CHAPTER 14

# Social Issues and Public Acceptance of Seawater Desalination Plants

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## 14.1 INTRODUCTION

In a prescient 2002 article, Means et al. write:

> *Utilities will likely turn increasingly to recycling, ocean desalination, and use of other "marginal" supplies in order to meet growing water needs. These supplies will bring unique water quality and perception issues to the forefront.*

The authors identified three trends: growing/aging populations with concerns about health impacts of drinking water; improved pollutant detection technologies that are outpacing the ability to equate the presence of small amounts of pollutants with health impacts; and global warming, which could disrupt historical surface and groundwater supplies. The combination of growing interest in water quality and supply unreliability is pushing urban regions toward new supplies, including desalination and urban water reuse. A new water world is upon us.

Public perception matters because infrastructure projects exist to serve the public good. The public also influences policy decisions through participation and voting. Attitudes can inform whether a project gets built, influence facility operational and expansion decisions, and determine whether to pursue similar projects elsewhere. Public opposition to essential infrastructure projects implies a failure of past policy to communicate the needs to the general public and could lead to future underfunding, weak oversight, or neglect of existing systems, threatening an essential service.

Means et al. [1] focused on what could be called the old rationality of public health and water reliability concerns. Historically, water agencies interacted with the public by presenting scientific and economic evidence to support recommendations on water infrastructure planning and

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management. Today's agencies recognize a new form of rationality that includes psychological aspects of perception, such as fear of contamination. Scholars note that "there are many examples where people's feelings or intuitions run counter to their own rationally considered self-interest, and sometimes the public interest" ([2], citations omitted). Psychological impacts of water supply are just one part of the water dialog; the public is also interested in water's connection to environmental impacts, urban congestion, economic growth, and regional independence. All of these topics contribute to understanding how the public views proposed and existing water infrastructure projects. Political questions concern whether and how public perception matters for policy making, and how public perception can be informed, influenced, or even manipulated.

Public perception and water resources management is a more complex and nuanced field in 2017 than it was even two decades earlier. The search for communications paradigms continues, including understanding what members of the public know about water supply, what they feel is important, what role the public wants to play in decision making and management, and how they want to be informed. These questions represent an ongoing research agenda and in this chapter we address one segment: public perception of desalination facilities.

Describing a treatment method such as desalination as a *source* of potable water is somewhat arbitrary. Nearly all water is part of the global hydrological cycle but, designating one intervention in the cycle as a distinguishing characteristic or origin of a water supply, we can begin the conversation on public perception. The origin of a water supply is commonly understood to be the location in nature from which water is captured for human use. A groundwater basin can be a source, as can a river, lake, spring, or the ocean. An actual use becomes a new origin for the same flow of water (e.g., urban water), and when the water is returned to a natural sink or conveyance, the perceived origin is updated again. When water from one origin is mixed with water with another, such as river water mixed with treated urban wastewater, the length of time the water is in the river before it is again captured for human use influences perceptions of the water's origin and its suitability for use. Water of natural origin is preferred to water of urban origin [3].

Throughout human history, knowledge of the origins of a water supply has been a useful proxy for water quality, and we should not be surprised that people feel revulsion as a defense against perceived contamination in water. As water treatment technologies improve, a struggle between perception/response and science-based assurances of water quality has emerged. Treatment technologies can turn any quality of water into potable quality. The ability to tap into previously unused source waters, such as the ocean, grows. Humanity is less dependent on natural biological and physical processes to deliver high-quality source water for human use. But, as Means et al. [1] explain, the technology and science of water treatment have advanced far beyond our understanding of how to communicate about water.

Technological advances in water treatment are timely and necessary because many of the natural and physical systems currently relied upon, such as groundwater percolation, have either been compromised by human activities or do not have the capacity to provide the amount of water needed by today's cities. Different approaches to potable water supply are needed.

Sources of potable water now emerging as crucial to urban water supply planning in the 21st century include saline water from either inland saline aquifers or coastal bays and shorelines. Inland saline aquifers present the fewest barriers to implementation, but they generally do not occur where large concentrations of people live. Historically, the existence of saline groundwater rather than fresh groundwater has been a hindrance to human settlement. In recent decades, human migration to the world's coastal regions has accelerated, creating both pressure and opportunity to reuse existing urban supplies and to develop seawater desalination. Urban reclaimed water and seawater desalination share the similarities of being located in growing coastal cities and of utilizing generally the same treatment technologies. However, public perception and policy implementation processes are different. Urban reclaimed water has undergone a great deal of scrutiny with regard to public perception and policy in recent years (for a summary, see Ref. [4]), but public perception of desalination has received less attention. Although desalination does not carry the negative baggage of prior human use, its public perception is more strongly associated with coastal environmental impacts and high energy demand. A long-standing preference for desalinated water for potable use over other alternative supplies was confirmed in a recent international survey [5]. The combination of continuing improvement in the economics of desalination technology, growing coastal populations, multiple demands on surface water and coastal groundwater supplies, reticence to utilize urban wastewater, and unlimited availability of seawater calls for greater scrutiny of desalination [6]. Coastal desalination projects are likely to be more numerous in the coming decades and have the potential for wide swings in positive and negative impacts depending on how they are implemented.

Because seawater desalination is a relatively new source of urban water in the United States, much of the social sciences literature has focused on processes for establishing new facilities and for accepting desalinated water as a safe drinking source. A more recent literature is now emerging that examines the effects of operating desalination facilities on the regions in which they are located. The benefits of an operating seawater desalination facility include overall water supply augmentation, a year-round reliable water supply that reduces drought risks, and a robust technology that reduces system failure risk and increases system resilience. These benefits are experienced by the region taking the desalinated water as well as nearby regions and uses competing for the same inland water supplies. Impacts of desalination are concentrated near the coastal location of the facility, both on shore and in the near-shore ocean. Other impacts, including the costs of constructing and operating desalination facilities, are additional considerations that may be experienced by the region consuming the water as these costs may be included in the cost for the water supply. A classic environmental context of disbursed benefits and concentrated costs/impacts calls for careful scrutiny of how significant are the impacts, who is bearing them, and are they being considered in the regional governance of desalination.

Public perception research can occur in many contexts. For complex engineering/natural systems, the intervening layers of technological/scientific complexity and interest group politics can influence the public's understanding of and support for a project. Researchers examine whether the public has been given adequate opportunity to express collective or individual opinions in ways that could influence a decision or action. Another issue is whether the public has been informed about potential impacts and benefits of a proposed system. Infrastructure projects have impacts in the short term and long term, both positive and negative, and it is the duty of proponents to provide baseline information on these impacts, after which robust debate contributes to an informed decision. Further research can examine the extent to which the public understands potential impacts and is therefore able to make an informed decision about a proposed project. In this chapter, we first list potential impacts of desalination, then explore how they are perceived by the public, and whether these perceptions influence public acceptance or opposition to a desalination facility. We also examine psychological and demographic aspects of acceptance or opposition to desalination facilities, before discussing future research needs.

## 14.2 POTENTIAL IMPACTS OF SEAWATER DESALINATION

For some individuals, any adverse impact on the ocean is unacceptable. This perspective could arise from recognition of the ongoing decline of ocean biota, growing ocean pollution, and changes in ocean chemistry, or from a spiritual or personal attachment to the ocean that does not countenance its use as a source of fresh water for onshore uses. This perspective could also arise as an opening salvo in a public policy process in which opponents state their strongest possible opposition to a proposed desalination facility about which they have other more specific reservations. A categorical rejection of terrestrial uses of ocean water means that one doesn't have to consider any categories of use.

Categories of potential physical and environmental impacts include piping, coastal water, coastal land areas including the atmosphere and construction. Coastal seawater desalination facilities require three separate pipelines. The first is the seawater intake, and its design influences its impact on nearby ocean ecology. In general, the greater the flow rates at the point of intake, the greater the potential for ongoing ecological damage through entrainment (capture) of marine organisms. With more widely dispersed intakes, less disturbance is likely. Intakes installed underneath sand have also been implemented at some locations and are considered to have lower entrainment rates. The second pipeline delivers concentrated brine from the facility back to the ocean. Numerous factors influence the potential impact of the brine on sea life, including the rate at which the brine mixes with ocean water thereby reducing the potential harm from localized concentrated salts. Although location, physical structure, and flow rates play crucial roles in determining the level of ocean impacts, it is impossible to have no impacts at all from the operation of a seawater desalination facility. The third pipeline is the onshore link between the treatment facility and the rest of the water system. With occasional exceptions, such as Riyadh's 400-km pipeline from the coast to the inland city, the proximity of treatment to end use means extensive inland piping is not needed. Urban wastewater treatment systems typically have unused capacity, so it is unlikely that an expansion to an existing treatment infrastructure will be needed with the addition of desalinated water. Potable water originating from seawater does not require special treatment after use.

In the onshore coastal area, a desalination facility takes the form of a small-to-moderate-sized factory. Inside the building are the water pumps, water treatment devices, piping, a water sampling/testing area, and other necessities of industrial facilities, such as offices. There is also a parking lot for the relatively small crew of facility operators. Sound is produced by the operation of water pumps and the occasional arrival and departure of vehicles. Desalination facilities do not generate noxious odors. Overall, a desalination plant is an unobtrusive light industrial facility except that it is located next to the ocean. For many coastal cities, near-shore real estate is valued both for private residences and for public spaces. The presence of a desalination facility can be detrimental to the alternative nearby uses, and a new facility might replace a previously valued public use where it is constructed. In addition, the facility uses electricity as its power source and is thus a net generator of atmospheric carbon dioxide, which is of concern because it exacerbates climate change impacts.

Construction involves laying the pipelines, often crossing both the surf zone and existing shoreline roads, building the facility, and attaching it to the existing potable water system through inland pipelines. The construction process could be preceded by a multi-year smaller scale pilot project utilizing temporary systems. Construction of inland piping is likely to interrupt transportation as streets are dug up and pipes laid. The coastal ocean impacts described above all occur in the zones adjoining the intakes and outfalls.

Another broad category of costs involves economic costs and benefits. In the United States, coastal desalination facilities can cost in the range of $100 million to design, permit, and build. Once built, operating costs are likely to be higher than for other existing water supplies because of the energy cost of removing salt from the water. These costs are distributed to the customers of the facility. The capital (construction) costs are typically bond financed and paid off over a few decades. Overall, the region's cost of water will increase with the addition of desalinated water. Economic benefits include the wages paid and purchases made to build and operate the facility, and the ongoing beneficial impact of the additional more reliable water supply.

## 14.3 PUBLIC PERCEPTION OF SEAWATER DESALINATION

Studies of attitudes toward desalination fall into three contexts. The first includes studies on general attitudes toward desalination as a water supply option by asking the public wide-ranging questions that are not attached to a specific project. The second are studies focusing on public opinions about actual forthcoming water projects, and the third examines attitudes in locations where a desalination system has already been established [6a], such as in Spain [7] and Australia [8]. To determine whose perceptions matter, one can generate such categories as all people, people who take water from the desalination-connected system, and people who live near the ocean and/or the desalination facility and infrastructure. For example, local residents might share regional feelings about the cost of monthly water bills while holding differing views about coastal impacts related to the desalination process that provides this water.

Most studies suggest that residents look favorably upon desalination solutions for potable water supply. In Carlsbad, a small coastal community in southern California with no previous experience with desalination, Heck et al. [9,10] found more than 70% of coastal residents supported the local seawater desalination plant. Gibson et al. [11] reported similar findings for desalination plants in Perth, Australia, where 74% of residents supported the expansion of desalination plants in the city. Perth, a large urban region, already receives about 47% of its water from two desalination plants [11a]. While there are only a few such studies, the similar high support in Perth and Carlsbad suggests that the size of a community and degree of experience with desalination may have little influence on support for specific desalination projects.

### 14.3.1 Perception of Environmental Impacts

Coastal residents may oppose desalination plants due to beliefs about biological, ecological, and environmental impacts from desalination plants on personal values, including effects on benthic organisms and small marine organisms that are entrained in the water intake [8–10]. While there is society-wide positive association with and support for ocean stewardship, coastal residents appear to value the local marine ecosystem very highly, including aspects that are less visible such as small marine organisms (e.g., fish larvae, phytoplankton) and marine life on the ocean floor. The public places importance on ecological functions of many species, not just charismatic flagship species such as marine mammals)[11b]. Evidence confirming coastal residents' concerns about new and complex impacts on marine ecosystems comes from a study on public perceptions of impacts on marine environments by Gelcich et al. [11c]. These findings suggest that even though people engage with marine areas in different ways compared to terrestrial areas, and impacts are commonly less visible in the marine realm [11d,e], local residents are aware of less visible ecosystem features and are concerned about impacts that affect ecosystem functions and lead to declines in the health of marine ecosystems.

## 14.3.2 Perception of Social Impacts of Desalination

Ocean access and scenic impacts are another onshore concern of coastal residents. Some coastal regions are industrial in character, such as harbors with commercial/industrial facilities, and a desalination facility would be an unobtrusive addition to a coastal industrial area. However, the best location for a coastal desalination facility is determined by other factors such as linkage to existing water infrastructure and offshore factors. It is also the nature of desalination, as a new water supply to be introduced into regions where the human population is growing, that results in competition for coastal locations to provide housing, commercial areas, recreation, and environmental benefits. A factory-like building of any kind would be an unwelcome addition to such coastal neighborhoods.

In the Carlsbad region of southern California, coastal neighborhoods had grown around an older power plant that was the proposed location for the desalination facility. The potential impacts of the facility on coastal scenery and coastal access significantly reduced support for the facility, even though the site was adjacent to and smaller than the existing power plant, and located further away from the beach (Fig. 14.1). Residents apparently


**Fig. 14.1** Carlsbad, California desalination facility, operated by Poseidon Resources, Inc. Colocated with and using inflow/outflow infrastructure of an existing power plant. Residential neighborhoods are located in upper left across the Agua Hedionda Lagoon. The public has access to the beach located across the coastal highway. *Source: Google Earth, 33°08′21.04″ N and 117°20′22.19 W (11/8/16).*

still did not appreciate the seemingly minimal additional impacts on coastal scenery. In Santa Cruz in central California, one resident speaking out in a public hearing on a proposed desalination plant stated that having paid over 1 million dollars for his ocean-front home, he did not want to be disturbed by the sound of water pumps. In Tampa, Florida, the state's largest desalination facility is also colocated with a power plant close to the community of Apollo Beach. This power plant's visual and ocean impacts are so much larger than those of the desalination facility that the latter has not been considered an issue of local scenic or sound concern. In general, coastal residents appear to feel protective about the remaining coastal scenery and natural quietude, and they do not welcome additional development close to the shore.

Residents sometimes oppose natural resource projects in their close proximity even though they would otherwise generally support them. The not-in-my-back-yard (NIMBY) framework has been widely used to explore whether proximity to a new development influences local residents' attitudes. NIMBY has been studied since the early 1980s in multiple natural resource contexts, including energy plants, natural gas extraction, wind farms, and offshore oil drilling platforms [12–18]. For desalination, NIMBY could provide insights to the question of whether coastal residents close to a facility oppose it more than those living further away. In these instances, the public may support desalination as a water supply option in general, but not the construction of such a facility in their immediate vicinity.

The Tampa Bay facility, colocated with the Big Bend Power Station, did not elicit NIMBY reactions from the community of Apollo Beach, and the Carlsbad facility also showed no significant effect of distance from the plant on support. Residents living closer to the plant did not support the new facility more or less than residents living further away. Limited explanatory power of proximity has also been found in multiple studies on public attitudes in other natural resource sectors [12,15,19] and desalination in Australia [19a]. The Carlsbad desalination plant is located in a mainly industrial area next to the Encina power plant and separated from residential areas by the Agua Hedionda Lagoon. Because this facility is small compared to the power plant and does not produce high levels of noise or visible point source air emissions, residents living closer to the plant may not be affected by the plant more than other residents, which may explain the absence of the NIMBY effect [10]. In contrast, the proposed desalination plant in Santa Cruz, California, would have been located close to or in an affluent residential neighborhood. It was put on hold after strong community resistance, including a number of complaints about expected impacts on quality of life and property prices [20]. The Santa Cruz resident mentioned earlier made a NIMBY-consistent point about the potential sound of pumps near his coastal residence and hence the details of coastal location seem to matter. Siting a plant in an existing residential area was hotly opposed, while operating facilities in nearby-yet-isolated locations such as the Carlsbad and Tampa Bay locations may have contributed to the absence of the NIMBY reaction.

### 14.3.3 The Influence of Social and Psychological Variables on Attitudes

The sociodemographic profile of a community may predict local support or opposition to some extent. Previous studies on public support in Australia and the United States investigated the influence of sociodemographic variables such as gender, age, education, and race on public acceptance for desalination plants. These studies found acceptance was correlated with all four of these variables. In Carlsbad, race and age were the only sociodemographic variables that predicted support for a coastal desalination facility, with white and older residents more likely to be supportive of the plant. Education and gender did not predict support in a study by this chapter's authors [9,10], which suggests that sociodemographic variables may have different, location-specific effects on the acceptance of desalination. Gibson et al. [11] also reported almost no influence of sociodemographic variables on the level of support for proposed desalination plants in Perth. Previous studies reported that sociodemographic factors shape acceptance to use desalination water. For example, in Australia, individuals receptive to using desalinated water were older, male, educated, and had previously used desalinated water [21]. These mixed findings suggest that the sociodemographic profile of a community in general might not be a decisive factor determining local support or rejection of a desalination facility.

Based on one study in Carlsbad, residents who frequently use local marine areas for fishing, surfing, swimming, and beach walking seem less supportive of seawater desalination. The Carlsbad plant is situated at a very popular beach with a high volume of recreational use. One potential explanation for less support by surfers and swimmers may be that these activities require physical contact with ocean water in the vicinity of the plant, and people may have concerns about the quality of ocean water in areas close to the point of discharge. Monitoring water quality may help reduce conflicts with recreational users close to a desalination facility, and with fishers who may worry about declining fish resources due to impingement and entrainment at the open-ocean water intake, or effects of brine discharge on food webs.

Psychological factors including beliefs and perceptions about seawater desalination outcomes have been found to influence attitudes toward the technology. Heck et al. [10] found that beliefs about negative impacts from the Carlsbad desalination facility are the strongest predictors of reduced support for seawater desalination. This facility is the largest desalination plant operating on the U.S. west coast, and the study spanned the construction/preoperation period of the facility and its initial operation. These findings are similar to the results of Gibson et al. [11] who also found that perceptions about outcomes predicted support for proposed desalination plants.

Another psychological variable that influences acceptance of local desalination facilities is place attachment to near-shore marine areas. While sense of place is concerned with factors creating bonds to a place (e.g., Ref. [22]), place attachment refers to the strength of bonds between humans and locations [23]. Place attachment can be assessed in many ways, but the two main dimensions with strong foundations in the academic literature are place identity and place dependence [24,25]. Place identity, or emotional ties to a place, usually develop over time and refers to the symbolic meanings of an area. Place dependence is the functionality associated with an area and is represented by its tangible physical characteristics and attributes [25]. As coastal residents and marine users often place emotional and functional importance on marine areas (e.g., Refs. [26–28]), place attachment can shape their attitudes toward the use or protection of these areas. Heck et al. [10] found that place attachment correlated significantly and negatively with support for a local desalination plant, indicating that strong emotional and functional ties to local marine areas shaped local views on the new facility. This finding is similar to a study by Devine-Wright and Howes [29] that found a perceived threat to place identity led to negative attitudes toward an offshore wind farm. In general, residents who attach high emotional and functional values to marine areas appeared to perceive the desalination plants as a threat to those values based on the expected negative impacts on local marine ecosystems. Place dependence on marine areas may also explain why marine users were less supportive of such facilities compared to other members of the community, since functional ties to an area and actual use are related.

Another consideration for public support of water supply systems is the notion of threat perception [30]. The public is more likely to support a proposed new water supply if there is a severe water crisis that threatens the existing system [31]. Studies on public support in the United States found that the strongest predictor for public support was concern about local water supply after a prolonged drought lasting multiple years that led to mandated emergency conservation [10,32]. Support therefore may decline in periods with higher precipitation and less concern about drinking water supply.

Research informed by theoretical approaches in social psychology and psychological risk perception (e.g., [33,34]) explore the influence of beliefs and attitudes toward desalinated water on the acceptance of using this water for different purposes. These studies found that concerns about the low quality of desalinated water and associated health concerns reduce acceptance of using desalinated water. Positive attitudes toward conservation and the environment, and social norms were also predictive of behavioral responses to using desalinated water [21,35].

### 14.3.4 Institutional Factors Shaping Attitudes Toward Desalination

Support or opposition to desalination or any other public project does not occur in a vacuum. Communities are aware, to some extent, of the institutional context in which decisions are made, and they have formed opinions about the institutional context. For example, in Carlsbad, trust was relatively low for the desalination plant operator and for the State Water Resources Control Board, both of which are heavily involved in operating and regulating the specific plant and seawater desalination facilities in general. Low levels of public trust in agencies to manage marine areas have been reported in other studies (e.g., see Refs. [11c,35a,b]). In California, agencies typically engage the public in open hearings, town halls, and public comments on draft proposals and Environmental Impact Reports related to seawater desalination. These approaches are widely used in numerous natural resource settings, and agencies face the dilemma of developing a plan with enough detail that meaningful discussion can ensue while not delivering a *fait accompli*. The process has been criticized as after-the-fact and lacking in early public engagement that helps shape the project under consideration. Lack of meaningful early and continuing public engagement has been found to reduce trust in management and oversight agencies [35c,d].

### 14.3.5 Management Strategies to Increase Public Support for Desalination

Since beliefs about negative environmental impacts erode support for desalination, it seems advantageous for gaining public support to design and build desalination facilities that minimize such impacts. One example is colocating a facility with an existing power plant and/or wastewater treatment plant and sharing the plant's ocean intake and/or outfall infrastructure. In such cases, the desalination facility does not require construction of additional infrastructure with its associated environmental disruptions. As with Florida's Tampa Bay facility, colocation with a power plant also reduces visual concerns. Adjacent marine ecosystems are already being affected by water intake and return flows from the existing infrastructures using seawater as a coolant in power production or releasing treated urban wastewater to the ocean. Even with these design elements, perceived negative impacts from the plant on the marine ecosystem may still be high and significantly reduce support for desalination plants [9,10]. Residents may be especially concerned about desalination-specific impacts (e.g., discharge of brine) that add additional stress to local marine ecosystems.

In California, the logic of combining desalination infrastructure with power plant infrastructure became enmeshed with an effort to end once-through cooling of coastal power plants. Once-through cooling uses orders of magnitude more ocean water than desalination. The water returned to the ocean is warmer than intake water, and tidal flow characteristics near intake and outfall are altered. Once-through cooling opponents feared that colocated desalination facilities would provide additional justification to maintain the operation of existing cooling systems through shared infrastructure. In California, the political skill and influence of the opponents, honed in hard-fought policy battles over coastal energy production, came as a shock to desalination proponents. The antidesalination effort ended a number of proposals while delaying others by several years. The rationale from the water production side for colocation remains, so the issue could emerge in other states in the future.

Onshore, expected $CO_2$ emissions from the desalination facility, driven by the power demands of high-pressure membrane separation of salt from water, also significantly reduced public support. Residents are aware that the means for generating electricity are predominantly fossil fuels, so operation of a desalination facility will increase greenhouse gas loading into the atmosphere. Energy demand and greenhouse gas emissions caused by desalination plants could further reduce public support if concerns about climate change and its impacts on marine ecosystems (e.g., ocean acidification) remain or increase.

The plant operator in Carlsbad developed a mitigation plan to offset impacts of greenhouse gas emission. Yet, residents may not be aware of the mitigation plan, or they might prefer that the plant directly reduce rather than offset emission through market-based methods. This would be consistent with a more general negative public attitude toward market-based approaches to greenhouse gas mitigation. The public has reacted ambivalently to this approach because it prefers to see polluters take individual action on site to reduce pollution, even if the actions are more expensive to the polluter [36]. Taking action at one's own facility makes it easier to hold the polluter accountable, since evidence of greenhouse gas reductions can be easily demonstrated. A plan to mitigate greenhouse gas pollution from a proposed desalination facility in Santa Cruz, California, encountered criticism for its proposal to mitigate greenhouse gas emissions via least-cost means because of the nonlocal market-based nature of the proposed means. The proposed approach involved purchasing greenhouse gas credits that represented greenhouse gas reductions in other sectors and parts of the world. Neither management strategy to address greenhouse gas impacts was particularly successful.

## 14.4 RESEARCH NEEDS IN PUBLIC PERCEPTION AND DESALINATION

Desalination has the potential to be a vital water supply source to millions of coastal residents. The small but growing body of research on public perception and attitudes toward desalination will be an important complement to ongoing research on technological and ecological impacts. Based on our review of the existing literature and our own investigations, we have identified the following research needs and opportunities. The focus is on public perception and social impacts, but there is an implied need in nearly all identified issues for ongoing and expanded technical and scientific research as well.

- *Public attitude dynamics*. While public attitudes toward desalination plants are important, they are not stable and statistically demonstrated predictors may change over time. Gibson et al. [11] explored public acceptance of expanding desalination in Perth, Australia, in 2007 and 2012 and found that support for the expansion of desalination remained high in both years (74.5% in 2007 and 73.4% in 2012), but the drivers of acceptance changed over time. In addition, public support may change between periods of sufficient water supply and drought. Since threat perceptions about local water supply appear to be a significant predictor for public support, support may wane once the threat recedes. One should not expect public perception to be stable since underlying environmental conditions themselves are not stable. Rather, one should expect perception to track and correlate with actual conditions (e.g., ocean impacts, onshore impacts) and how individuals evaluate them. The dynamic nature of public perception and public support/opposition is an important, underexplored issue. Dynamic public opinion contrasts with multidecadal or permanent impacts of a proposed infrastructure facility, and focuses our attention on what the appropriate role of public attitudes should be in infrastructure planning.

- *Use of existing offshore piping infrastructure*. One aspect of desalination environmental impacts is the construction of ocean intakes and outfalls, including piping to and from the facility. Colocation with coastal power plants that already have intake/outfall infrastructure and the utilization of existing outfalls from wastewater treatment plants present opportunities to avoid additional construction of ocean infrastructure. To determine whether colocation has any effect on local perceptions and support for desalination facilities, future studies could investigate whether perceived impacts on marine ecosystems are different for desalination plants that utilize pre-existing infrastructure and those that do not.
- *Energy and water supply*. Surveys have identified the importance to the public of reducing the energy demand of desalination and delinking water treatment from greenhouse gas generation. Technical research on improved membrane processes and integration of novel pre-reverse osmosis steps could help reduce this cost and negative perception barriers. Another relationship concerns the global warming impact of desalination. This can be reduced by the water utility or facility owner/operator investing in renewable energy, or by the regional power utility reducing the fossil fuel share of its primary energy. Further public perception research is needed to delve deeper into the connection between greenhouse gas emissions and water utility installations. It appears that the public focuses more on water utility emissions than on private industry emissions, even when the private industry product is less essential to public wellbeing than potable water. A deeper understanding into how the public evaluates the performance of natural resource-related utilities versus other private sector actors could influence how society understands and implements greenhouse gas regulation.
- *Users of marine ecosystems*. As desalination expands, the incidence and impacts of increased offshore physical infrastructure, additional inflows, and additional brine discharges will grow. Marine resource users, such as fishers, kayakers, and divers, directly engage the regions of impact and may have specific concerns. Understanding their uses and how new

facilities could impact them could be an important part of avoiding and/or managing conflicts.

- *Place attachment*. Individuals living near coastlines have personal and community connections to the ocean. If this connection is to be honored and integrated into coastal policy decision making, it needs to be better understood. Studies on place attachment to marine areas, and its related concept NIMBY, would help clarify the meaning and potential importance of place attachment.
- *Immediate vs. long-term planning*. A desalination facility takes several years to design, approve, build, and operate. A study of public perception captures a snapshot in time in this long process. In doing so, it can reveal what long-term elements are influencing opinion, versus ephemera. Some issues that initially do not emerge as influential, such as long-term projections of water supply and demand, could be emphasized more in the public debate regarding new water infrastructure. It could also help set agendas for early discussions between utilities and the public, avoiding the critique of ex post facto consultation. Further studies and meta-studies can identify short-term and long-term drivers of public opinion

## 14.5 CONCLUSION

Even in the highly technical world of potable water supply, the public plays an important role in decisions to build and manage new systems. Public policy processes should arrive at the best option on the table, or identify a better one through dialog. Processes should also avoid the outcomes of failure to build a needed facility or the construction of an unneeded facility. An informed and engaged public can influence technical and managerial choices. An informed public will not only grasp and evaluate valid points in the policy discourse, but it will also be able to dismiss misleading or inaccurate representations. Water supply broadly, and seawater desalination in particular require further investigation of public knowledge and perception of desalination processes and impacts.

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