed	expenses; restrictions
Fisheries	high	potential impact on livelihood	monitoring of fishery health	revenue; fishery health

Table 1 (Major Stakeholders in Seawater Desalination Plants within the Monterey Peninsula)

Residents of the Monterey Peninsula region have a medium to high stake in seawater desalination facilities. If more desalination plants with high capacity were constructed in the future years to come, then the majority of the available drinking water in the region would come directly from the output of these plants. Monterey County residents are primarily focused on increasing the region's freshwater supply and addressing the needs of the current and future populations. The general public is a powerful stakeholder in the creation of new policy since local communities usually vote for new law and regulation. Although not every citizen in the local area knows the extent to which the water is being safely treated for contaminants, a major concern should be public safety of adequate drinking water for the community. Local residents generally want to increase freshwater supply through production; however, people will become concerned if utility bills rise as a result of the costs to produce more freshwater. According to John Kennedy, the executive director of engineering and water resources at the Orange County Water District, if prospective plants are approved, the average California household water bill is expected rise by three to six dollars each month (Williams, 2017).

The California Department of Water Resources is a state agency that regulates and monitors the current water supply of the entire state. If coastal communities like the Monterey Peninsula were to start producing their own freshwater supply, then there would be less stress on other surrounding areas in the state like various freshwater aquifers and the Carmel River. Because production of freshwater in the Monterey Peninsula only increases the state's total current supply by less than one percent annually, then there is very low impact by the construction and operation of such facilities. This state agency is able to contribute funding for various proposed projects in the Monterey Peninsula region; however, these expenses equate to large investments and there are additional fees for required permits within the national marine sanctuary.

Of the various owners and operators of desalination plants located in Monterey Bay, Monterey Peninsula Water Management District and California American Water are the few that have taken sustainable measures for operating and constructing new seawater desalination facilities. The general manager of Monterey Peninsula Water Management District, Dave Stoldt, explained that these seawater desalination projects are last resort after exploring other cost-effective alternatives. He further explained that subsurface wells are used for his company since it minimizes the entrainment of marine fish (Stoldt, 2017). The impact of installing desalination plants in the Monterey region is rated as low to medium since these companies and agencies are responsible for diversifying the community's water portfolio and meeting the freshwater needs of the population. They have a slightly higher stake than state agencies, like the California Department of Water Resources previously mentioned, since they are focused on the municipal supply. This means that a larger proportion of this local water portfolio will be affected by these seawater desalination facilities, since the plants have the ability to supply a lot of water to the coastal city, where the state's portfolio would only be affected by a net increase of 1.2 percent as mentioned prior in this report (Reeb, 2017). Owners and operators value an increased freshwater supply and can contribute funding towards desalination projects. They are also responsible for proposal of technologies that will be installed within each facility. Similar to the state's Department of Water Resources, there are setbacks of high expenses and regulatory obstacles that need to be considered.

Out of all the major stakeholders involved in the impacts of seawater desalination plants on marine life, fisheries have the highest stake. According to Dr. Carol Reeb, a resident scientist at Stanford University's Hopkins Marine Station, fisheries like California market squids' will start to see the long-term effect of higher salinity levels. The brine discharge, if not properly mixed, has the potential to settle on top of benthic communities of squid eggs and hatchlings and affect their overall development and success. If fish populations, such as the market squid, begin to deplete and not replenish, they have the potential to become "commercially extinct." This will affect the livelihoods of not only the fisherman reaping revenue from the fishery, but also the costs of seafood for both locals and tourists will rise dramatically. Fisherman and the U.S. Department of Fish and Wildlife are able to contribute in helping a variety of fisheries by monitoring fish population abundance and health.

Discussion

Threats to marine organisms come with additional altercations for Monterey County residents since some fisheries' health may decline or even have the potential to completely collapse. The impingement and entrainment of these marine organisms will not only affect species population numbers, but also the long-term effects of the bay. Some alternatives are explored for mitigating California's water shortage while minimizing the ecological impacts to marine biota in Monterey Bay. The newest options explored are wastewater desalination, seawater desalination using subsurface wells, and increasing freshwater conservation efforts. Two options in *Table 2* below, *Option 2: Seawater desalination using subsurface wells and Option 3: Seawater desalination using open ocean intake pipes,* are compared as viable options since they are the alternatives currently pursued in Monterey County. If these options are to be considered further, then the community is essentially not making any new change in current policy.

Criteria	Option 1: Wastewater desalination	Option 2: Seawater desalination using subsurface wells	Option 3: Seawater desalination using open ocean intake pipes	Option 4: Increase freshwater conservation efforts
Sustainable	++	+	+	+++
Price	++	+	++	++
Public safety	+++	++	+	+++
Environment	++	++	+	+++

Table 2 (Evaluation of Major Stakeholders for Seawater Desalination Facilities)

('+' is low impact; '++' is neutral impact; '+++' is high impact.)

Wastewater desalination uses the same processes as seawater desalination, but the method is more sustainable since it requires half of the energy input per unit of water produced. Since this alternative uses less energy than seawater desalination this option is also more cost-efficient and leaves a smaller carbon-emission footprint. The public health of the water quality produced is safer than seawater desalination facilities because after contaminants undergo reverse osmosis and contaminants are removed, the water is then stored underground and tested under federal and state regulations before being dispersed among communities (Reeb, 2017). Groundwater desalination plants are less impactful on the environment since there are no intake pipes connected to the ocean due to the recycling of already-used water as well as stormwater.

Furthermore, the discharge of contaminants is more soluble than the saline concentrate composed in brine; therefore, the environmental impact is lessened since the discharge dilutes into the ocean.

Seawater desalination using subsurface intake wells requires large amounts of energy input to produce freshwater. The amount of energy required is positively correlated to the costs of operation, so this alternative is considered to be costly. Also, the newer technology of the wells costs more than the open ocean intake pipelines (Reeb, 2017). The quality of the water is always a concern for stakeholders but using subsurface wells below the sandy seafloor reduces the risk of taking in harmful algal blooms that occur most springs in Monterey Bay. The water dispersed to communities from seawater desalination facilities are not held to high regulations of aquifer storing and testing, so harmful dinoflagellates found in red tides can be drawn through the pipelines located in the open ocean water column. Besides the harmful disposal of brine into the ocean, the subsurface wells eliminate ecological impacts of entrapment and entrainment for marine microorganisms and small fish larvae.

Seawater desalination using open ocean intake pipelines requires just as much energy as *Option 2* mentioned above; however, installation and maintenance of subsurface well technologies are more expensive than the open ocean intake since this is considered older technology. This alternative has the highest concern for public safety since the water quality is not stored and handled in the same manner as other water purification methods. Open ocean intakes are faced with the challenge to determine absence of harmful dinoflagellates, known as red tides, before operating these technologies and taking in water to be processed in the facility. This technology is the least sustainable towards marine ecosystems since the impingement and entrainment of marine biota is a plausible factor in addition to the discharge of brine waste onto benthic communities.

Although increasing conservations efforts will not increase the region's freshwater supply, this option helps to mitigate the real, underlying environmental issue at hand–California uses excessive amounts of water. The majority of California residents currently use 120 gallons of water per person daily and Monterey is leading the efforts in water conservation with sixty gallons per day (Potter, 2015). There are many stakeholders who feel that this is the greatest effort that can be possibly made for this region, but if places like Australia can reach thirty gallons of water per day (Reeb, 2017), then how can we? Furthermore, if Monterey County produces more freshwater, then the real problem will continue–using an unreasonable large amount of freshwater. Water is not valued enough and is not seen as a non-renewable resource, but the rate at which it is being consumed is higher than the rate at which is being replenished. There is skepticism towards seawater desalination because some think that this will promote the region's growth since Monterey is a coastal region and has an abundance of ocean. However, education and conservation can help relieve any new negative impacts from an increasing regional population. Increasing water conservation efforts across the region and state is the most sustainable alternative available and promotes public safety and well being for present as well as future years to come. Conservation is also environmentally sound and will not harm or pose a threat to current marine life in Monterey Bay. In order to pursue this option though, policymakers need to create legislation and propose funding for the project.

Recommendation

The potential benefits of ocean desalination are great, but the economic and environmental costs of operating these types of facilities remain high. Although ocean desalination addresses California's ongoing water shortage problem head-on, it is not the most sustainable and efficient alternative available. Water conservation efforts have been perfected elsewhere in the world, so there is no reason why Monterey cannot also lead the state and nation in these sustainable practices. To address the need of more freshwater supply, after the water conservation efforts have been maximized, the community should resort to wastewater recycling and desalination. This helps save money, energy, and the environment when compared to the operation of seawater desalination plants. Ocean desalination should be last resort for Monterey Bay, and if it is pursued, subsurface wells should be required and open ocean intake should be prohibited. Regarding the brine waste, the municipal, state, and federal agencies should conduct long-term studies on its effects as well as provide funding for research of new, more sustainable discharge technologies. Perhaps with an increase in water conservation and the recycling of wastewater, the state of California will be able to sustain its own freshwater supply for now and many decades to come.

Conclusion

Social, environmental, and political issues arise with the development of desalination plants along the central coast of California. In order to pursue an alternative to address the normative claim that Monterey County residents should explore other alternatives besides seawater desalination facilities to help mitigate the impacts to marine life, these questions first to be answered: What are the issues with the current policy? What's at stake? What are the varying alternatives and tradeoffs? What policies should be considered? The answers to these questions may vary for each stakeholder, but all answers are relevant and should considered before creating new policy. Because desalination plants directly affect residents and other stakeholders, they should be the ones to take action and propose a recommendation for now and the future.

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