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The World Ecology of Desalination

From Cold War Positioning to Financialization in the Capitalocene

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Abstract

World-systems scholars are increasingly engaged in issues at the intersection of ecological and economic concerns since the proliferation of debates on the Anthropocene. Recently, the alternative concept of Capitalocene—age of Capital—has emerged to draw attention to the world-ecological disruption of capitalism founded on cheap nature appropriation at ever-emerging extraction zones. This paper extends these discussions to the oceanic frontier, as the latest trend in the abstraction of value from the environment. Based on original archival research conducted in the context of a larger ethnographic project on the politics of industrial desalination—creating potable water from the sea—the article analyzes how this practice emerged in two phases. First, the Cold War opened the ocean as a commodity frontier during the pax Americana. Then, when this technopolitical agenda stagnated, financialization techniques were deployed to appropriate seawater, utilizing a mode of financial engineering—desalination via financialization reinstates the cultural hegemony of the Capitalocene that privileges infrastructure for water supply management solutions. As such, the article highlights the co-production of nature with financial capitalism.

Keywords: Anthropocene, Capitalocene, desalination, financialization, world-systems

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Potable water is at the top of global concerns for a sustainable future (Gleick 2018; Gleick and Palaniappan 2010; Kummu et al. 2016). Alongside concerns about energy and oil, freshwater availability has become a core issue (Rockström et al. 2014) in debates about the "Anthropocene," the proposed contemporary geologic epoch unmistakably marked by human intervention in the natural world (Crutzen 2002; Franchini, Viola, and Barros-Platiau 2017; Lidskog and Waterton 2016). According to the World Health Organization (2020), water demand often exceeds the supply necessary for basic needs like drinking, eating, and sanitation (between 13 to 30 gallons, or 50 to 100 liters per person per day).[1] By contrast, the United States of America (USA) has some of the highest water consumption rates in the world. The United States Geological Survey estimates daily average consumption is 80 to 100 gallons per person (300 to 380 liters). And while it is true that myriad concerns remain in *periphery* nations, regarding water provision and access (Dill 2010; Dill and Crow 2014; Lorrain and Poupeau 2016; Mascarenhas 2017; Mascarenhas 2018; Poupeau 2014; Poupeau and Hardy 2017; Schroering 2019), there have also been recent troubling trends in the *core* nations as well. For example, water quality crises have occurred in cities like Flint, Michigan (Krings, Kornberg, and Lane 2018; Miller and Wesley 2016; Pauli 2019), and water quantity problems are expanding in urban regions around the world (Srinivasan et al. 2012). When high water consumption is combined with a physical situation of scarcity and droughts in semi-arid regions with increasing urban populations, the effect is especially pernicious.

Opinions about solving these problems vary. On the one hand, demand management—reducing use through efficiency—has become increasingly important for resource management since the turn of the 21st century. For one, the Environmental Protection Agency (2020) in the USA describes such an approach as consisting not only of reducing demand, but of implementing policies for maintaining water resources to meet the needs of future populations.[2] Rather than large scale infrastructure like dams, this approach aligns with what some scholars call "soft-path" solutions; "the soft path for water strives to improve the productivity of water use rather than seek endless sources of new supply" (Gleick 2003: 1526). On the other hand, supply side solutions often involve high volume "mega" projects (Fainstein 2008; Obertreis et al. 2016) that many have criticized (David and Brandes 2011; Gerlak et al. 2018; Patrick 2011). For example, scholars examining water policy reforms have shown that in "the absence of active and disruptive policy entrepreneurs" (Marshall and Alexandra 2016: 679) path dependency—institutional and policy patterns hindering innovation and adaptation (David 2007; Pierson 2000)—can have detrimental socio-ecological impacts promoting infrastructure and technology that may not be ideal for future needs (Ingram and Fraser 2006; Sehring 2009). Such issues can lead not only to economic inefficiency (Harris 2011), but also to ineffective conservation efforts (Libecap 2011). In particular, the relative role of desalination – creating potable water from the sea – and its effect on

[1] The World Health Organization (WHO) regularly publishes statistics and reports about water, health and hygiene: https://www.who.int/water_sanitation_health/publications/2000-2005-publications/en/

[2] Readers interested in the U.S. Environmental Protection Agency's (EPA) efforts can begin here: https://www.epa.gov/greeningepa/water-conservation-epa

conservation remain an ongoing debate, with some scholars arguing that the technology has enabled the avoidance of policy change that would have systemic positive sustainable outcomes (Teschner, Garb, and Paavola 2013). And while various forms of the so called "soft path" have been attempted (Campbell and Scott 2011; Chow 2018; Meehan and Moore 2014; Palazzo et al. 2017; Woods et al. 2012), technological fixes like desalination remain a seductive option (Scott 2011) because of the high volume of water they provide (Elimelech and Phillip 2011). While dams were the preferred "hydrosocial fix" (Swyngedouw 2013) of the 20th century to store enormous liquid volumes (Perramond 2019; Teisch 2011; Worster 1985), they have the negative characteristic of being subject to natural phenomena like droughts in which reservoirs may be drawn down causing infrastructure to fail,[3] as well as their problematic ecological and social history (Carroll 2012; Walton 1991).

Today, cities, governments, investors, and private companies in both core and periphery nations are increasingly looking to desalination. Advocates of this "unconventional water" (Gandy 2014: 12) promote it as "drought-proof" and "reliable" (Bernabé-Crespo, Gil-Meseguer, Gómez-Espín 2019; Speckhahn and Isgren 2019; Williams 2018a). As climate change predictions look increasingly dire, desalination is presented as a burgeoning solution with an industry of an estimated value approaching $20 billion in 2020 (see also Swyngedouw 2013).[4] However, given global concerns about water affordability and access (Bruns and Frick 2014; Mack and Wrase 2017; Roller et al. 2019), and environmental justice (Butts and Gasteyer 2011; Montag 2019), desalination may pose an increased burden because it is an expensive source of water and specific ecological questions remain (Haddad 2013; Jones et al. 2019).

Drawing upon world-systems analysis (Wallerstein 2004) and its recent environmental social science extensions, I argue that desalination can be interpreted as an interaction at one of the final *encounter zones* of society and nature. Building on the work of world-systems theorist Jason Moore, this article aims to conceptualize the ocean as a site where multiple forms of power, culture, and knowledge confront markets, society, and nature (Patel and Moore 2017: 19). In this way, the historical examination of desalination has much to tell us about the different needs, benefit structures, dependencies, and transnational relations imbricated in industrial practices. This agenda is especially relevant given world-systems scholars engagement in issues at the intersection of

[3] In 2015, as record drought conditions threatened the viability of Lake Mead—the largest reservoir in the USA, with a capacity of 32.4 million acre-feet or 40.1 km^3—actually had a "third straw" installed. $817 million dollars were spent on an additional pipeline so that even at extremely low levels water could be drawn into Las Vegas' water system (Associated Press 2015). See https://www.cbsnews.com/news/las-vegas-uncaps-lake-meads-third-straw-for-water-supply/

[4] From various financial sources, one can determine what some comparable industries might be, although the desalination industry itself is difficult to pin down beyond a few scattered reports and references in the newly emerging literature on the subject. In terms of revenue annually generated, the water industry, according to Water World Magazine is worth $160 billion annually (Water Technology 2016). One can compare the desalination industry estimates of about $20 billion to that of oil revenues ($80 trillion), electricity ($390 billion), and solar power ($47 billion in 2007 to over $200 billion by 2017).

ecological and economic concern since the proliferation of debates on the Anthropocene to understand the expansion of capitalism to new resource frontiers.

Based on original archival research conducted in the context of a larger ethnographic project, the article uses the case of desalination to analyze how it emerged in two phases. First, the Cold War opened the ocean as a commodity frontier as part of the *pax Americana*. When this stagnated, financialization techniques were then deployed to appropriate seawater—desalination via financialization reinstates the cultural hegemony of the Capitalocene that privileges infrastructure for water supply management solutions. In contributing to world-systems research, this article aims to open new avenues for research within the world-systems perspective, and into movements shaping the "struggles for blue gold" witnessed in core and periphery contexts (Poupeau et al. 2018; Spronk and Webber 2007; Sultana and Loftus 2013). This historical examination empirically deepens the postulates of Moore's Capitalocene thesis, as he proposed to study socioecological problems as emergent through the contingent relations of humans and nature furthering our understanding of how the "history of capitalism has been one of recurrent frontier movements to overcome that exhaustion [of the webs of life], through the appropriation of nature's free gifts hitherto beyond capital's reach" (Moore 2011: 109). Moore's framework allows for a more complete vision of historical processes that are driven by accumulation strategies and crises, but also by technological advancements, local and regional ambitions, as well as resource scarcity.

Cheap Nature Appropriation in the World-System

While world-systems theory was not originally conceived with the intention of drawing connections between ecology, economy, and politics, it was not long before scholars made these linkages (Bartley and Bergesen 1997; Bergesen and Parisi 1997). Some of the most well-known traditions are in the studies of ecologically unequal exchanges (Jorgensen 2012; Jorgensen and Clark 2009), ecological footprints (Jorgensen 2005; York, Rosa, and Dietz 2012), and metabolic rifts (Foster 1999; Moore 2000; Schneider and McMichael 2010). Most recently, environmental historian and social theorist Jason Moore has provided a sweeping critique of capitalism (and simultaneous theory of it as an ecological regime) with his notion of *Capitolocene*, which he argues stands in contrast to the notion of the "Anthropocene" that originated nearly twenty years ago in the physical sciences (Steffen and Crutzen 2003).

Anthropocene or Capitalocene?

Jason Moore (2016) argues that current intellectual debates surrounding the contemporary world ecological crisis fall roughly into two categories. First is the idea conceived by Dutch atmospheric chemist and 1995 Nobel Prize winner Paul Crutzen and colleagues (Steffen, Crutzen and McNeill 2007; Steffen et al. 2011; Rockström et al. 2009), who argue for rethinking humanity's relation to nature on a geologic basis and locating the pivotal moment of transformation with the Industrial Revolution. Their notion of Anthropocene "emphasizes the central role of mankind in geology and ecology," given that "the global effects of human activities have become clearly noticeable" based on evidence from glacial ice core data indicating rising CO2 and CH4 concentrations in the atmosphere (Crutzen and Stoermer 2010: n.p.).

At the forefront in responding to this argument are scholars working in the nascent field of Earth System Science (ESS). A kind of "super discipline," ESS is a perspective of interlocking biomes and emphasizing how humans are inextricably linked to natural outcomes (Lövbrand, Stripple, and Wiman 2009). Rather than comprehending the world in fragmented spheres of the chemical, biological, physical, and social, ESS eschews the sharp delineation of the world into constituent components (Pitman 2005). However, while Earth System Scientists argue that addressing the fundamental questions of a changing planet requires deep integration of the bio-geophysical with the social (Steffen et al. 2018), social scientists have debated the novelty and efficacy of the assertions of ESS scholars and the progenitors of the Anthropocene concept (Bauer and Ellis 2018).

A second perspective emerged questioning the emphasis on stratigraphic indicators and periodization. This view aims to fundamentally reinterpret modern history as "the age of Man," thus locating the source of ecological destruction in Enlightenment paradigms rather than the steam engine (Haraway et al. 2016; Swanson et al. 2015; Tsing 2016; Tsing et al. 2017). Crucially, they point to global inequalities and domination to show the unequal drivers of the ecological crisis (Jorgensen 2016), which should include dimensions of racial politics (Davis et al. 2019) and multispecies understanding (Tsing 2015). As world-systems scholars have long identified, the burdens of the core's prosperity has too often come with grave consequences for the semi-periphery and periphery (Foster and Holleman 2014). Others have identified patterns of what Leslie Sklair calls the "culture-ideology of consumerism" (2019: 1014) to demonstrate the importance of class distinctions and markets in producing an unsustainable world. Among these critiques, the commonality they share lies in the analysis of ecological harm that appears inherent to global capitalism, a theme shared with the eco-Marxist antecedents underlying much of this work (e.g. O'Connor 1988). Relatedly, Andrew Bauer and Erle Ellis have argued that the "Anthropocene" may actually obscure, rather than clarify socio-natural relations—the effects of societal impact on the planet is not the "synchronous product of a global humanity but rather result from heterogeneous activities rooted in situated sociopolitical contexts that are entangled with environmental transformations at multiple scales" (2018: 209). Social scientists aim to emphasize the social as shaped in varied ways through and by nature, which cannot be easily boiled down to geological markers that threaten to "misrepresent the continuous nature of human changes to our planet" (Ellis et al. 2016: 192).

Jason Moore has attempted to offer a remedy to these debates. His solution is to engage an eco-Marxist framework with world-systems analysis to better understand the coupled processes of capital accumulation and the production of nature (see also Deckard 2016: 147). Rather than the age of man, he prefers "the age of Capital" to describe the various world-historical transformations that have led to the current global crisis. The Capitalocene concept argues for an understanding based on historical continuity in the exploitation of people and nature since 1492 (the arrival of Christopher Columbus in the Americas)—the appropriation of cheap natures came with "New World" conquests, and colonialism secured a steady flow of the labor-power to subdue and transform nature into commodities. Thus, it was not only the Industrial Revolution that inaugurated

the current ecological crisis, but the expanding exploitation of *cheap natures*—labor, energy, food, and natural resources. Moore's project shows the ways in which capitalism is not only acting upon nature, or as something external to nature, but rather *through* various natural systems (Moore 2015: 6). Specifically, in the most recent neoliberal regime (1970 to present), Moore identifies the drive to accumulate and appropriate as an acceleration in the process of locating the final resource frontiers, or "encounter zones," for capital (Moore 2011).

Importantly, the neoliberal era has an added characteristic that makes it unique when compared to previous centuries: *financialization*. This phenomenon, which Aaron Pitluck, Fabio Mattioli, and Daniel Souleles call "more finance," is the temporal and spatial expansion of finance and financial logics in all aspects of daily life, including the provision of natural resources (2018: 157). As such, this era has been remarkably unlike other historical periods in which production and labor were central. This "more finance" has brought new emphasis to the practices of financial speculation in the world-system (Pitluck 2012), which has become particularly acute since the dawn of the 21st century and global commodity price bubbles (Goldman 2011; Sassen 2013). Relatedly, neoliberalism is often regarded as a return to a form of "primitive accumulation" with new aspects, such that an "ecological and economic colonialism" has taken place wherein systems of privatization have become the answer to the problems of state authority over public resources (Mascarenhas 2007: 566). However, financialization is an especially acute issue because of its fluid, mobile dimension, because it involves a "pattern of accumulation in which profits accrue primarily through financial channels" (Krippner 2005: 174). These issues may become problematic when it comes to the networks of public goods like water when the private sector is developing modes of financing about which states may have comparatively meager experience. Some scholars arguing that financial innovations have left the public sector at a disadvantage because private firms restructure deals and make profits based on more advanced knowledge of structured finance (Coval, Jurek, and Stafford 2009; Sclar 2015; Warner 2013). In this sense, appropriating cheap nature becomes about *financial engineering* as the private sector pursues the development of public assets (Ashton, Doussard, and Weber 2012), of which water has been an often-contentious issue.

The World Ecology of Cheap Water

Moore effectively draws attention to the idea of the disruption, not of the world economy per se, as a classical political economy approach might have it, but of the *world ecology* of capitalism; the historical interactions between the environment and society are founded upon the availability, however limited, of various types of "natures" (Moore 2015). *Cheap nature appropriation* came with conquest securing the labor-power to transform nature into commodities. And so, beyond Moore's and Patel's (2017) "seven cheap things"—nature, money, work, care, food, energy, and lives—we must also understand how water may perhaps be an eighth, if not cheap, then essential "thing." For example, control of water systems (e.g. river basins) via engineering capacity has been central to nature appropriation historically, which Moore recognizes. During the agricultural revolution of the 16th century, the Dutch mastered waterscapes through dams for large-scale "accumulation by appropriation" (Moore 2017: 614; Moore 2018). While Moore does not take the

question of water in the world-system further, other scholars have addressed how it has been an example of profound and repeated attempts at privatization, and market disciplining (Bakker 2010; Williams 2018b).

One of the most cogent discussions of the question of water in world-ecological regimes has been provided by world-systems scholar Sharae Deckard. In her formulation, the decline of "cheap water" is due to "the exhaustion of water frontiers" (Deckard 2019: 108) through production processes. Water is increasingly central to the world economy because "domestic consumption of water has been commodified on an unprecedented scale, at the same time as industrial sources of 'crude water' confront limits to appropriation" (Deckard 2019: 108). It is precisely this idea of a "confrontation with limits," from a technical engineering perspective, but also from a *financial and economic perspective*, that historically indicates how capital accumulation processes and resource appropriation unfolded with water. It is not just a matter of crafting governance reforms allowing non-state actors to price water for the purposes of efficient management; instead, it is about a world-system of shareholder capitalism fragmenting water, and crafting an abstract social nature into various resource types that became tradable and purchasable for "long-term strategies of fixed capital investment and development of new productive capacities" (Deckard 2016: 155). Deckard (2016: 166) has dubbed mechanisms underlying these patterns "biofinancialization," (see also Bresnihan 2016) indicating the creation of novel relationships between two types of global flows—water and money—within financial markets and via investments in water infrastructure projects.

There has also been important work coming from outside world-systems analysis. For example, political ecologists have been elaborating various notions of "socioecological fixes" (Ekers and Prudham 2017). Industrial water projects in particular can be interpreted as "fixes," because they always have social and ecological dimensions that impact landscape transformation via the influence of institutions, finance, laws, and politics. Such elaborations have led to their proliferation of applications in a variety of contexts. Erik Swyngedouw has proposed the concept of "hydrosocial fix" (2013; 2015) to describe when practices and policies are implemented to provide a solution to the dysfunction of the "hydrosocial cycle" (Linton and Budds 2014) to "reproduce a development trajectory based on increasing water supply" (Swyngedouw 2013: 262). In this sense, the fix is very often to pin down water infrastructure in specific geographical locations. A hydro-social fix like desalination may aim to transfer water resources management problems from old locations to new ones that are free from political and legal baggage that may have hampered processes of accumulation, production, and consumption in the past. And while this is not universally the case, Swyngedouw describes this clearly with desalination in Spain (2015), whereby new megaprojects were built to escape the formal rules of water allocations on the mainland, making the ocean an attractive supply option. Water supply then could be "fixed" in terms of a new location—the spatial dimension—and also in terms of "fixed costs and capital" in a new space of the built-environment, which may ultimately provide a temporary "fix" to the thirst of a water-scarce region. In this way, a "fix is typically seen as capitalism trying to negotiate its

inherent crisis tendencies to reproduce itself in perennially iniquitous forms" (Castree and Christophers 2015: 379).

Methodology

While utilizing world-systems theory as an analytical base, the methodological principles used in conducting this research draw from the extended case method tradition developed by sociologist Michael Burawoy and colleagues (Burawoy et al. 1991; 2000; Burawoy 1998). As opposed to grounded theory that attempts to grasp overarching social patterns by "ransacking" the data for emergent properties (Burawoy 1991: 10), my aim was to expand existing theories, articulating data collection, analysis, and reflexivity throughout the fieldwork. One important advantage of this approach is that it "bursts the conventional limits of participant observation, which stereotypically is restricted to micro and ahistorical sociology" (Burawoy 1991: 6). While my research centered around participant observation of town halls, community organizing, and public hearings about desalination, as well as in-depth interviews, it quickly became clear that historical understanding was necessary beyond these obvious representations. Like ethnographer Zsuzsa Gille who studies the environmental politics of waste and industrial projects by finding ways to "apply the ethnographic method to data available from the past" (2000: 241; see also 2010), I traced my research through time—and followed the leads of informants—to the National Archives in College Park, Maryland, which houses the records of the Office of Saline Water (OSW). This federally appropriated department represented America's first attempt at implementing the practice I was now observing a half-century later. Sifting through hundreds of press-releases, scientific and promotional reports, presentations, and the financial records of the OSW allowed me to return to the field with a greater appreciation for the legacy of desalination in the institutions and collective consciousness of the social agents with whom I was working. Additionally, through snowball sampling, I spoke with an array of people, from residents of the community in which I lived, to public and private sector experts, and elected officials, many of whom have been engaged in the debate about desalination in California for more than a decade. In what follows, I focus on unpacking the historical dimension of desalination in the world-system and bring this history into the present by investigating the links between technology, expertise, and finance to understand the power of desalination as a world ecological transformation. The first section on Cold War positioning draws from my archival work, after which I transition to contemporary examples of financial engineering, building on the historical analysis with ethnographic data.

Cold War Positioning

Following the Second World War, the "USA found itself in an exceptional position" (Wallerstein 1993: 1). Via economic growth, strong technology sectors, a relatively large share of global production, and much of Europe needing significant infrastructural reconstruction, the USA successfully promoted a *pax Americana* (Wallerstein 1993). This hegemonic USA led social order was based upon a notion of responsibility to the world-system for peace and prosperity operating in counterpoint to the Union of Soviet Socialist Republics (USSR) (De Graaff and Van Apeldoorn 2011). It is in this context that the USA reevaluated its internal empire—what environmental

historian Donald Worster called the "hydraulic society" of the American West (1985, see also Wittfogel 1957), a social system based on the dynamics of power working through infrastructure towards mastery of nature and peoples. Eventually, federal officials saw this region as increasingly under threat from population pressure and water scarcity, what the Office of Saline Water would routinely call "the water problem." Thus, a dual-threat emerged. Water scarcity appeared as a more pernicious problem than nuclear war as the first decade after the world war passed. The question of water scarcity in the USA became one of "water security" and therefore, of how to position the nation within the world-system to lead the way in opening the new resource frontier of the ocean.

The Ocean becomes a New "Frontier" of World Ecological Transformation

On July 3, 1952, Harry S. Truman signed the Saline Water Conversion Act into law, which created an American initiative to produce desalinated water for drinking. The group charged with this new effort was the OSW, which operated in Washington D.C. from the early 1950s until 1972, before its staff was absorbed into other departments, namely the Office of Water Resources Research. The aim of this federally appropriated program was to open new opportunities for socio-economic development, not only in the USA but around the world in the pursuit of affordably priced seawater. As OSW Director Frank DiLuzio said in 1966, "It is no exaggeration to say that the successful development of low-cost desalting processes could result in removing the impediment to progress that is created by water shortage."[5]

The OSW would quickly receive an increasing number of staff and capital in the late 1950s and early 1960s. During the first five years of operations, the OSW received less than $1 million of the Department of the Interior's support. However, by 1964 they were receiving $10 million, or about $83 million in 2019 dollars. Eventually, the progress the organization was making gained the attention of the Capitol. In 1961, President Kennedy signed the Anderson Aspinall Act that funneled $75 million ($623 million in 2019 dollars) to the OSW for the next five years, significantly bolstering the test facility imitative. For comparison, the 2020 proposed budget for the entire Bureau of Reclamation was $1.1. billion for roughly 5,000 employees. By contrast, the OSW always remained a small program, peaking at 60 staff members in 1962, but increasingly commanded the resources necessary to drive the research and development of saline water conversion. In advocating this mission on May 26, 1961, Director Charles F. MacGowan stated that "anything less than total development will not be enough."[6] The drive to conquer the oceanic frontier – to bring about a world ecological transformation of the sea for "beneficial use" – would

[5] National Archives and Research Administration, College Park Maryland (NARA), Record Group (RG) 380: Records of the Office of Saline Water, 'Press Releases,' 1958-1972, Box 1. Page 2 of Office of Saline Water Director Frank C. DiLuzio's comments at the groundbreaking of the Point Loma (near San Diego, California) Desalination test plant on August 10th, 1966.

[6] NARA RG380 Records of the Office of Saline Water - Press Releases, 1958-1972, Box No.1 "Press Releases 1961." Page 6 of Charles F. MacGowan comments before a gathering of the Pacific Northwest Industrial Waste Conference in Pullman, Washington.

became focused around their test plant program to build small-scale facilities and experiment with various desalting techniques.

In particular, five demonstration facilities were built and operated in the early 1960s. The first, which President Kennedy inaugurated in 1961 was at Freeport, Texas, and used multi-effect long-tube vertical distillation for seawater conversion. The incredible promise of this project, and global agenda of American involvement in desalination was unmistakable in his comments:

> We want to join with them, with the scientists and engineers of other countries, in their efforts to achieve one of the great scientific break-throughs of history. I'm sure that before this decade is out, that we will see more and more evidence of man's ability at an economic rate to secure fresh water from salt water, and when that day comes then we will literally see the deserts bloom.[7]

Thus, the USA would be a key player in the drive to confront seawater as a limit to society over the next decade. In addition to the Texas site, a facility was built in Webster, South Dakota that utilized electrodialysis and plastic membranes for converting brackish groundwater to drinking water, as did the Roswell, New Mexico plant that experimented with a form of vapor compression. Wrightsville Beach, North Carolina tested freeze separation for ocean water and the plant at Point Loma, California used multi-stage flash distillation (MSF) and produced one million gallons per day (mgd) of water. However, it was not long before the OSW began developing plans for an even more ambitious agenda for seawater desalting—what was dubbed "the large plant program."

Beginning in the early 1960s, the OSW envisioned a cascading timeline of goals allowing them to develop desalination plants for public water supplies. The model for this vision began with the Point Loma plant, and by 1966, they projected the development of a 2 mgd facility. Using technological achievements advanced in smaller projects, three subsequent facilities of increasing volumes could be constructed through 1975 at capacities of 17, 50 and 150 mgd. In addition, several smaller projects were envisioned leading to a 60 mgd dual-purpose nuclear desalinating facility.

Despite early advances, these goals involved a technopolitical agenda that became problematic. If technopolitics is the active utilization of technological development to further a political goal (Hecht 1998; Kellner 2001; Mitchell 2002), then the OSW constituted the technological—and financial—hub of water desalting to allow the USA to enact other geopolitical aims (Low 2020). While the most popular example of international competition is the "space race" between the USA and former USSR, the OSW's records indicate that experts at multiple levels of authority saw the ocean as a frontier to be mastered in an analogous fashion—the sea would be intimately tied to the relative position of the USA in the world-system. On September 16, 1960, OSW Director A.L. Miller expressed this agenda directly:

[7] Transcription made from recording (Kennedy 1961) at http://www.jfklibrary.org/Asset-Viewer/Archives/JFKWHA-040-003.aspx

> Today we are on the threshold of the great frontier of outer space and the grotesque helmet of the astronaut is the mark of a glamorous new pioneer. The infinity of space is not the last frontier to conquer. There are the great challenges and the new frontiers of inner space. The men in laboratory aprons who quietly labor on basic research are today's pioneers who are opening new frontiers of knowledge to feed the insatiable appetite for applied research and development. Without this new knowledge, without new science, applied research and development will stagnate…To maintain our position as the world's greatest nation, we must place greater emphasis on basic research for scientific knowledge—the most challenging and exciting frontier we have ever tried to conquer. Our ability to compete in world markets in the coming decades will be determined by the research and development we are willing to support today in order to penetrate the ever-expanding frontiers of science.[8]

Discussed in contrast to the frontiers of "outer space," the "inner space" of cheap nature constituted an opportunity to align the ambitions of science and technology with markets. In this vision, the OSW's production and application of knowledge to develop successful desalting practices was believed to lead the way to access a new global marketplace. Desalination technology could then serve an important dual-purpose—it would be a remedy for water-scarce regions, while also presenting an opportunity to assert American authority in the world-system after cosmonaut Yuri Gagarin's successful 1961 orbit of the earth. Therefore, from rather modest beginnings, it soon became an international player gaining the attention of the highest offices. For example, OSW Director Frank DiLuzio made the global agenda of his office and its departments abundantly clear throughout his tenure, and was especially transparent in his 1966 comments before the groundbreaking of the Point Loma, California desalination test facility:

> We must remember that the search for ample water is not alone a United States problem. Many of the underdeveloped nations of the world suffer because they do not have enough water to turn the wheels of industry, to irrigate their parched fields, or even to maintain in health their populations…For this reason, the efforts of the Department of the Interior to develop low-cost desalting processes is of prime interest to many countries and territories already water destitute.[9]

Not only would the OSW draw on the "inexhaustible" resource of the ocean, but an ever-expanding class of scientists and technical professionals would rally to its cause. As DiLuzio argued, it would be through this scientific model of water management that the USA would become the great benefactor of the periphery to grow new industries and irrigate arid lands. In this way, his statements exhibit a notion of cheap water within a teleological understanding of societal

[8] RG380 Office of Saline Water – Office of the Assistant Secretary for Water pollution Control/Office of Saline Water – Entry # A1 4: Statements of Director Arthur L. Miller 1960-1966. This statement is taken from Page 6 of his September 16th address before the Armed Forces Chemical Association's 15th Annual Meeting at the Sheraton Parks Hotel in Washington D.C.

[9] NARA, RG 380: Records of the Office of Saline Water, Press Releases, 1958-1972, Box 1. Page 2 of Office of Saline Water Director Frank C. DiLuzio's comments at the groundbreaking of the Point Loma (near San Diego, California) Desalination test plant on August 10th, 1966.

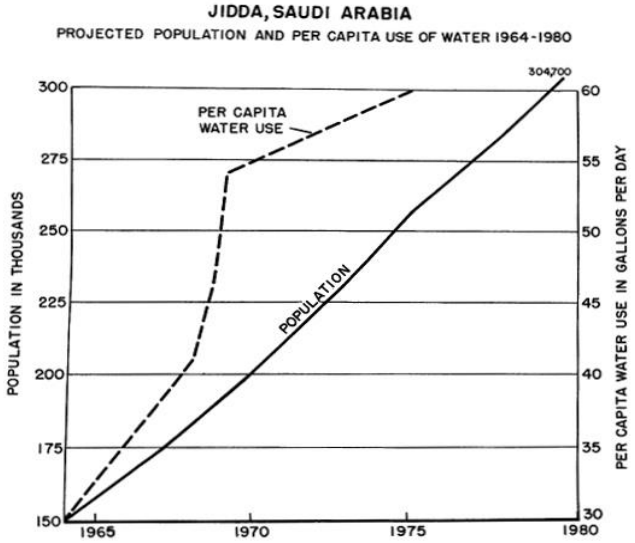
development that would also be economically sound. Establishing desalination as a solution in this double sense enabled its practical component of providing potable water to a world with an expanding population, which served as a compelling narrative. For example, Fred Seaton, the Secretary of the Interior under Dwight Eisenhower addressed the American Water Works Association in San Francisco, California on July 14, 1959, arguing that water supply could "easily become" the "Nation's number one domestic problem" unless appropriate measures were taken. And population growth was a key driver of this issue. In the same statement, Seaton set forth several projections: "there will be 275 million of us by 1980….[and] By the turn of the next century, only 40 years away, we will have doubled our present population to 350 million souls." In his view, the future demands placed on the country's water supply could only lead to the solution offered by "the inexhaustible oceans and seas of the world."[10]

It is clear from these examples how desalination became a favored *technological fix*, emerging in the classical sense described by Dane Scott (2011; see also Shoffstall and Gille 2015). These early discussions of desalting were rhetorically useful in that it could be implemented to promote an emergent technology that had the benefit of cementing the USA's position globally. It also provided, or was supposed to provide, a common good—the world needs freshwater. This agenda is corroborated when considering the alliance of the OSW's large plant program with the Oak Ridge National Laboratory, then headed by the technocrat *par excellence*, Alvin Weinberg (Johnston 2018), in this same period. The plans for this alliance was to create nuclear desalting facilities, although never fully realized due to growing concerns about nuclear technology and the dissolution of the OSW.

The OSW's technocratic agenda, however, stands in contrast to the current arguments about desalination. Whereas desalination constitutes an intensive supply side policy, many argue that much can still be done in terms of demand management. However, the idea of simply reducing the consumption of water, even of making more efficient use, did not appear on the OSW's agenda. It seems to have gone unquestioned that the consumption of water would increase, and that the only viable solution would be to produce new forms of water. In hindsight, the OSW's technopolitical conception of desalting produced a narrow view of water management focusing on producing supply. And as the OSW became more globally oriented, the hundreds of reports and studies that they produced from the shores of California to Saudi Arabia, Israel, Greece and more, all indicated a world of less water, but with more demand—a world of water scarcity in which the USA would be a technological and policy leader. For example, Figure 1 shows 1964 projections of water demand increasing with population growth in "Jidda," Saudi Arabia, the major commercial port city along the Red Sea. Figure 2 shows proposed desalination projects using a model of incremental supply production increases to meet a 1966 projected water demand for the greater Athens, Greece region until 2000. By this logic, population growth creates a larger demand for water, which can be met by developing large scale desalination projects.

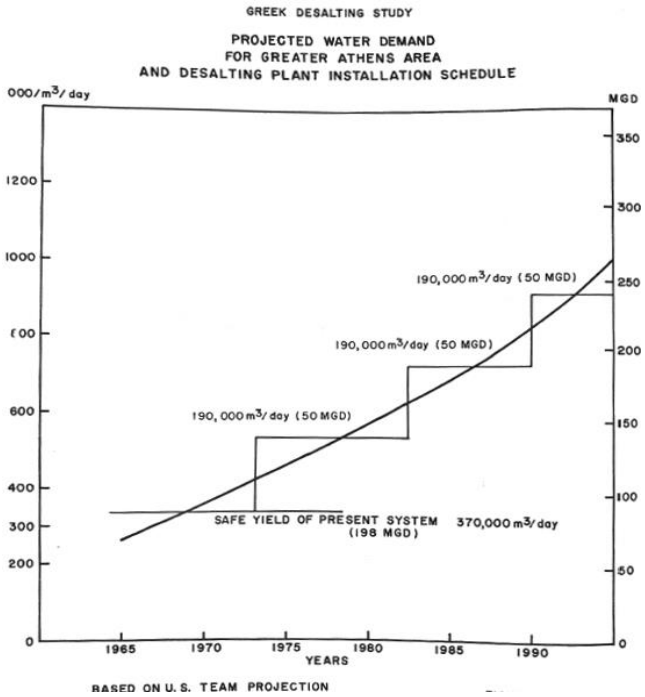
[10] NARA RG 380: Records of the Office of Saline Water, Press Releases, 1958-1972, Box 1.

Figure 1: Water demand and population projections from the OSW's *1964 Jidda, Saudi Arabia Water Study*.



Copy Courtesy of the National Archives.[11]

Figure 2: Water demand projections considering the installation of increasing desalting capacity for the OSW's *1966 Athens, Greece Water Study*.



Copy Courtesy of the National Archives.[12]

[11] NARA RG 380: Records of the Office of Saline Water. Box No.1 "Reports and Studies 1960-69"

[12] NARA RG 380: Records of the Office of Saline Water. Box No.1 "Reports and Studies 1960-69"

Despite the twenty years of OSW operations, it would come to a rather abrupt halt in the 1970s. In the aftermath of the Bay of Pigs Invasion, the Point Loma facility was shipped to Guantanamo Bay after Fidel Castro cut water supplies to the base. Then, considering shifting national priorities and the 1973 oil crisis, the program was pushed aside because of the perpetually high cost of desalinated water. Despite their efforts, the OSW and its many contractors were ultimately unable to find a successful way to keep the energy cost of desalinated water down, and the water always remained at an unreasonable price. This remains a major issue for the emerging desalination industry today. The scholarly literature indicates the cost of energy depends upon the source used and for what desalting process, but to desalt seawater using non-renewable energy, the cost will be in the range of \$0.43 to 3.34/m^3. When using wind, photovoltaics, or solar, the price becomes more expensive, up to nearly \$10/m^3 (Karagiannis and Soldatos 2008).

And yet, the world ecological and socio-political transformative potential of desalination was not left totally unrealized. The remnants of the OSW would eventually be picked up by the private sector, especially after the turn of the century. Where the narrowness of the technopolitical agenda failed, desalination would be taken up at the nexus of water and finance. Rather than through scientific and technological prowess, desalination would make its return with the new frontier of cheap water appropriation becoming effective when it could be reframed as a financial asset in the Capitalocene.

Financialization in the Capitalocene

From its inception, the OSW was envisioned with a limited scope of work. In hindsight, this contributed to its narrow view of the issues of water scarcity as being focused solely on supply. The second position was that while it wanted to pursue cheap water seemingly at any cost, there was little interest in the long-term implementation of the projects. Due to their approach, the OSW was a somewhat ambiguous federal entity for its time when the model of other agencies like the Bureau of Reclamation and Army Corps of Engineers supported direct involvement in project development and implementation. By contrast, the OSW's goal was to promote infrastructure, but ultimately pass off the responsibility for it to the private sector, due to the financially risky prospects of large-scale development. When it came time to build desalination plants, the OSW would hire external contractors, awarding millions of dollars to various consultants and universities working in the USA and abroad. As members of the OSW discussed in December of 1959, the "policies of research and development would be continued with the expectation that local communities and private industry will be able to take over and facilitate construction of saline water conversion plants without further Federal encouragement."[13] The agenda of the OSW was "to prove technology and then sell the projects to the highest bidder," meaning that "participating communities will not necessarily receive these plants even though they are thoroughly integrated

[13] NARA RG380 Office of Saline Water-Office of the Assistant Secretary for Water Quality and Research/Office of Saline Water. Page 9 of December 4, 1959 "Notes of Secretary's Advisory Committee Meeting."

with their water supply system."[14] What they could not have envisioned at the time was the financial model that could actually make large scale desalting a reality.

Where the OSW's focus was in leveraging notions of scientific progress to assert the USA's position in the world-system, private sector finance would eventually pave the way for realizing the OSW's "Cold War dreams" (Low 2020: 27). The conquest of the oceanic frontier is a preeminent example of the interlinked manner by which capital and nature are brought together, not just in a strictly neoliberal context, but through the transition between two world ecological regimes.

Table 1 delineates some of the key differences in the transition from the state-centered paradigm of the Cold War for desalting to the contemporary situation based on a decentralized arrangement of actors and processes that facilitates local to global relations. Where the key social agents of the Cold War regime were national departments like the OSW, today they reside in private firms seeking to liaise between public water providers and financial markets. Aside from the aforementioned differences in the movement from small scale projects to large scale, the main areas of innovation moved from technological, such as in membrane technology, to crafting financial packages. There are also differences in the views of environmental impact, views of community, and regulation.

Table 1: Periodization of the World Ecology of Desalination

Historical Period	**Cold War**	**Neoliberal Era**
Social Agents	Nation State Departments	Private firms and banks
Institutional Level	National → Local	Local ←→Transnational
Area of Innovation	Technological	Financial Packages
Project Scale	Small (e.g. 1 mgd)	Large (e.g. 50+ mgd)
Environmental Impact	Unknown/not recognized	Brine and coastal ecology
Community Impact	Unknown/not recognized	NIMBYism
Regulatory Regime	None	Localized regulation

For example, the records of the OSW indicate very marginal interest in brine, the hypersaline byproduct of desalination techniques. Even then, brine was discussed in terms of potential unrealized value.[15] Furthermore, the socio-ecological impact to communities did not command any deliberation, nor was there any sense of a regulatory regime for desalting. However, to take a recent example, the state of California adopted amendments to its Ocean Plan that specifically address concerns about desalination technology, plant construction, and ecological impact. While the Ocean Plan initially became law in the 1970s, it would only be after the first 50 mgd desalination plant was finally built in 2015 in Carlsbad, CA that it could take full effect.

[14] NARA RG380 Office of Saline Water-Office of the Assistant Secretary for Water Quality and Research/Office of Saline Water. Page 9 of December 4, 1959 "Notes of Secretary's Advisory Committee Meeting."

[15] NARA RG380. Folder 1: Statements 1961-1963 Box A1 4. Pages 3-6 of September 7, 1961 Director MacGowan speech before the Salt producer's Association of Chicago.

Additionally, the community response to large-scale desalination might be roughly described as a form of NIMBY (not in my backyard) politics—citizens object to corporate influence in the water sector as well as a host of ecological concerns.

Trends in the Financial Engineering of Desalination

As part of the pattern towards financialization—the introduction of markets and financial logics into new socio-economic fields—scholars have observed public infrastructure projects subject to trends in what Ashton et al. (2012) call *financial engineering*. This refers to a host of techniques asset investors utilize such as financial swaps, interest rate derivatives, deferred payment options, etc. (Pacewicz 2016; Singla and Luby 2020). To that end, studies of roads, parking, and highway systems have examined the ways in which infrastructure is increasingly "prospected for value" across the world (Langley 2018: 174), with scholars raising concern that the public sector "undercharges" for projects when not adequately examining how the private sector can package revenue (Ashton et al. 2012: 300). As such, financialization processes involve influencing the valuation of assets to a greater degree than with privatization models that seek to create efficiency in operations and improve the capacity and capabilities of infrastructure (Davis and Kim 2015; Loftus, March, and Purcell 2019; O'Neill 2009). Of course, historical and contemporary case studies repeatedly emphasize water's *uncooperative* nature (Bakker 2003), in the sense that "capital has actually found it remarkably difficult to profit from water privatisation" (Loftus 2009: 956). In fact, this recalls the work of Karl Polanyi, who has largely gone unrecognized in forming an additional basis for the world ecological framework of Jason Moore. Although Polanyi (1944) referred to land, labor, and money as three fictitious commodities underlying society's institutional and economic arrangements, he treats land as a proxy for nature, of which water is arguably a part, if not an additional, fourth one. Water must always be transformed into a commodity—*it must be disciplined* to be produced for sale and consumption by society (see also Fourcade 2011).

While many scholars have discussed the issues of water privatization, often arguing that it constitutes a form of dispossession by appropriation (Swyngedouw 2005), financial engineering's distinction is that the focus becomes less about the creation of surplus value (Loftus and March 2016), and more about the extraction of rent and the packaging of debt. Water bills go up, and in the process, funds are redirected to diffuse assemblages of global investors and financial intermediaries (e.g. Pryke and Allen 2019). While these actions open up expanding urban areas to new financial channels, scholars continue to question the virtues of private sector involvement in projects like desalination in contexts of exacerbated scarcity (Bayliss 2014; see also Aalbers 2020; Ahlers and Merme 2016). However, there are a few examples to help elucidate some of these processes.

For one, the World Bank has been an advocate for large scale desalination by financialization. In 2014, it launched its "Water Global Practice" group that brings together "financing, knowledge, and implementation" in one platform. By combining the Bank's global knowledge of country investments, their model generates more "firepower for transformational solutions to help countries grow sustainably" (World Bank Group 2019: 2). In light of the history of the world ecology of desalting during the Cold War, the World Bank's statement makes the current patterns

in the *avant-garde* of water supply management clear, and remains ideologically similar to the Cold War paradigm that economic expansion and growth go unquestioned. Water is viewed as a means through which to "grow sustainably," rather than as a common good, or even a human right that still has not been delivered adequately to so many across the Global North and South. However, there is a key difference here that stands in contrast to the model based upon scientific development pioneered by the OSW – the solutions for global financial actors and the desalination industry lie in the expertise of financing that can be combined with an ecomodernist optimism in the synergistic relationship of industry and the environment (Spaargaren and Mol 1992), of finance capital and natural resources. Capitalism becomes, quite blatantly, an ecological regime (Moore 2011).

Another example that continues to gain attention is the success of the semi-peripheral country of Israel, which has been a key early innovator of financial packages for desalination. Currently, Israel is one of the most heavily invested countries in drinking ocean water due to the arid environment and the geopolitics of the Middle East, with some commentators arguing that the "prominence of desalination in defining the hydropolitics of the region will grow as Israel continues to expand its reliance on desalination" and has been a component of the Jordan River negotiations (Larson 2012: 770). Indeed, Israel has been especially prolific, with the majority of its water supply coming from desalination plants (Kress, Gertner, and Shoham-Frider 2020; c.f. Zetland 2018). But, Israel's "miracle" desalination program has been a financial feat as well as a technological one. For example, in order to secure the largest seawater desalination plant in the world (Sorek) at a capacity of nearly 165 mgd (624,000 m^3/day), and in the wake of the global financial crisis of 2007-8, a multiple tranche (portions of bonds or securities that have been grouped together based on a rating system) finance package mixing Israeli New Shekels and Euros was crafted with an 80% debt/20% private equity financing structure ratio (Lokiec 2011).

In order to gain a more specific sense of how value is created from infrastructure and technology designed to make seawater potable, it is also helpful to see how financialization techniques are taken up in a core context as well. Most notably in the USA, one company has become the face of seawater desalination using a mode of asset-based financial engineering known as *project finance*. According to financial scholar John Finnerty, infrastructure for natural resources has been an area "ripe for innovation" (2007: 6) and the aptly named Poseidon Water (Poseidon), originally composed in the mid-1990s out of General Electric Capital executives and analysts, sought to do just that, eventually moving into desalination (Interview with former Poseidon executive, April 2020; see also Finnerty 2007: 5). As opposed to the direct government financing model that created the megaprojects of the American West, project finance is increasingly part of the accrescent "grammar" of public-private partnerships (Linder 1999) for its ability to create isolated assets and financially insulate companies. In such projects, "the providers of the funds look primarily to the cash flow from the project as the source of funds to service their loans and provide *the return of and the return on* their equity invested (Finnerty 2007: 1, emphasis added). As one financial analyst explained during my fieldwork:

> In project finance, it's all pretty much, here's a cash flow: I'm gonna purchase water. I'm gonna pay $2,500 per acre-foot[16] for thirty years and it's gonna escalate. That's you, the new company—that's your revenue stream, *go and monetize it*! So, in that sort of formulation there is a big risk transfer because it's up to the private partner either to succeed and produce water for $2,500 an acre-foot and if they produce it for less they can make a ton of dough, and if they can't produce it they'll probably go bankrupt. But that's all transferred—their investors are taking that risk and that's one of the advantages of project finance—the ability to transfer that risk (June 2020, emphasis in original).

In this view, the value added of a project development firm, like Poseidon, being involved in attempting to bring desalination to California cities is that they can serve as the linchpin between the municipal bond markets and private equity after procuring the rights to specific sites (often power generating stations for which the water intake infrastructure can be used for desalting) and taking on the "regulatory risks" of permitting within multiple arms of government—local, regional, and state. And while critics of desalination in this context remain uneasy about the involvement of private companies in water because they may view it as a public good (Fieldwork, February-June 2020), it is important to understand the financial logic at work: "Poseidon is not privatizing the ocean" (Interview with Poseidon executive, July 2020). In a sense, by recognizing the shortcomings of the previous wave of water privatization approaches, owning water, per se, proved inviable. Financial logics shift the vision of what the water market might be towards understanding infrastructure deals as an investment opportunity:

> It didn't make any sense to own the product and the engineering service and then try and create the deal. It was far better to try and use the competitive forces of what can you give me for this, that, and the other, and drive that into *a complete package that is more financially attractive* (Interview with former Poseidon executive, March 2020, emphasis added).

By 2015, costing $1 billion—according to Finnerty (2007: 1) this would place the project in the upper 10% of the most expensive financial ventures of its kind—the largest seawater desalination plant in the Western Hemisphere was completed in Carlsbad, CA. In the context of recurring droughts, the regional water provider, the San Diego County Water Authority (SDCWA) joined Poseidon to create a 50 mgd plant. The agreement eventually created a thirty-year performance-based contract, meaning the public entity does not pay for water not delivered to its system by the private entity. Although, according to the SDCWA Fiscal Year 2017-2019 reporting, the average cost of water per acre-foot has increased in each year of operation (from $2,412 in 2017 to $2,685 in 2019), and has been above projected costs.[17] At the end of the thirty-year

[16] One acre-foot is one submerged acre of land covered one foot deep with water. It is a peculiar convention of Western American water accounting; 1 af= 1233.48 cubic meters of water.

[17] See for example pages 41-5 from the SDCWA September 18, 2019 report (https://www.sdcwa.org/sites/default/files/2016-12/Board/2019_Agendas/2019_09_26FormalBoardPacketSEC_0.pdf#page=41) and the August 23, 2017 SDCWA

contract, the SDCWA would be eligible to buy the plant for $1. Such deals are consequential for investors as they aim to find a way to monetize revenue streams that are recession proof—in essence, banking on the fact that people will pay their water bills. Furthermore, as Ashton et al. (2012) have argued, brokers operating at the interstices of these financial schemes may create discrepancies in the value of the public infrastructure turned asset, by extracting fees for transactions and intermediary services. For example, revenue streams can be negotiated to pay high dividends, but in turn create fees related to the underwriting of securities, often by transnational banks. As Pryke and Allen (2019) argue in their evaluation of the Carlsbad desalination plant, everything from the valuation of operational cash flows to future value streams, "feed into expected returns" (1331). As the regulatory process for the plant began to reach an end, a host of international investors came on board in the USA, but also Malaysia, the UK, and the Netherlands (Pryke and Allen 2019). And so, while it is true that such long term performance-based contracts may not directly create "guaranteed" rates of return, an essential component of this model of project finance remains: a "project is unlikely to generate revenue until the operations period and so it is going to be key to lenders and other investors that the revenue stream is certain and that forecasts of revenues are accurate" if they are to successfully garner the necessary investment (World Bank PPLRC 2016: n.p.).

At the same time that financialization involves typologies of risk, it also is about predictability. As private equity firms have explained their interest in desalination to investors, there is "low operational risk / stable cash flows (no price or volume risk) producing double-digit projected cash flow yield" due to the long term "take or pay" nature of the contract with a highly rated public agency and a "fully amortizing debt structure (no refinancing risk)." For them, the kind of infrastructure investment that desalination offers is opportunity in the form of "long-lived, essential, difficult-to-replicate, hard-asset businesses" with a "focus on stable, visible cash flows supported by long-term contracts or sustainable competitive advantage."[18] And as the desalination industry looks to expand in the USA, public water providers often see advantages to the project finance process to take on the difficulties of managing "a lot of money and a lot of risk," because "a public company could never take these risks" (Interview with Executive Director of a public Southern California water agency, June 2020).

report (https://www.waterboards.ca.gov/santaana/water_issues/programs/Wastewater/Poseidon/2019/Carlsbad_Tour_of_Claude_BUD_Lewis_Desal_Plant.pdf). Retrieved July 29, 2020.

[18] Examples of these selling points of desalination as an investment take a similar form across the private equity firm reports and documents I examined for this research. The excerpts referenced here come from (in the order of appearance above) page 9 and 2 of Stonepeak Infrastructure Partners Fall 2015 presentation for the Employee's Retirement System of Rhode Island. At that time, Stonepeak reported $103 million invested in the Carlsbad project. Retrieved July 28, 2020 (http://data.treasury.ri.gov/dataset/2f3045db-9bf4-4540-aa2d-333b7b997e1d/resource/106a5a48-ae41-4d66-b5d6-22092fc2b75b/download/Stonepeak-Presentation.pdf)

Conclusion

In his essay *Maps, Maps, Maps*, Immanuel Wallerstein asserted that "we need to go further, along paths hitherto little explored, to see the successive synchronous patterns of historical social systems within the ecological whole that is the earth" (1980: 159). In so doing, he proposed a historical and holistic approach to the world-system that could accommodate the study of socioecological problems. Jason Moore has taken the environmentally oriented project of world-systems research a step further, arguing that capital accumulation, speculation, and financialization must be understood as dialectically constituted with the production of nature and human social reproduction. Rather than seeing capitalism as emerging as external to nature, we can appreciate how it emerged through the relations of humans *with* nature. In Moore's words, "capitalism as world-ecology is therefore a protest against, and an alternative to, the Cartesian worldview that puts nature in one box and society in another (2011: 117).

Building on Moore's approach, this article presented an historical analysis of the pursuit of cheap natures in the world-system, using the case study of what this paper calls *the world ecology of desalination*. It has sought to empirically deepen and theoretically expand the understanding of the progression of capitalist processes by focusing on the encounter zone of the ocean and recognizing the centrality of finance to the reorganization of the world-system (e.g. Tabb 2007). The Cold War opened the ocean as a commodity frontier as part of the *pax Americana*. Then, when this stagnated, financialization techniques were deployed to successfully appropriate seawater. Because value is extracted locally and distributed globally to investors, the role of international finance reinstates the cultural hegemony of the Capitalocene that privileges supply-side water management solutions.

This is problematic for several reasons that may be consequential in years to come. First, this particular manner of emphasizing infrastructure reinstates a modernist vision of nature by necessitating control—the ocean as a "free gift"—that damages the victories of the environmental movement generally, and other water supply alternatives and practices. Second, questions remain about the extent to which the ocean, while a last frontier, can effectively be protected from the expansion of capital, industry, and finance. Already, desalination plants across the world are producing an amount of brine that some scholars have estimated would be enough to cover the state of Florida one foot deep in the hyper-saline waste by-product (Jones et al. 2019). And yet, besides emerging regulations there is little discussion about how to deal with this problem in a global sense. Third, large scale desalination opens up questions not only about finance, but about very concrete issues regarding the provision and pricing of water. In the recent proposals for major plants in California, activists and scholars have begun examining environmental justice concerns about rising prices and the damaging impact of project and pipeline construction to marginalized communities (Pierce et al. 2019). Finally, in some cases, large-scale desalination elides notable alternative "soft-path" solutions and directs attention, time, and resources away from the development of smaller scale strategies, like water conservation, that have been proven to be effective in curbing water demand in water-scarce regions.

The goal of this research has been to provoke further questions for world-system scholars engaged in debates about the Anthropocene generally and for scholars of the water sector. For example, to what other resource frontiers is global capitalism expanding and how? If we take seriously the direction of the world ecological framework that Moore and others have developed, then it is worth noting that the history of capitalism is also a history of adaptability and disjuncture (c.f Arrighi 2004). This is the case in the context of the world ecology of desalination—it is the story of an industrial process stagnating and then proceeding in fits and starts until new circuits of capital were innovated. However, unlike the work of Arrighi and others, the case of desalination is useful in illustrating the dynamics of how a specific sector of industry has led to financialization. The world-ecological framework of Moore allows one to see that historical processes are driven by accumulation strategies and crises, but also by technological advancements, local and regional ambitions, and resource scarcity; while not emerging as it was originally envisioned, desalination promises not only new ways of thinking about water supply, but a world ecological transformation that imbricates nature in society in unprecedented ways. And let us not forget local communities, both human and nonhuman. Future research could usefully integrate the macro-theoretical framework of world ecology and the Capitalocene with more focused and empirical studies of grassroots struggle. Not only can the world-historical patterns of specific industrial practices of large-scale ecosystemic importance shape core and periphery relations, but arguably, there is a potential for communities in the Global North to link their struggles, for example, to those in the Global South where desalination is currently being proposed, such as in Chile or South Africa, and vice versa. What are the prospects for social change that might emerge out of such manifestations?

Rethinking the socioecological relations of the world-system as world ecology continues to deliver insightful theoretical critique, empirical research directions, and hopefully, an actionable agenda for an increasingly crisis-ridden world.

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