

**KJELL DAVID ERICSON\***

## **The Puzzle of the Thinly Coated Pearl: Aquacultural Ecology and the Politics of Density in Ago Bay**

---

### **ABSTRACT**

This article takes animal materials as contested elements of ecological knowledge production. The focus is on Ago Bay, a Japanese inlet at the mid-twentieth-century global epicenter of demand for “cultured” pearls that formed inside surgically manipulated shellfish. In 1950s Ago, long-established pearl cultivators complained that their pearls had thinner outer coatings than they expected. Tracing shifting ideas about shellfish stocking densities, smallholder aquaculture, rates of pearl formation, and the accumulation of organic wastes in water over time, this article reconsiders the puzzle of the thinly coated pearl. In its guise as host to thousands of working pearl farms and a network of researchers studying the effects of intensive pearl cultivation, Ago Bay is a rich site from which to think about aquaculture’s ecological and infrastructural limits. The bay was not simply a natural receptacle that housed pearl cultivation. The shore, water, seafloor, and floating pearl oyster raft-and-cage systems could be—and were—defined as infrastructure that could undergo regulation and rearrangement. Pearl cultivation did not just happen *in* the bay; it was part *of* the bay—and it reshaped ideas about the bay. This paper is part of a special issue entitled “Making Animal Materials in Time,” edited by Laurence Douny and Lisa Onaga.

KEY WORDS: pearl cultivation, aquaculture, ecology, infrastructure, Japan, fisheries rights

---

Pearls are composed primarily of nacre, a complex mixture of polysaccharide, protein, and mineral components secreted from the outer mantle tissues of many kinds of shellfish. A pearl can appear, upon cross section and under increasing levels of magnification, as layers of crystalline calcium carbonate bound by an

\* Center for the Promotion of Interdisciplinary Education and Research, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto, Japan 606-8501; ericson.kjell david.6a@kyoto-u.ac.jp. Unless otherwise noted, all translations are by the author.

---

*Historical Studies in the Natural Sciences*, Vol. 53, Number 3, pps. 256–277. ISSN 1939-1811, electronic ISSN 1939-182X. © 2023 by the Regents of the University of California. All rights reserved. Please direct all requests for permission to photocopy or reproduce article content through the University of California Press’s Reprints and Permissions web page, <https://www.ucpress.edu/journals/reprints-permissions>. DOI: <https://doi.org/10.1525/hsns.2023.53.3.256>.

“organic mortar” composed of chitin set inside a proteinaceous matrix.<sup>1</sup> Underneath those layers we sometimes find the remains of a once-living visitor. As French zoologist Raphaël Dubois put it in the early twentieth century, a pearl was “the brilliant sarcophagus of a worm.”<sup>2</sup> Pearls are the calcified traces of a defensive response to anything that gets inside a mollusk’s shell. They are products of a repositioning of shell-forming mantle tissues; instead of forming an outer carapace with an inner-shell mother of pearl sheen, these tissues coat and seal off intruders with a varying iridescent outer coating. Pearls, in short, are heterogeneous assemblages rather than uniform matter. They are multispecies artifacts. They are considerably more than their often-lustrous exteriors.

Pearls form according to the irregular affordances furnished by any organisms or other things around which living shellfish secrete nacre. As such, roundness was an ideal not achieved in most pearls traded through the nineteenth century. But visions of engineering shellfish to produce spherical pearls absorbed imperial and transimperial networks of entrepreneurial zoologists and zoologically minded entrepreneurs. Since the 1920s, the products of pearl cultivation—“cultured” pearls—have come to be defined in terms of human agency (they are not “natural” pearls), yet pearl farming remains utterly dependent on the biological life cycles of aquatic animals.<sup>3</sup> Still, neither the presence of human agents to induce pearl formation through nucleus implantations and tissue transplantation surgeries nor the presence of living pearl oysters alone encompasses the longer-term interactions that constitute the production cycle of pearl cultivation. To speak about “engineering” or “inducing” bivalve oysters to form pearls is to bring questions of human control and its limitations to the forefront. But pearl cultivation has involved envirotechnical interactions that exceed dichotomies between human culture and nonhuman nature, or between land and sea.

In Japan at the turn of the twentieth century, practices of pearl cultivation emerged in a few inlets in and around Nagasaki prefecture’s Ōmura Bay and, above all, in southern Mie Prefecture’s Ago Bay.<sup>4</sup> After 1945, even more would-

1. Julian H. E. Cartwright and Antonio G. Checa, “The Dynamics of Nacre Self-Assembly,” *Journal of the Royal Society Interface* 4 (2007): 491–504, on 491.

2. George F. Kunz and Charles H. Stevenson, *The Book of the Pearl: The History, Art, Science, and Industry of the Queen of Gems* (New York: The Century Co., 1908), 43.

3. Kjell D. Ericson, “Judging the Perle Japonaise: The Techno-Legal Separation of Culture from Nature in 1920s Paris,” *Technology and Culture* 62 (2021): 1032–62.

4. Ōshima Jōji, “Ōmura-wan no shinju yōshokugyō: saibai saisō gyoson to senkai yōshoku gyoson,” *Rekishi chirigaku kiyō* 13 (1971): 39–60; Ōbayashi Hideo, *Mikimoto Kōkichi* (Tokyo: Yoshikawa Kōbunkan, 1971).

be cultivators rushed to Ago's coasts to try their hands at one or another of the tasks of surgically manipulating, rearing, buying, farming, or guarding *akoya* pearl oysters. Markets grew for a far-flung trade in "mother oysters" (*bogai*), the gendered term with which people in Japan had described the productive financial potential of living *akoya* (and other bivalve varieties) since at least the late nineteenth century. Pearl farmers across Ago Bay began to specialize in the captive raising of surgically manipulated shellfish, which they bought as two- and three-year-old mother oysters raised in other parts of Mie Prefecture and elsewhere in western Japan. These mother oysters did not live on the seafloor. Tens of thousands of pearl culture rafts bobbed in mid-twentieth-century Ago Bay, with many more metal cages and synthetic fiber nets hanging beneath them. Inside those cages and nets, millions of pearls formed, layer by layer, within the soft bodies of surgically reengineered manipulated shellfish (figure 1).

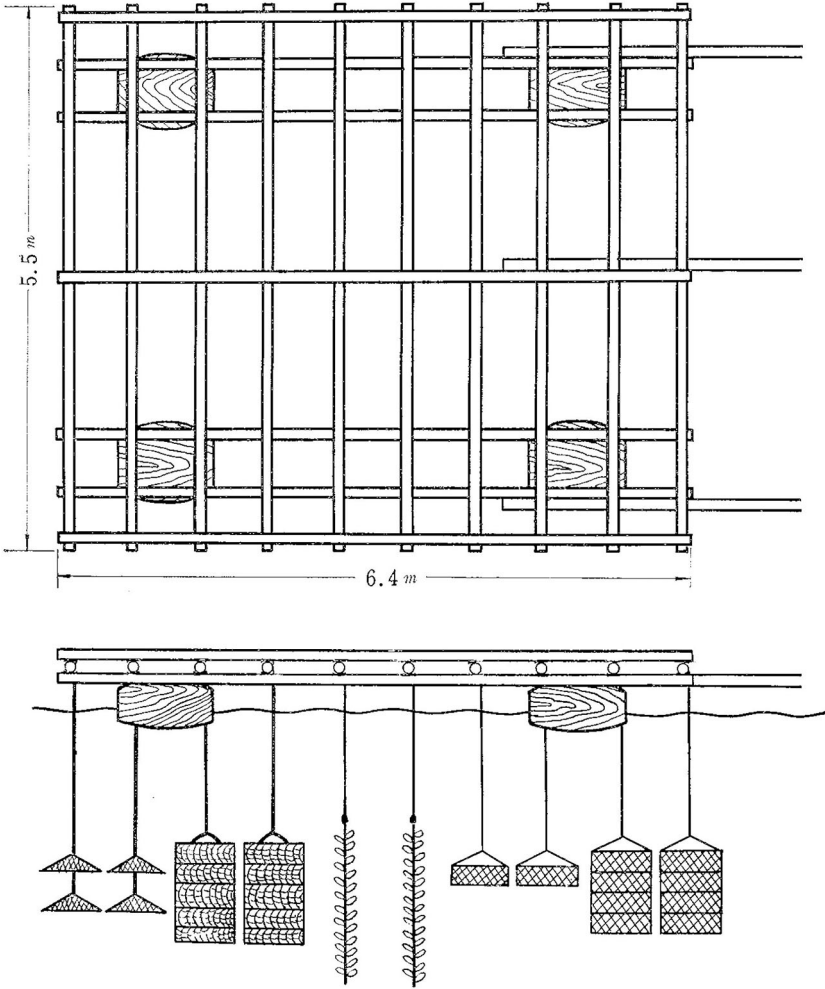
By the mid-1960s, more than four hundred million surgically nucleated shellfish were suspended from rafts along the shores of around half of postwar Japan's forty-six prefectures.<sup>5</sup> Around 70 percent of the four-thousand-odd pearl cultivators in Japan operated farms in Mie Prefecture with family-based and outside waged labor.<sup>6</sup> Most were in Ago Bay, along with an estimated two hundred million mother oysters that circulated regionally according to seasonal efforts to avoid the bay's midwinter cold and to "finish" pearls in cooler waters prior to the end-of-year harvest, shellfish slaughter, and pearl sorting.<sup>7</sup>

Pearls are calcified time. Like the rings of tree trunks rooted in soil, pearly layers indicate the months and years that shellfish have lived in changing waters and seafloors. In western Japan, cultivators distinguished between "same-year" pearls (*tōnen-mono*)—removed from oysters in the winter less than a year after spring or summer nucleus implantation surgery—and pearls that had continued to form inside shellfish into the following winter or beyond (*koshimono* or *koshidama*). In general, the larger the size of the spherical implanted nucleating object, the longer cultivators wanted to leave the nucleus inside an oyster in

5. Suisanchō gyogyō shinkōkai, ed., *Shinju sangyō no genkyō to shōrai e no hōkō* (Tokyo: Nihon Shinju Shinkōkai, 1966), 33. Okinawa, the forty-seventh prefecture, became subject to Japanese sovereignty in 1972 under an agreement made between the Japanese and United States governments.

6. Uraki Shin'ichi, *Shinju no keizaiteki kenkyū* (Tokyo: Tokyo Daigaku Shuppankai, 1970), 125. Uraki notes the difficulty of estimating individual cultivator numbers from government statistics that only counted farming units (*keieitai*).

7. "Usudama seisan de umi ni chokin ga nai," *Shinju* 10, no. 5 (1965): 5.



ちようちんかご パールネット 開放式養殖 ひらかご たてかご  
 化学繊維 ナイロン吊 金網

第1図 真珠養殖施設

**FIGURE 1.** A diagram of floating rafts, viewed from above (top) and, in a cutaway view from the surface of the water, affixed with several different kinds of suspended cages, nets, and nylon ropes into which or against which living shellfish could be placed (bottom). Slightly modified from the original image in Sawada Yasuo, "Shinju yōshoku gyojō ni okeru misshoku oyobi gyojō rōka no mondai," *Suisan zōshoku* (Jun 1965): 53–58, on 54.

order for a thicker succession of nacreous layers, secreted by a sac composed of transplanted shellfish tissues, to accumulate around it. Pearl farmers in Ago Bay, notably the largest firms like the Mikimoto Pearl Company, had treated

pearl cultivation as a multi-year activity throughout the early twentieth century. But understandings of pearl cultivation's temporalities shifted in the bay during the 1950s and 1960s. Amid a wider intensification of pearl cultivation, some began to reassess the dangers of keeping their surgically nucleated pearl oysters in the water for several years at a time.

This essay traces the contested simultaneous production of ecological and infrastructural knowledge in Ago Bay. Longer-established pearl cultivators in 1950s Ago complained that the outer coatings of nacre on their pearls were thinner than expected, considering the amount of time that their mother oysters had spent in the water. They and other observers grouped rafts, cages, shellfish, and pearl thicknesses together as interlinked elements of a named problem: "dense cultivation" (*misshoku*). Dense cultivation was tied to the longer-lasting after-effects of the intensive raising of living shellfish: the temporal notion of "fishery aging" (*gyojō rōka*) due to the degradative effects of excrement from billions of shellfish (and any other organisms that had latched onto them) atop the seabed, along with the decomposing flesh of dead mother oysters. By massing shellfish together in shallow, noncirculating waters, raft complexes had seemingly shortened pearl-producing oysters' lives and reshaped bay environments for the worse.

Problems like dense cultivation and fishery aging present watery analogs to histories of terrestrial range science, which took shape amid debates over how to manage livestock and survey pastures; how to estimate carrying capacities; and how to diagnose (and whom to blame for) disease, desertification, or deforestation.<sup>8</sup> Likewise, sites like Ago Bay offer opportunities to trace the mobility of oceanic ideas about aquacultural excess, several decades before a post-1980s burst of cornucopian "Blue Revolution" discourse and its subsequent critiques.<sup>9</sup> The issue was not one of taking too many fish out of the

8. Nathan F. Sayre, *The Politics of Scale: A History of Rangeland Science* (Chicago: University of Chicago Press, 2017); Diana K. Davis, *The Arid Lands: History, Power, Knowledge* (Boston: MIT Press, 2016); Pamela McElwee, *Forests Are Gold: Trees, People, and Environmental Rule in Vietnam* (Seattle: University of Washington Press, 2016); David Fedman, *Seeds of Control: Japan's Empire of Forestry in Colonial Korea* (Seattle: University of Washington Press, 2020); Paul Kreitman, "Attacked by Excrement: The Political Ecology of Shit in Wartime and Postwar Tokyo," *Environmental History* 23, no. 2 (2018): 342–66.

9. John Soluri, "Something Fishy: Chile's Blue Revolution, Commodity Diseases, and the Problem of Sustainability," *Latin American Research Review* 46 (2011): 55–81; Stephen Bocking, "Science, Salmon, and Sea Lice: Constructing Practice and Place in an Environmental Controversy," *Journal of the History of Biology* 45, no. 4 (2012): 681–716.

water—overfishing—but rather one of managing too many marine plants or animals in the water—what one might call overcultivation.

Ago Bay provides a window onto networks of aquacultural knowledge production that have until recently been submerged—both under the water and in historiographical discussions.<sup>10</sup> At the 1956 Scripps Institution of Oceanography Marine Biology Symposium, Victor Loosanoff, an oyster scientist at the United States Fish and Wildlife Service’s Milford Laboratory, discussed the effects of raft-and-cage shellfish cultivation with Matsui Yoshiichi, a zoologist who headed the Nippon Pearl Research Institute (*Nippon Shinju Kenkyūjo*), then housed within Kyoto University’s Shirahama Marine Biological Laboratory.<sup>11</sup> At Scripps, Matsui presented a paper arguing that raft-based pearl farming in Ago Bay and elsewhere in coastal Japan had transformed local environmental conditions. A surprised Loosanoff noted that Matsui’s observations in Japan were “difficult to reconcile with the conditions found on our natural oyster reefs or bars where generations of oysters have succeeded each other for hundreds or perhaps even thousands of years and where, nevertheless, oysters continue to exist even now.” Matsui replied that “natural oyster reefs” in the United States differed from the situation in parts of Japan “where a large number of organisms are attached to culture rafts, cages, and on pearl oysters.” Rafts and cages supported masses of organisms—including but not limited to pearl oysters—that together produced enough excreta and detritus to alter the bay’s “chemical constitution.”<sup>12</sup>

Matsui and Loosanoff’s exchange reveals unaddressed questions on relationships between marine ecologies and floating infrastructures. Had shellfish-filled rafts been placed by humans into preexisting “natural” ecologies, or did bay ecologies encompass those rafts, too? What, if anything, separated a floating raft, cage, and oyster setup in Ago Bay from a “natural” oyster reef in the

10. See, for example, Lijing Jiang, “The Socialist Origins of Artificial Carp Reproduction in Maoist China,” *Science, Technology, and Society* 22, no. 1 (2017): 59–77; Marianne Elisabeth Lien, *Becoming Salmon: Aquaculture and the Domestication of a Fish* (Berkeley: University of California Press, 2015).

11. The institute formed in 1946 through the support of transwar pearl industry leader Ōtsuki Kikuo and Kyoto Imperial University biologist Miyaji Denzaburō. See Matsui Isao, ed., *Kingyo to shinju no kenkyū ni seiryoku o sasageta nōgaku hakase Matsui Yoshiichi tsuitōki* (Matsui Isao, 1982), 128.

12. Yoshiichi Matsui, “Aspects of the Environment of Pearl-Culture Grounds and Problems of Hybridization in the Genus *Pinctada*,” in *Perspectives in Marine Biology*, ed. Adriano A. Buzzati-Traverso (Berkeley: University of California Press, 1958): 519–31, on 531.

Chesapeake tidelands or the Gulf of Mannar?<sup>13</sup> There is a tendency to treat infrastructure in terms of human-built material culture—something that, regardless of its hidden everyday workings or noticeable breakdowns, was at one point introduced into nature. In a recent intervention, Ashley Carse has argued against making a priori distinctions between nature and built infrastructure.<sup>14</sup> Ecology and infrastructure, in other words, do not map onto separate natural and unnatural components. Like “cultured” pearls and the oysters in which they formed, pearl cultivation rafts were more-than-human and more-than-oyster assemblages, too—in this case, constituting living organisms, wood, bamboo, metal, hemp and nylon fibers, seawater, sand, shellfish shit, and more. Ago Bay’s ecology was inextricable from the bayscape of pearl cultivation.

This essay traces entanglements of pearls, pearl oysters, pearl cultivators, and pearl scientists in time. Doing so directs attention toward the floating raft complex, which included but also exceeded the organismal or the biological. As such, this essay takes a somewhat different tack from Michel Callon’s well-known 1984 evocation of actor-network theory, which centered on French scallop farming experiments. Callon described how three French marine biologists attempted to “translate” a more-than-human problem of scallop larval collection in ways that allowed them to speak on behalf of fishermen, a broader scientific community, and nonhuman shellfish, in and around St. Brieuç Bay. Callon wrote that “translation is a process before it is a result.”<sup>15</sup> So too in Ago Bay, where two decades of efforts by larger pearl cultivators and pearl scientists to represent pearl cultivation in Ago Bay were incomplete and ongoing, even as

13. Christine Keiner, *The Oyster Question: Scientists, Watermen, and the Maryland Chesapeake Bay since 1880* (Athens: University of Georgia Press, 2009); Tamara Fernando, “Seeing Like the Sea: A Multispecies History of the Ceylon Pearl Fishery 1800–1925,” *Past & Present* 254, no. 1 (Feb 2022): 127–60; see Scott Gilbert, “Shells, Gills, and Gonads,” this issue.

14. Ashley Carse, *Beyond the Big Ditch: Politics, Ecology, and Infrastructure at the Panama Canal* (Boston: MIT Press, 2014). See also Brian Larkin, “The Politics and Poetics of Infrastructure,” *Annual Review of Anthropology* 42, no. 3 (2013): 27–43; Atsuro Morita, “Multispecies Infrastructure: Infrastructural Inversion and Involutionary Entanglements in the Chao Phraya Delta, Thailand,” *Ethnos* 82, no. 4 (2017): 738–57; Gerald Figal, “Life with Tetrapods: The Nature of Concrete in Okinawa,” *Cross-Currents: East Asian History and Culture Review* (e-journal) 30 (2019): 150–170; Stefan Huebner, “Earth’s Amphibious Transformation: Tange Kenzo, Buckminster Fuller, and Marine Urbanization in Global Environmental Thought (1950s–present),” *Modern Asian Studies* 56, no. 4 (2022): 1053–82.

15. Michel Callon, “Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuç Bay,” *The Sociological Review* 32, no. 1 (May 1984): 196–233, on 224.

countermeasures to the problems they identified contributed to the bay's transformation. As a historical episode, however, Ago Bay pearl cultivation differs somewhat from the farming of St. Brieuc Bay scallops. The immediate context to Callon's study was a 1970s period of intensified, transnational exchanges involving Japanese aquaculture specialists (whom Callon introduced as "the Japanese").<sup>16</sup> Callon focused on the materiality of scallop farming in terms of the first days and weeks of larval collection and shellfish development, writing that "although the collectors are necessary for the *interessement* of the scallops and their larvae, this type of 'machination' proves to be superfluous for the *interessement* of the fishermen and the scientific colleagues."<sup>17</sup> St. Brieuc Bay's larval collectors, in other words, featured in Callon's account primarily as an element of molluscan rather than human concern. In contrast, the Ago Bay problems of dense cultivation and fishery aging took shape amid debate about the months and years *after* such larval attachments had occurred. The temporalities of pearl cultivation provide the opportunity to see how pearl oysters and human pearl cultivators remained connected to the very marine conditions that the presence of massed, raft-suspended shellfish had fostered.

The following sections introduce three ways of reading Ago's pearl cultivation bayscape. The first section focuses on the politics of floating rafts by examining a 1957 Mie Prefecture policy that tried to control the rafts in Ago Bay through registration. Regulating raft ownership put new pressures on smallholder pearl cultivators while simultaneously exposing the limits of prefectural enforcement measures. The second section shows how a group of scientists in Ago Bay began to look below the water's surface, reframing "dense cultivation" and "fishery aging" as problems of shellfish management. The center of this activity was the National Pearl Research Laboratory (*Kokuritsu Shinju Kenkyūjo*, 1955–1979), a Japanese state-sponsored facility in Ago Bay. NPRL scientists analyzed the internal anatomy of individual shellfish as a site of pearl formation but saw the saltwater footprint and excretions of raft-and-cage aquaculture as a threat to the very project of pearl farming. The third section follows larger pearl cultivators, Mie Prefecture government officials, and NPRL-affiliated scientists involved in efforts to re-engineer Ago Bay. Different groups began to think of Ago as a nearly closed system that either

16. Callon, "Some Elements" (n.15), 209–10; Fukunaga Mayumi, *Sake o tsukuru hitobito: suisan zōshoku to shigen saisei* (Tokyo: Tokyo Daigaku Shuppankai, 2019); Heather Anne Swanson, *Spawning Modern Fish: Transnational Comparison in the Making of Japanese Salmon* (Seattle: University of Washington Press, 2022).

17. Callon, "Some Elements" (n.15), 210.



needed limits on the amount of pearl cultivation (and more specifically, the number of rafts and oysters) or the physical re-engineering of watery environments that might result in thicker-coated pearls.

In the mid-1960s, the waters of Ago Bay held more raft-suspended shellfish than pearl cultivators had ever attempted to raise there, before or since. A wide range of scholarship has examined Ago Bay's pearl cultivation boom and the causes of its post-1967 bust, later known as a nationwide "pearl depression" (*shinju fukyō*) or "pearl crisis" (*shinju kyōkō*).<sup>18</sup> Many scholars identified dense cultivation in particular as a factor leading to the crisis. But the concept of dense cultivation, far from a stable and reliably measured phenomenon that contributed to the end of the pearl boom, was itself transforming amid observations of pearl farming in Ago Bay.

Animal materials—which included but extended beyond pearly nacre—were part of debates over the boundaries between infrastructures of pearl cultivation and the environments in which pearl cultivation took place. Along the way, a round pearl's outer layers came to be seen as a remnant of shellfish lives and an indicator of the conditions that multiyear practices of pearl cultivation had helped to produce.

## GOVERNING PEARL THICKNESS THROUGH RAFT DENSITY

Bamboo and wooden rafts were the building blocks for the expansion of a littoral geography based on long-term relationships with shellfish. Rafts, from which were suspended metal cages (or, by the 1960s, nylon nets) full of pearl oysters, turned into floating markers of "cultivated" waters. The raft-and-cage system was a permeable scaffolding into which water flowed and from which excrement floated out or sunk down. By the same token, raft-suspended cages filled with mother oysters and other hangers-on including barnacles and algae also presented physical obstacles to the circulation of water throughout the bay.

To understand how raft densities became indicators of excessive cultivation in Ago Bay, one place to start is Japan's 1949 Fishery Law. A clause in the law

18. See, for example, Uraki, *Shinju no keizaiteki kenkyū* (n.6); Tange Makoto, *Nihon shinju sangyōron* (Tokyo: Shinju shinbunsha, 1986); Nishimura Morichika, *Utsukushiki shinju sensō: sono gurōbarizēshon* (Tokyo: Seizandō Shoten, 2001); Yamada Atsumi, *Shinju no sekaishi: tomi to yabō no 5000-nen* (Tokyo: Chūō kōron shinsha, 2013); Okamura Yōichirō, *Sangyō chitsujo no hōshakaigaku: ika ni shite sangyō wa 'honmono' to naru ka* (Tokyo: Nihon Hyōronsha, 2016).

specified that “experienced individuals” (*keiken ga aru mono*) would be given preference for pearl cultivation rights over the newly established local fisheries cooperative associations. Unlike trends in other fishery realms, when it came to pearl cultivation, postwar (and, in particular, 1945 to 1952 U.S.-led Occupation-era) fishery slogans of “democratization” did not end up giving more control to fisheries cooperative associations. What took place instead, according to larger pearl cultivators, was a “liberation” from village-based management.<sup>19</sup> The largest pre-war cultivators were able to maintain demarcated fishery rights to farm pearls in Ago Bay because they could claim “experience” from before the war. They also had opportunities to expand to pearl cultivation frontiers across western Japan, where they could declare priority due to their past pearl-farming activities in Ago Bay. But the Fishery Law did not mean that only the largest cultivators could make rights claims. Some people who had worked for the largest cultivators as waged labor also had opportunities to open their own pearl farms. The 106 pearl cultivators circa 1945 had, by 1951, increased nationwide to 750 (701 based in Mie Prefecture), double the pre-war peak in the 1930s. More would follow.<sup>20</sup>

A side effect of the reformed Fishery Law was an increase in the number of smallholder pearl cultivators, notably the figure of the “four-raft farmer” (*yon-dai gyōsha*) later criticized as a driving force behind overcultivation.<sup>21</sup> Rafts could be found all across the surface of Ago Bay, where, as of 1958, one five-by-six-meter raft floated in every fifty-five square meters of waters demarcated as spaces of pearl cultivation under the Fishery Law.<sup>22</sup> Limiting raft densities became a priority among larger pearl cultivators. As an article published by the Japan Pearl Promotion Society (*Nihon Shinju Shinkōkai*) put it in early 1957,

In Mie Prefecture, fisheries are beyond saturation point—there are rafts everywhere and even boats cannot pass through them. It may be quicker just to say that there are strips of ocean between the rafts. If the number of rafts increases further, boatmen and rafts alike will be pushed onto the shore. We have reached the point where they clearly need to be thinned out. If the

19. Makino Yoshirō, “Shinju yōshoku no seiritsu/tenkai to gyogyō kumiai,” in *Shima gyoson no kōzō*, ed. Makino Yoshirō (Nagoya: Meicho Shuppan, 1996), 67–100.

20. Uraki, *Shinju no keizaiteki kenkyū* (n.6), 271.

21. Ibid., 262–65; Hamamoto Tadashi/Tadafumi, “Misshōku bōshi ni saidai doryoku o,” *Shinju*, no. 100 (Mar 1965): 5.

22. Uraki, *Shinju no keizaiteki kenkyū* (n.6), 274.

number of rafts increases instead, the result will be unbearable. Even now there are too many rafts, which is producing unease about the quality of pearls.<sup>23</sup>

Soon thereafter, Ago Bay saw a concerted policy of decultivation in which rafts, rather than human cultivators or their shellfish, became the unit of governance in the water. Starting in June 1957, Mie became the first prefecture in Japan to order the yearly registration of every pearl farming–related raft in the water. As a result, all Mie-based cultivators—both those who raised mother oysters as part of a village fisheries cooperative association and those who operated on shellfish to induce pearl formation outside of local fisheries governance—had to pay an annual fee for every raft they used. The number of (registered) pearl cultivation rafts in Mie Prefecture fell by around one-third between 1957 and 1961, from nearly 90,000 to around 62,000.<sup>24</sup> This level remained stable for the rest of the 1960s. Mie was the only prefectural government in Japan that actively restricted raft numbers; governors in other prefectures across central and western Japan were taking active measures to attract Mie-based pearl capital.<sup>25</sup> Mie’s raft registration policy converged with, and helped to propel, a wave of pearl cultivator migration to other parts of western Japan.<sup>26</sup> Yet even as some cultivators packed up and left Mie, thousands remained in Ago Bay.

Raft regulations produced new categories of illegal cultivation among those who stayed. The figures at the heart of the post-1957 pearl farming bayscape were the “illicit cultivator” (*moguri gyōsha*) and the “unregistered raft” (*yami ikada*). In order to pursue both, Mie prefecture authorities set up an Ago Bay compliance office in the Hamajima-based Mie Prefecture Fisheries Experiment Station.<sup>27</sup> Inspection vessels made the rounds in Ago Bay. Coastal patrols

23. “Gyogyōken no san mondai,” *Shinju* 2, no. 1 (1957): 12–13, on 12.

24. These figures do not count rafts used for mother oyster raising. Uraki, *Shinju no keizaiteki kenkyū* (n.6), 132; Nishioka Mitsuo, “Yōshoku shinju no yushutsu to seisan no shomondai ni tsuite,” *Shinju kenkyūkai Ise bukai kaihō*, no. 43 (Jun 1963): 16–24, on 22.

25. “Jimu renraku kyōgikai kyōgi jikō: shinju jigyō shinkōjō no shomondai,” *Shinju gijutsu kenkyūkai kaihō* 16 (Nov 1958): 38–47; *Shinju yōshoku jigyō shingikai kaigi gijiroku*, no. 10 (Dec 1959), 33.

26. Oguri Hiroshi, *Nihon no shinju: sono yūbokuteki yōshoku no shokeitai* (Tokyo: Kokon Shoin, 1968). Raft restrictions—along with thousands of rafts destroyed after the 1959 Ise Bay typhoon and the 1960 tsunami produced by the Valdivia earthquake off the coast of Chile—persuaded some Ago-based cultivators to move out of the prefecture. Uraki, *Shinju no keizaiteki kenkyū* (n.6), 134.

27. “Shinju yōshoku no ihan tekihatsumo: ken ga torishimari honbu o setchi,” *Ise Shinbun*, 10 Sep 1957.

resulted in tensions between small cultivators and government fisheries officials, spurred at times by competing cultivators who served as state informants.<sup>28</sup> As a Mie Prefecture official in charge of pearl affairs noted, “it is impossible to monitor the number of oysters, but with rafts it is doable.”<sup>29</sup> The shortcomings of raft inspections, however, were soon apparent. News of checks often reached villages ahead of inspectors’ boats. Because inspectors simply checked whether or not registration placards were affixed to rafts, small cultivators found they could keep their unauthorized rafts by averting inspectors’ attention and passing registration placards from hand to hand.<sup>30</sup>

Grasping density in terms of shellfish proved even more elusive. Anecdotal reports suggest that pearl farmers suspended more oysters beneath each registered raft than before the 1957 regulations—as many as five or six thousand adult shellfish apiece.<sup>31</sup> Ostensible two-dimensional reductions of raft densities at the surface of Ago Bay were paralleled by increasing three-dimensional densities of shellfish below the water. This situation attracted the attention of a growing cohort of pearl researchers in Ago Bay who attempted to clarify relationships between the underwater lives of shellfish and the thicknesses of pearls growing inside them.

## STUDYING THE EMBAYED ECOLOGIES OF PEARL CULTIVATION

Relatively few sites of sustained research into the ecological effects of marine aquaculture existed in the mid-twentieth century. Elsewhere in Japan, researchers were studying links between the density of *nori* seaweed poles and harvests in Tokyo Bay or the impact of hanging edible oyster cultivation on fisheries in Miyagi Prefecture’s Matsushima Bay and Mangoku-ura lagoon.<sup>32</sup>

28. See, for example, “Gyogyōken kakutoku e dōmei: ken no mutōroku ikada torishimari ni shōgyōsha ga tsuyoku hantai,” *Chūbu Nihon Shinbun*, undated newspaper article likely from late 1957, held in the Mie prefectural history editorial office (Mie kenshi hensanban, Tsu, Mie).

29. “Jimu renraku kyōgikai” (n.25), 41.

30. Kuroki Saburō, *Gyoson no kōzō to gyogyōken kōshi no jittai: Mie-ken Shima-chō Fuseda oyobi Kisei-chō Nishiki no baai* (Toyohashi: Aichi Daigaku Chūbu Chihō Sangyō Kenkyūjo, 1974), 39.

31. Uraki, *Shinju no keizaiteki kenkyū* (n.6), 132; Kuroki, *Gyoson no kōzō* (n.28), 35.

32. Susumu Ito and Takeo Imai, “Ecology of Oyster Bed 1: On the Decline of Productivity Due to Repeated Cultures,” *Tohoku Journal of Agricultural Research* 5, no. 4 (1955): 251–68; Katada Minoru, *Asakusa nori seisuiki: nori no gobyakumen* (Tokyo: Seizandō Shoten, 1989), 101–20. On seaweed farming in Tokyo Bay, see also Jordan Sand, “Tokyo Bay as a Productive Landscape,” *Global Environment* 9, no. 1 (2016): 13–35.

In Ago Bay, the study of pearls reached beyond calcified objects to the shellfish in which they formed—and to the watery environments in which those organisms lived.

In 1955, the main laboratory of Japan's government-affiliated pearl institute, the National Pearl Research Laboratory, opened in Ago Bay.<sup>33</sup> NPRL members developed a comprehensive vision of pearl research that included everything from the analysis of a pearl's structure to the oceanographic measurement of conditions in the water and at the seafloor. The NPRL's agenda had not simply arrived as a wholesale import from Tokyo officials in Japan's Fisheries Agency. On the contrary, the laboratory tapped into a network of institutions that had emerged to study coastal waters and pearl oysters. A prime example was the NPRL's first director, Takayama Katsuo, who had previously led the Mie Prefecture Fisheries Experiment Station in the Ago Bay town of Hamajima.<sup>34</sup> Most of the laboratory's first generation of researchers had studied outside Tokyo, at universities in Kyoto, Sendai, Fukuoka, and Sapporo where programs in ecologically focused biology and fisheries science had emerged. One was the Kyoto University-trained Sawada Yasuo. Known at times as "Dr. Pearl," Sawada was among the first scientists in Japan to do graduate work that focused specifically on pearl issues.<sup>35</sup> He was part of an NPRL group that attempted to observe the limits of pearl cultivation in the water.

NPRL researchers investigated relationships between packed-together rafts and thin-covered pearls in terms of two problems at the center of pearl oyster management: dense cultivation and fishery aging. Dense cultivation was a problem of flow: packed-together rafts, cages, and shellfish would lead to less nutrients reaching shellfish, the spread of parasites, and slower pearl

33. Transwar pearl cultivator-dealers had helped to subsidize the formation of a multisited research center under Japan's 1952 Pearl Industry Law. They did this with a substantial and—because it involved what appeared to be a direct attempt by private interests to fund state policy—remarkably controversial donation of nearly forty million yen that came from the auction of pearls kept by a wartime holding company. See Okamura Yōichirō, "Sangyō chōsei to hō no yakuwari (2): yōshoku shinju sangyō o sozai to shite," *Hōgaku ronsō* 173, no. 3 (Jun 2013): 127–45.

34. Takayama headed the station from 1949 to 1953. See Mie-ken suisan kenkyūjo, "Mie-ken suisan kenkyūjo ni 100-nen," Mie Prefecture. [www.pref.mie.lg.jp/suigi/hp/15835016996.htm](http://www.pref.mie.lg.jp/suigi/hp/15835016996.htm)

35. One article highlighted Nakahara Hiroshi at Hokkaido University and Sawada at Kyoto University as the first people in Japan to receive PhDs for pearl-focused dissertations. Both worked at the NPRL. See "Kokuritsu shinju kenkyūjo no Sawada-san," *Chūbu Nihon Shinbun*, 4 Jul 1962, in *Shinju gijutsu kenkyūkai kaibō*, no. 41 (Aug 1962): 39.

formation.<sup>36</sup> Rafts and their suspended, mollusk-filled cages were, quite simply, physical impediments to movements of seawater. A corollary was that if one removed rafts, flows might improve. By contrast, fishery aging was a problem of sedimentation: a buildup of wastes and shellfish-attached organisms on the bay floor that could lead to “red tide” algal blooms and a variety of mass shellfish mortalities.<sup>37</sup>

Research into dense cultivation and fishery aging fit into a longer, transwar history of ecological research at “terrestrial water” (*rikusui*) and “inner bay” (*naiwan*) sites in and around the Japanese empire. In 1944, a group led by Kyoto Imperial University biologist Miyaji Denzaburō proposed the concept of “degrees of embayment” (*naiwando*).<sup>38</sup> Bay ecologies, Miyaji argued, varied depending on the shape of the inlet and the spot of observation. Such research can be read alongside efforts in Euro-American contexts to seek out microcosms, notably lakes, through which one might comprehend ecological interactions both holistically and synoptically. Indeed, for the freshwater-trained Miyaji and his Kyoto colleagues, the limiting case of embayment was the lake.<sup>39</sup>

36. There was, however, no single idea of dense cultivation as *misshoku* in mid-twentieth-century Japan. Indeed, one could contrast the 1950s problem of aquatic *misshoku* (often glossed as 密殖 for finfish and as 密植 for edible algae) against more positive contemporaneous assessments among some Japanese biologists and agricultural scientists of landed *misshoku* (密植 C: *mizhi*) as a close-planting principle of Great Leap Forward-era Maoist grain cultivation in the People’s Republic of China. Sigrid Schmalzer, *Red Revolution, Green Revolution: Scientific Farming in Socialist China* (Chicago: University of Chicago Press, 2016) 29, 238n10; “Suitō tashūkaku no shuyō sochi to shite no gōriteki misshoku,” *Chūgoku keizai shiryō*, no. 13 (Apr 1959), 1–8.

37. Sawada Yasuo and Taniguchi Miyasaburō, “Shinju yōshoku gyojō ni okeru rōka gyojō no seijō to sono kairyō hōhō ni kan suru kenkyū,” *Suisan doboku* 5, no. 1 (1968): 13–18.

38. Miyaji Denzaburō, Masui Tetsuo, and Habe Tadashige, “Naiwando to naiwan no seibutsu gunshūkei ni tsuite,” *Seiri seitai gyōseki* 3 (1944): 1–20. It should be noted too that such surveys often erased or denigrated local human (and nonhuman) practices, while at the same time eliding scientists’ reliance on fishers and other knowing informants. In other transwar contexts, this was indeed the case on land and deeper in the sea. See, for example, Miriam Kingsberg Kadia, *Into the Field: Human Scientists of Transwar Japan* (Stanford, CA: Stanford University Press, 2019); Nadin Heé, “Negotiating Migratory Tuna: Territorialization of the Oceans, Trans-war Knowledge and Fisheries Diplomacy,” *Diplomatic History* 44, no. 3 (2020): 413–27; and, in the case of marine diving practices (including studies of female divers in villages around Ago Bay), Jaehwan Hyun, “Rearticulating the ‘Primitive’: The Sea Women and the Emergence of Trans-Pacific Physiology,” *Historia Scientiarum. Second Series: International Journal of the History of Science Society of Japan* 30, no. 3 (2021): 159–75.

39. Raf de Bont, *Stations in the Field: A History of Place-Based Animal Research, 1870–1930* (Chicago: University of Chicago Press, 2015); Miyaji, Masui, and Habe, “Naiwando” (n.38), 1.

Ideas of embayment persisted in Miyaji's and previously introduced zoologist Matsui Yoshiichi's post-1945 surveys of Ago Bay's pearl fishery.<sup>40</sup> Subsequent researchers described Ago as a highly embayed inlet vulnerable to seasonal shifts in temperature, shellfish excretions, and flows of water. Mie Prefectural University fisheries scientist Ueno Fukuzō wrote that “when you raise huge quantities of pearl oysters over and above the amount of animals naturally living there, you must then increase the amount of material cycling through in proportion to the quantities of akoya oysters, just like a goldfish bowl” (figure 2).<sup>41</sup> Ueno extended his field observations to Canada's Prince Edward Island. Malpeque Bay—an inlet where “the topography is similar to that of Ago Bay”—served Ueno as a yet uncultivated control area to which the “densely cultivated” conditions of Mie Prefecture might be compared.<sup>42</sup>

At the NPRL, the focus of ecological and oceanographic pearl research changed over time. In the mid- to late 1950s, Sawada Yasuo and his colleagues had considered dense raft-and-cage cultivation—accompanied by slower water flows and lower plankton numbers—to be the more pressing concern. The long-term buildup of excrement and other organic materials on the seafloor might result in mass pearl oyster mortalities, they admitted, but the processes they grouped under the category of “fishery aging” did not necessarily impact rates of pearl formation.<sup>43</sup> By the following decade, however, Sawada and others in the NPRL had recast fishery aging as an equally serious problem for pearl cultivation in highly embayed inlets across Japan. Longer histories of intensive pearl cultivation meant that shellfish continued to form thinner pearls in some parts of Ago Bay than others. But even if densely packed rafts went away, the accumulated effects of fishery aging would remain.<sup>44</sup>

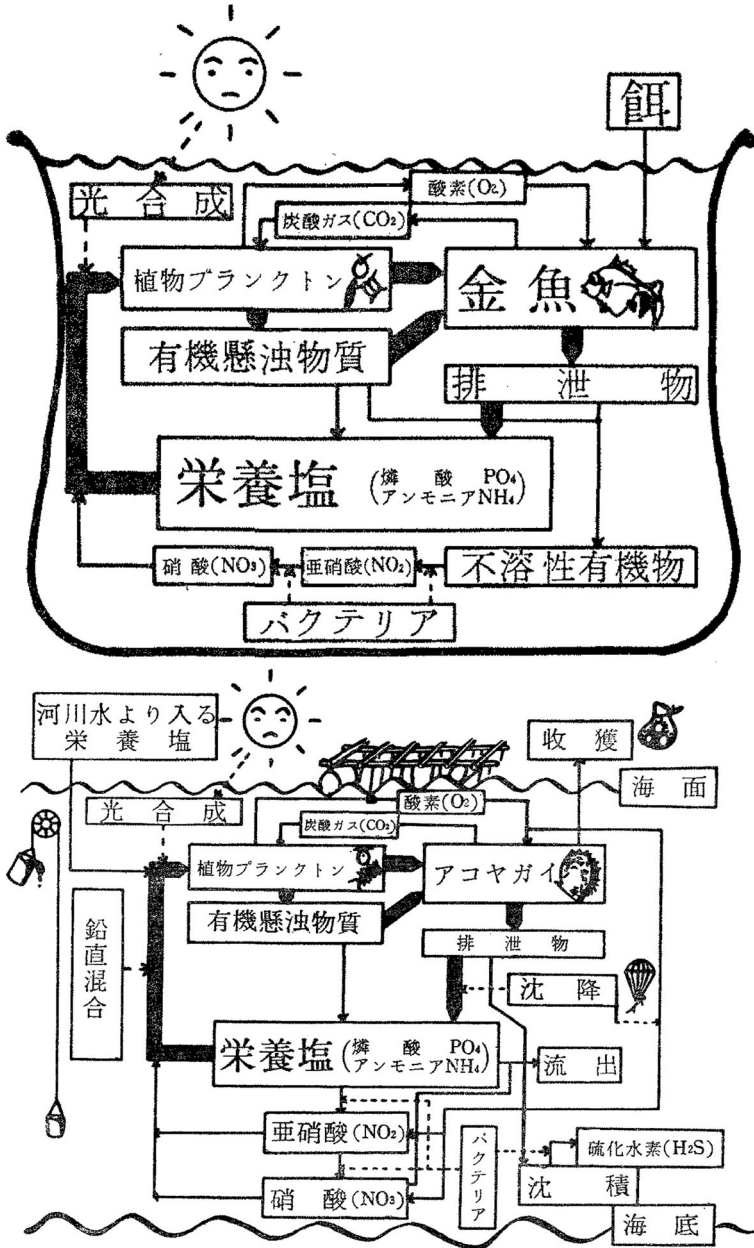
40. See the two groups of Ago Bay pearl fishery reports (“Ago-wan no shinju gyojō ni kansuru kenkyū”) published in the Dec 1950 and Apr 1951 issues of *Kyōto Daigaku rigakubu seiri seitaigaku kenkyū gyōseki*.

41. Ueno Fukuzō, “Naiwan ni okeru suisan seibutsu kankyō to busshitsu juncan,” *Engan kaiyō kenkyū* 4, no. 2 (1965): 4–12, on 8.

42. Fukuzo Uyeno, “Nutrient and Energy Cycles in an Estuarine Oyster Area,” *Journal of the Fisheries Board of Canada* 23, no. 11 (Nov 1966): 1635–52.

43. Sawada Yasuo and Tange Makoto, “Shinju yōshokujō no yōshoku kaiyōgakuteki kenkyū,” *Kokuritsu shinju kenkyūjo hōkoku*, no. 5 (Dec 1959): 459–80, on 477–79.

44. Sawada Yasuo, “Shinju gyojō no rōka to sono kairyō hōhō ni tsuite,” *Shinju gijutsu kenkyūkai kaihō*, no. 58 (1967): 34–40.



**FIGURES 2 AND 3.** Mie Prefectural University fisheries scientist Ueno Fukuzō compared the ecology of material circulation in a goldfish bowl (top) to the ecology of pearl cultivation in Ago Bay (bottom, with akoya shellfish linked to a floating raft at the surface). Original image in Ueno Fukuzō, "Akoyagai no jiryō seisan to gyojō no kaiyō kōzō ni tsuite," *Shinju giyutsu kenkyūkai kaihō*, no. 37 (Jul 1961): 21–33, on 23–24.



## RESPONDING TO THE SPECTER OF OVERCULTIVATION IN 1960s AGO BAY

If Ago Bay's pearl fishery had "aged," one response was a program of "rejuvenation" (*wakagaeri*).<sup>45</sup> In 1965, Mie Prefecture received Tokyo funding to explore the possibility of re-engineering Ago Bay. An associated survey had two main goals. The first was to investigate large-scale dredging of the inner bay. Since the early 1960s, researchers including Sawada Yasuo and Ueno Fukuzō compared the effects of scooping up the top layers of accumulated sediment versus tilling up the seafloor. Tilling was effective, wrote Ueno, but had to be done every year. Wholesale dredging promised longer-lasting effects but was costlier and more logistically difficult.<sup>46</sup> A second goal was arguably more ambitious: to redirect the flow of water through the bay in order to support the continued raising of encaged living shellfish. Mie officials proposed the digging of a series of canals across the peninsulas that jutted into the bay and to increase the numbers of waterways between the inner bay and the outer Pacific Ocean. Canal building in Ago Bay had an earlier precedent in the Fukaya Canal, which opened in 1932 between the Saki-Shima peninsula villages of Katada and Funakoshi.<sup>47</sup> Mie officials envisioned new waterways (which included four new channels and the widening of Fukaya Canal) as a means of increasing the volume of water that flowed through the inner bay, bringing nutrients in and flushing wastes out.<sup>48</sup> For his part, Sawada teamed up with Kyoto University researchers to test the detonation of underwater explosive charges as a way to blast away sediments from Ago's inner bay seafloor.<sup>49</sup>

Ideas for reshaping Ago Bay were accompanied by plans to permanently relocate smallholder cultivators' rafts away from the inner bay. Two sets of actors were behind the scheme: pearl cultivator Yamamoto Katsu, who headed a group of Japan's largest pearl cultivators and exporters (the *Nihon shinju jigyōsha kyōkai*), and leaders of the national association of pearl cultivation

45. "Ago-wan wakagaeri jigyō: 7-gatsu kara chōsa," *Ise Shinbun*, 4 May 1965, quoted in *Shinju* 10, no. 7 (Jul 1965): 8.

46. Ueno Fukuzō, "Gyojō no rōka to kaki no teishitsu ijō ni tsuite," *Shinju gijutsu kenkyūkai kaihō*, no. 50 (May 1965): 93–99, on 99.

47. Daiō chōshi hensan iinkai, *Daiō chōshi* (Daio-chō, Mie Pref.: Daio-chō, 1994), 411–15.

48. "Gyojō meguri: senkai gyojō (Ago-wan shinju gyojō) daikibo kaihatsu jigyō keikaku ni yoru gyojō kairyō ni tsuite," *Shinju gijutsu kenkyūkai kaihō*, no. 51 (Oct 1965): 34–37.

49. Sawada Yasuo and Wakazaono Yoshikazu, "Shinju yōshoku gyojō ni okeru suichū shōgaibutsu no bakuha jokyo ni kansuru kenkyū," *Suisan doboku* 5, no. 1 (1968): 7–11.

associations (*Zenkoku shinju gyogyō kyōdō kumiai rengōkai*), a Mie-based organization often known as Zenshinren after its 1961 formation.<sup>50</sup> Zenshinren leaders and Yamamoto made a provisional agreement with Ishikawa Prefecture officials for certain Ago Bay cultivators to float their rafts more than 300 kilometers to the north in Nanao Bay, on the opposite coast along the Sea of Japan (East Sea).<sup>51</sup> The largest cultivators like Yamamoto had visions of inner-bay small cultivators moving their shellfish and rafts out of Ago Bay for good: clauses linked relocation to bans on any future cultivation increases in the Mie areas from which farmers removed their rafts. Some middling-sized cultivators also supported smallholder relocations: one was a self-proclaimed eighteen-raft pearl farmer writing under the pen name Ago Bay Raft Tarō (*Ago-wan Ikada-Tarō*).<sup>52</sup> Others in the Mie government stressed that incoming smallholders would create chances for local fishers in Ishikawa Prefecture to learn pearl farming skills from Ago Bay migrant cultivators. It was, as one Mie official argued, a mutually beneficial “tie-up” (*taiappu*).<sup>53</sup> By the mid-1960s, however, new restrictions on pearl cultivation were appearing outside Mie Prefecture.<sup>54</sup> Officials in Ishikawa decided they would allow only two hundred formerly Mie-located rafts into Nanao Bay, a far cry from the mass relocation of at least three thousand rafts that Yamamoto and Zenshinren leaders had envisioned.<sup>55</sup> It also is unclear how many cultivators would have been willing to take up a relocation offer that prohibited future (legal) pearl farming in Ago Bay. Pearl farmers were not eager to nominate their own rafts for removal.

After 1967, Japan’s pearl industry saw an unprecedented fall in export orders that came to be known as the “pearl crisis.” Amid the downturn, some still saw a future of fewer rafts, stronger flows, and better pearls. Mikimoto Pearl Company scientist Kuwa Morihiko wrote that “if we can do production restrictions on a scientific basis, I think we can have thick-coated pearls with the value of true precious stones like in the past.”<sup>56</sup> For Kuwa, the improvement of pearls meant nothing less than cultivation’s contraction. At the same

50. “Usudama seisan” (n.7), 5.

51. “Yōshoku meguri: Ishikawa-ken Nanao-wan no shinju yōshoku kaihatsu ni tsuite,” *Shinju gijutsu kenkyūkai kaihō*, no. 46 (May 1964): 43–48.

52. Ago-wan Ikada-Tarō, “Mie-ken no shinju yōshoku gyōsha ni teian suru,” *Shinju* 10, no. 2 (Feb 1965): 14–15.

53. “Shinju yōshokugyō no genkyō to mondaiten: Mie-ken,” *Shinju* 10, no. 2 (Feb 1965): 11.

54. *Shinju handobukku* (Tokyo: Shinju Shinbunsha, 1964), 74–77.

55. Inoue Iwao, “Nanao-wan shinju kaihatsu ni tsuite,” *Shinju* 11, no. 7 (Jul 1966): 14.

56. Kuwa Morihiko, “Shinju yōshoku kanri ni tai suru kōsatsu,” *Shinju gijutsu kenkyūkai kaihō*, no. 61 (Mar 1968): 47–57, on 56.

time, Kuwa's goal of thicker-coated pearls implied countermeasures against dense cultivation and the environmental consequences of aging fisheries: a simplified floating architecture for remaining rafts and a rechanneling of seawater throughout and beyond the inner bay.

As with the Ishikawa-bound raft relocation scheme, dreams of a dynamite-excavated, excrement-flushing canal system in Ago Bay never materialized. Nevertheless, demands for lower-density pearl cultivation informed a plank of Japanese state intervention in the wake of the pearl crisis: a 1969 national law that allowed for prefectural governors to order the compulsory reduction of rafts in zones that the law's adjustment committee designated as "densely cultivated ocean areas" (*misshoku kaiiki*).<sup>57</sup> But the post-crisis retreat of rafts from bays across Japan was so great that the restrictive provisions of the 1969 law remained largely hypothetical. Many smallholder pearl cultivators and mother oyster raisers turned to other cash crop sidelines, including the growing of flowers and citrus fruits and the raising of seaweeds or finfish. Some people repurposed pearl rafts as floating campsites.<sup>58</sup> Fisheries economist Uraki Shin'ichi wrote in 1975 that "even in places once deemed densely cultivated waters, pearl production has declined today to the point where the adjustment committee is not necessary."<sup>59</sup>

By the 1970s, historical accounts had begun to portray Ago Bay and the surrounding area as a region to which the previous heights of pearl cultivation would not return.<sup>60</sup> Subsequent changes also dulled links between Ago and pearl research. A culmination came with the 1979 shuttering of the NPRL. Former NPRL members continued to pursue projects as members of the Japanese Fisheries Agency's National Research Institute of Aquaculture (originally styled as the *Kokuritsu yōshoku kenkyūjo*), which opened the same year in neighboring Gokasho Bay.<sup>61</sup> Leaving the mid-twentieth-century politics of

57. Suisanchō gyogyō shinkōka, ed., *Shinju yōshoku tō chōsei zantei sochihō no kaisetsu* (Tokyo: Shinju Shinbunsha, 1970).

58. "'Shinju ōkoku' no tenshin sakusen," *Yomiuri Shinbun*, 21 Jan 1969; "Fūgawari na hishochi," *Yomiuri Shinbun*, 27 Jul 1969.

59. Uraki Shin'ichi, "Genjiten ni okeru shinju yōshokugyō no mondaiten to kihon taisaku no hōkō," *Shinju gijutsu kenkyūkai kaihō*, no. 75 (Aug 1975): 1–37, on 9.

60. Terao Yukiaki, "Shima chihō no shinju yōshoku no seisui," in *Mie-ken no chiri: Mikawa Osamu kyōju taikan kinen*, ed. Mie Daigaku Chirigakukai (Tsu: Mie-ken Kyōdo Shiryō Kankōkai, 1975): 150–60; Uraki Shin'ichi, "Shinju sangyō wa naze katsuryoku o ushinatta ka: umi no osen ga gyojō o ubai hinshitsu o teika saseta," *Ekonomisuto* (Sep 1979): 58–63, on 59.

61. "Yōshoku kenkyūjo no shinsoshiki," *Shinju kenkyūjo nyūsu*, no. 8 (Feb 1979): 9–10.

density unmentioned, travel writers and tourism boosters further naturalized pearl oyster rafts as essential features of Ago's bayscape, part of a panoramic "scenery" (*keikan*) not to be missed.<sup>62</sup>

## CONCLUSION

Multiple contestations underlay the project of pearl cultivation in Ago Bay during the 1950s and 1960s. As Megan Raby has argued, "putting land first can uncover and foreground the often-hidden politics inherent in scientists' land use."<sup>63</sup> Similarly, putting water first can uncover how pearl research was no less linked to floating and subaqueous political ecologies. Dense cultivation and fishery aging became problems in which the figure of the raft-owning Ago Bay smallholder took a prominent place.

Pearls, pearl oysters, and Ago Bay itself came to be seen as timekeepers and as time-limited entities. New conceptions of time in the water included ideas about productivity in the form of rates of pearl deposition in the water. Deposition carried with it several meanings, not only with regard to the formation of pearl layers but also to the accumulation of shellfish wastes. The thickness, or rather, thinness of the secreted nacre that layered around a pearl oyster's implanted nucleus became an index of Ago Bay's water and seafloor conditions. People in and around Ago Bay increasingly understood the goal of improving a pearl's thickness in terms of the watery surroundings in which defecating and pearl-secreting shellfish lived. Policy prescriptions focused on ways to control shellfish excretions while maximizing their nacreous secretions. The covering of implanted nuclei with nacre—an after-effect of surgically rearranged shellfish physiologies—became tied to spatiotemporal understandings of pearl cultivation in terms of aquacultural ecologies that were neither natural nor human built. As NPRL researcher Uemoto Haruhiko put it, "[pearl thickness] is also controlled by fisheries' conditions...the area of water, the depth of the water, the number of rafts, the density of cages, and the number of shellfish in each cage can result in problems, in particular with regard to the flow of water."<sup>64</sup> Ideas of dense cultivation and fisheries ageing

62. See, for example, *Nihon no kyōshū: yūyake koyake* (Tokyo: Heibonsha, 1999), 105.

63. Megan Raby, "Slash-and-Burn Ecology': Field Science as Land Use," *History of Science* 57, no. 4 (2019): 441–68, on 445.

64. Uemoto Haruhiko, "Shiage sagyō no yōten," *Shinju gijutsu kenkyūkai kaibō*, no. 50 (1965): 72–85, on 73.

were inseparable from bay spaces of pearl farming, which fostered visions of goldfish bowl feedback loops that led to waste accumulation, weakened or dead pearl oysters, and pearls with thinner outer coatings. The identification of an ecological connection was of a piece with diagnoses of infrastructural failure. Attempts to redefine Ago Bay's aquacultural ecology suffused discussions about who (and whose pearl-oyster-laden rafts) could stay and who, or what, might go.

Even as the notion of animal materiality decenters organisms, it also furnishes opportunities to recover historical processes through which human and nonhuman beings have been rendered less visible. Other contributions to this issue allow us to reconsider the obscuring and reworking of animal materials in conjunction with practices of observation and making.<sup>65</sup> This essay has treated pearls as a sometimes submerged locus of animal materiality. Pearls—and the living molluscan organisms in which they formed—are “technoscientific thick things” that embody multiple knowledges.<sup>66</sup> Tiago Saraiva has reminded us, however, that even seemingly cosmopolitan and multilayered things are not uniformly inclusive.<sup>67</sup> As a foil to the problematic thinly coated pearl, the thickly coated pearl was a “thick” thing that brought together aesthetic visions of exportable adornment and scientific plans to exclude unwanted organisms and more-than-organismal infrastructures from certain places altogether.

### Acknowledgments

This article has benefitted from comments by special issue editors Lisa Onaga and Laurence Douny, *HSNS* associate editor Edna Suárez Díaz, and two incisive reviewers. Matthew Booker generously commented, too, on an earlier version of this article. I received crucial editorial support from Gina Paartridge-Grzimek and the rest of the Department III publications team at the Max Planck Institute for the History of Science (MPIWG). In addition to Laurence and Lisa's Animal Materialities workshop at the MPIWG, I received welcome feedback in several other venues. Harald Fuess included me in a Transcultural Encounters conference for the 2019 inter-university HeKKSaGOn meeting at Heidelberg University. Cyrian Pitteloud invited me to present at a 2020 workshop on Water, Waterways and Seas in Modern Japan, hosted by

65. See Sarah Lowengard, “On the Disappearance of the Animal Body,” this issue; and Sarah Teasley, “Sticky Solutions,” this issue.

66. Tiago Saraiva, *Fascist Pigs: Technoscientific Organisms and the History of Fascism* (Boston: MIT Press, 2016), 3.

67. Saraiva, *Fascist Pigs* (n.66), 237–42.

the Kyoto Centre of the École Française d'Extrême-Orient and the Scuola Italiana di Studi sull'Asia Orientale. Finally, I participated in a panel organized by Setoguchi Akihisa and chaired by Fujihara Tatsushi at the Fifth Biennial Conference of East Asian Environmental History in Tainan, Taiwan. I extend special thanks to both of them as well as to Iwaki Takuji and Ishii Miho, who offered invaluable support along with other members of the Kyoto University Institute for Research in Humanities working group *Kansekai no Jinbungaku* 環世界の人文学 (The Studies of *Umwelten*).