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Harvesting a knowledge commons: collective action, transparency, and innovation at the Portland Fish Exchange

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Abstract: While localist visions of alternative food systems advocate for the expansion of local ecological knowledge through more proximate producer-consumer relationships, globalized seafood supply-demand chains persist. Moving beyond this dichotomy, commons scholars recognize that collective action among resource users at the local level can shape cross-scalar producer relations with government and more capitalized firms operating in regional and global markets. In the case of the New England groundfishery, a quasi-public fish auction not only transformed the scalar, logistical, and financial parameters of harvester-buyer relationships, it altered the production and use of local knowledge among some harvesters, and their technological choices. Resulting markets offer potential benefits that extend to broader publics, by increasing the monetary value and experimental development of a knowledge commons. Qualitative analysis of field data shows that with new market transparency, fish are no longer valued as an undifferentiated commodity, but as a variety of products with individually nuanced price structures. Displacement of local seafood buyers incurred some shoreside job losses, but fishers on smaller, owner-operated boats in multi-generational fishing harbours benefit particularly from new opportunities compared to larger, fleet boats due to different labour relations, allocations of decision-making responsibilities, observational contexts, and associated information flows. Implications for the mobilization of knowledge-action linkages to influence formal resource management arenas merit further research.

Keywords: Firm size, fisheries, fishing gear, institutions, LEK, Maine

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1. Introduction

As activism promoting alternative food systems spreads globally, advocates assert that the most personal and spatially proximate relationships between consumers and producers advance the public good by increasing consumer scrutiny of producers' resource stewardship practices, and thereby nurturing some shared body of local ecological knowledge (Hayden and Buck 2012). Nonetheless, even if a spatially circumscribed pattern of production-consumption might be desirable in some respects, local exclusivity is not always practical, and tradeoffs inevitably arise at other socio-ecological scales (Sonnino and Marsden 2006; Tregear 2011; Slocum and Saldanha 2013). The established history of common property scholarship anticipates precisely such an evolution in perspective. Foundational commons research demonstrates how dense and multivalent social relations among natural resource users can facilitate development of extra-legal, non-market collective action mechanisms for resource monitoring and conservation at a local scale (McCay and Acheson 1987; Ostrom 1990; Bromley et al. 1992). More than a decade of subsequent commons study now points to the prevalence of socio-ecological drivers that cross nested institutional scales (Ostrom et al. 2002; Berkes 2008; Vollan and Ostrom 2010; Larson and Lewis-Mendoza 2012; Blomkvist and Larsson 2013). It recognizes that institutional innovations can mediate relations between local, resource-reliant collectivities and supra-local markets, firms, governments, and non-governmental organizations (Singleton 2000; Berkes and Davidson-Hunt 2009; German and Keeler 2010; Mwangi and Wardell 2012). Commons authors also emphasize the public utility of knowledge as non-rival or non-subtractible commons, ones in which the use and development of knowledge and information does not result in depletion, but rather provides expanded benefits, potentially shared by users and non-users across analytical scales (Hess and Ostrom 2007; Wilson 2007; Douglas and Dietz 2011).

Several investigators have focused specifically on the benefits of local knowledge and learning in the management of fisheries (Wilson et al. 2006, 2012, 2013; Murray et al. 2010). Extensive field evidence demonstrates that fishers can contribute important information streams for decision-making, but that integration into corresponding scientific, management, and policy frameworks remains challenging (Pinto da Silva and Kitts 2006; Gray and Hatchard 2008; Johnson 2009; Burns and Stöhr 2011). For example, natural scientists raise concerns about conservation costs of fishing gear interactions with target and non-target fish,

benthic flora and fauna, and marine mammals and seabirds (National Research Council 2002; Chuenpagdee et al. 2003).

Nonetheless, management and research tend to pay less attention to how fishing industry rationales and information streams influence gear use decisions – the where, when, how, and why of gear deployment. Like any technological choice, these are subject to a range of socio-ecological drivers, such as market demand, capital and labour availability, interpersonal networks, and exposure to a diversity of fishing practices. Throughout a fishing career, each fisher collects a unique array of indirect observations and anecdotes about fish behaviour and other biotic and abiotic components of the marine environment. Each gear deployment constitutes an experiment, an opportunity to collect new information.

Many of the most committed fishers have also spent countless hours listening to elders expound on lessons about how to find and catch fish. Some knowledge they elect to keep private, but some they share, often selectively, strategically, as a valuable currency (Wilson 1990; St. Martin 2001). Even while fishers compete for catch and income, they often form cooperative relationships, whether based on kinship, friendship, residence proximity, gear choice, species targets, boat size, or other mutual interests. Over time, some information and beliefs become generalized, transmitted, and accepted among a number of individuals as a knowledge commons, albeit one that is largely undocumented.

Of course, this body of industry understanding is not infallible. Like anyone, fishers adopt some beliefs because they are well supported by empirical evidence and logic, and some because they serve convenient cognitive functions as heuristic shortcuts, or carry useful symbolic meaning in a particular social contexts (Neis and Felt 2000; Tversky and Marsh 2000; Kahneman 2003; Haggan et al. 2007; Ruddle and Davis 2011; Thornton and Maciejewski Scheer 2012). Inevitably, some fishers are more innovative and entrepreneurial than others (Thorlindssen 1988; Pálsson 1994). Some will always prefer to harvest and market fish the same way they first learned (Eggert and Lokina 2007). Others will experiment with new markets, grounds, and gear configurations, tolerating the financial risk. A promising new market can turn out to be a bust, and variation in fishing strategy yields variation in harvests. Practical innovation on the water also involves a great deal of inference, assumption, and critical assessment, since aquatic species and habitat are mostly invisible below the ocean surface. We might ask, therefore, what conditions can facilitate increases in the extent and rigor of such a knowledge commons, for the prospective benefit of resource harvesters and broader publics.

This article examines the transformation of a knowledge commons through this lens. Close consideration of the New England groundfish case reveals a relationship between the market structures in which seafood pricing takes place, and the rationalities under which fishers[1] collect and use information about the marine

[1] Virtually all New England fishers, male and female, identify themselves as fishermen. Nonetheless, I use the neuter term fisher here to emphasize the extent to which individuals act as economic agents balancing multiple rationalities, not wholly bound by past experience.

realm. When a centralized, regional auction co-organized by fishers and civic interests replaced local ex-vessel fish buyers, it precipitated subsequent changes along the market chain from harvest to consumption, and raised the economic value of industry knowledge. By extricating initial product sales from dense and multivalent social relations long entrained by undifferentiated commodity markets and localist dependencies, it provided a newly transparent and information-rich arena in which a wider range of differentiated product standards could arise and compete. Fishers were no longer blind price takers, like most commodity producers, but became active agents in the inception, formation, and expansion of multiple specialized product markets. This unprecedented information flow and transparency in market transactions changed fishers' motivations and the device and deployment of gear technologies, rewarding and fostering innovation and knowledge-making. Smaller harvesting firms particularly benefitted from these changes, being mostly owner-operated and in close communication with other fishers who generate, adapt, and share knowledge over time. Ultimately, socio-ecological benefits accrued despite the persistently regional to global scope of market endpoints, and may hold broader public value.

2. Methods

These findings derive from several datasets, collected and analyzed following a modified grounded theory approach (Glaser and Strauss 1967). This inductive technique seeks and compares data sources in an iterated fashion to identify commonalities, differences, and categories, explore counter-examples and contingencies, then extract themes to support first- and higher-order conclusions. Background data collection began in 1989 investigating collective action and local knowledge in fisheries decision making, mainly in New England. As a series of studies, this included more than 2 years of participant observation (on and off the water), three randomized surveys (summarized in Table 1), interviews, focus groups, and document review (blinded citations). Key informant interviews in the groundfishery took place between 2000 and 2013, using snowball, convenience, and stratified sampling (summarized in Table 2). Industry experience included vessels ranging from to less than 30 to more than 100 feet, using otter trawl, gillnet, tub trawl, reel, and handline gear. The cumulative list of informants totals more than 300 people, including commercial fishing boat captains, owners, and

Table 1: Summary of randomized surveys.

Survey years	Mode of contact	Sample frame	Total respondents	Respondents w/ groundfishing experience
2005–2006, 2010	Phone	Maine-based groundfish permit holders and crew	44	44
2002, 2003	Mail	Maine lobster/other fishery license holders	49	13

Table 2: Summary of informants' experience in New England groundfishery.

Groundfishery experience	Minimum number of informants
Fishing	65
Professional fishing firm management, consulting, advocacy	5
Related shoreside businesses (buying, processing, supplies, etc.)	10
Other members of fishing families	12
Government	20
Non-profit staff and affiliates	25

crew; other members of fishing families; harvester co-op managers; seafood buyers, processors, and retailers; auction personnel; industry suppliers and other shoreside businesses; public sector officials and contractors; recreational fishers; and non-profit organization staff and volunteers.

3. Groundfish, gear, management, and markets

3.1. Case context

The underwater seascape in which groundfish dwell is ecologically complex, in both its spatial and temporal dimensions. In this fluid, expansive, and largely invisible environment, tracking relationships between physical and biological processes, and between human and non-human variables challenges the quantitative limits of fisheries science (Longhurst 2010). Along the coast, bays, inlets, river mouths, and peninsulas descend to sandy, muddy, and cobble bottom; to ledges, boulders, and crevices; to basins, crevasses, seamounts, canyons, and shallow offshore banks; then to the edge of the continental shelf. Seasonal upwelling, storms, and riparian flows mix warm and cold water masses originating in the Labrador Current and Gulf Stream, and carrying unique loads of nutrients, flora, and fauna. Bathymetric contours channel smaller ocean currents and gyres, entraining plankton and consumer species in a three-dimensional seascape. Spending most of their lives on or near the sea floor, commercially harvested groundfish species include cod, haddock, halibut, flounders, pollock, whiting, hake, redfish, and monkfish. Some comprise metapopulations, with subpopulations mixing at times in deeper water, then returning seasonally to shallower natal spawning grounds in more dense concentrations (Bigelow 1924; Ames 2004; Reich and DeAlteris 2009; Skjæraasen et al. 2011). Most groundfish are harvested with otter trawls dragged behind boats more than 40′ long, and some exceeding 100'. They can also be caught with stationary gillnets or hooks, which can be set out from smaller boats. The largest and most dedicated groundfish fleets[2] have been in Massachusetts and

[2] The term "fleet" simply refers a group of boats, small or large. The grouping may be based on commonalities such as location, gear type, size, or ownership structure. The term "fleet boat," however, generally refers to a boat owned by a company with several boats.

Maine, with fewer boats based in Rhode Island, New Hampshire, Connecticut, and New York.

Groundfish markets have been international since the earliest years of European colonization, first supplying Europe and the Caribbean with salt cod as a staple protein. Later markets included more fish, crustacean, and mollusk species, salted, pickled, canned, frozen, fresh, and cooked (Vickers 1994; Lipfert et al. 1995; O'Leary 1996). National seafood markets expanded across the US after refrigeration and rail transport became available, and global markets grew with cheaper and faster air transport. Today, groundfish comprise a tiny fraction of the 4000 aquatic plant and animal species traded internationally as food products, exported from almost every country in the world (Anderson 2003). Expanding to around 145,000,000 metric tons over the last decade, world fish production, including both capture fisheries and aquaculture, has been about half that of other meats in recent years. Export comprises about a third of production in the case of fish, however, compared to only about 10% export of other meats, making fish one of the most internationally traded food categories, and intensifying pressures to overcapitalize the harvest sector (Smith et al. 2012; UN FAO 2012).

3.2. Local-to-global markets before the auction

Until the 1980s, most New England boats unloaded and sold groundfish through long-term relationships between fishing boat owners and small, private fish buyers. Buyers were located in dozens of harbours along the coast, most owning and operating waterfront wharves at which boats could offload fish, buy fuel, and use other shoreside facilities (see Figure 1). These deeply local relationships were especially prevalent in more remote harbours. Compared to southern New England, Maine had more small harbours, fewer large ports, fewer highways or other efficient freight options, greater distances from urban areas, and less investment capital. Some small buyers treated fishers well, developing amicable and trusting but carefully calculated relationships over years, if not generations (Wilson 1980). They generally offered a per volume price for fish unseen, still in the boat hold.[3] While larger volumes could produce higher net profits, or, alternately, market gluts, local buyers were sometimes willing to buy small and large boat catches at similar prices to retain loyal and generally profitable relationships (Wilson 1980). Small boats are limited in their fishing times by seasonal storms, but because they can set out on little notice and return quickly, they can play an important market role by partially filling short-term product shortages at high prices, between the large volume landings from bigger boats.

Buyers unloaded the catch, then trucked it to major markets in Boston or New York, sold it to another buyer to truck, or sold it to a broker. In some instances, brokers accepted fish directly from boats, on consignment. Some buyers ran trucks up and down the coast, maintaining somewhat regular relationships with

[3] A hold is a space below deck for cargo or storage.

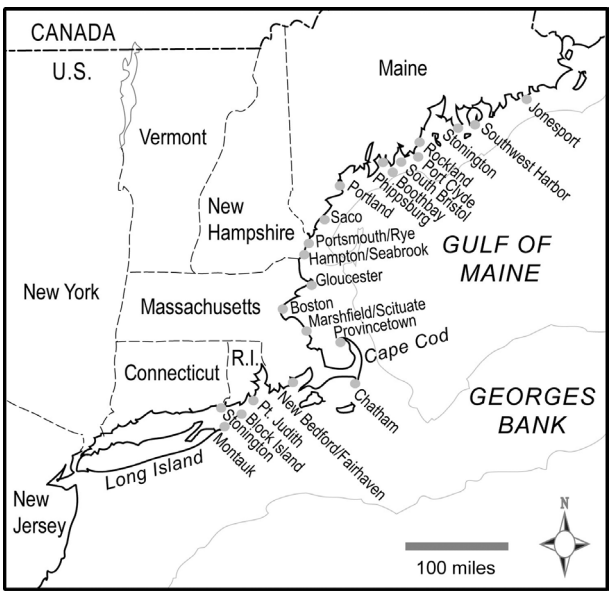

Figure 1: New England groundfishing region.

individual boat captains in a few harbours. Price information was not widely disseminated on a timely basis and bargaining was rare, however (Wilson 1980). Further, fishers perceived some buyers to hold local monopolies, cooperate with other buyers to fix prices, or disadvantage fishers by loaning them money to be repaid in landed fish at low prices. Regardless of any ill intent, the decentralized network was conducive to product gluts and shortages, with prices sometimes dropping precipitously between the departure of a boat from her home harbour and her return to sell the catch.

Interview data documents that larger, faster boats with advance knowledge of low local prices might opt to land in higher volume ports of Boston or New Bedford. When smaller boat fishers encountered particularly low prices at the dock, they had the option of trucking the catch south themselves. With more ability to clear volume rapidly, urban wholesalers often paid better prices, but outside the context of long-term relationships, commitments by distant buyers were unreliable. Fishers were hampered in negotiations by their need to unload the perishable harvest and return home; hitting a market glut could still result in fish dumped overboard. One fisher narrated his experience of the "medieval days," after forming a cooperative trucking enterprise:

> "A bunch of us used to have a fish company... Oh Jesus, it was horrible. If I had the money... that we got stiffed when we had this little fish company, I probably wouldn't have to work again. Philadelphia, Washington, DC, New York. There's sixty, seventy thousand we're owed. We were just a tiny little

company. But that's the cost of doing business with them. You get established. You find out the good ones from the bad ones... I'd probably go work as a janitor if I had to think about peddling my own fish again. I can tell you stories about trucking fish to Boston. My uncle was a truck driver in Boston and he told us how we'd have to get in... We'd have to go see a cleaning woman down there because she had a mafia control. I mean, they'd steal the fish out of your boxes, so you had to give her a little bit of money. And we did business with this one guy and we did all right for a while and then he stiffed us. But that was all part of it. But I would hate to think about going back like that."

3.3. Industry expansion

Many New England groundfish populations are now at all time lows, but they previously supported a significant industry. In recent years, the National Oceanic and Atmospheric Administration (NOAA) has estimated gross revenues between $80–$90 million, compared to an estimated $500 million value of a fully restored fishery. Management has proven challenging since prior to 1976, when NOAA received jurisdiction in the Fishery Management and Conservation Act (FCMA). Partially explaining subsequent fish population declines, between 1977 and 1992 the total number of New England fishing vessels increased by 80%, and the number of fishers increased 140% (National Oceanic and Atmospheric Administration 1995). The size of the vessels and the sunk capital of vessel-owning firms also grew. After the FCMA expelled foreign processor-trawlers hundreds of feet long from US territorial waters, federal loans and tax breaks such as the Fisheries Loan Fund, Fisheries Obligation Guarantee Program, Capital Construction Program, and Saltonstall-Kennedy Fund encouraged US firms to build bigger boats and develop new markets to "Americanize" the reclaimed fisheries.

In those years, one young couple wanted to build a small trawler, but found that federally subsidized 3% loans were only available for larger boats. The wife recounted, "You could not get a government loan. [We] had to…put our house up as collateral with a 15.5% loan." Her husband elaborated:

"The guy told me, I remember when I went in, I said, "I want to build a boat, I want to switch from gillnetting to dragging." And he said, "Ok." And then he said, "Well, ok you probably need about $750,000." I said, "No, I don't need that much, I only need about $150,000 to build what I want to build." And he said, "Well, we're trying to build world class fishing fleet. We want to loan you $750,000." And he had drawings. They had stock drawings they pulled out from various shipyards for 80 to 90 foot vessels. "These are our stock drawings, you take this to this yard and they'll build this boat and you can go to Georges Bank. I said, "I don't want to go to Georges Bank. I don't like Georges Bank. I want to see my kids grow up." I said, "I want to do what

> I've always done. I want to be a dayboat."[4] "Oh, well we don't want them. They're archaic, and they're going to way of the dodo. We're going to have a world class fishing fleet. We're going to show the world how to manage the fisheries." And I said, "You're going to destroy the fisheries is what you're going to do." And the guy said, "Well, we can't help you." And I left."

Further, Reagan-era tax policies sped depreciation schedules and reduced taxes on business equipment, encouraging investment and the growth of harvest-processor corporations with shoreside plants and multiple large boats (Hennessey and Healey 2000). Otter trawls had been introduced to New England early in the 20th century, and offered increased return on investment, but adoption of large trawls was slow in Maine until financing for larger boats became readily available in the 1980s. Gillnets remained in use, but were set in increasing numbers per boat, and hooks fell out of favor. Increasingly affordable sonar technology revealed bathymetric contours of the seafloor, and sometimes schools of fish. In the 1980s, most groundfishers were making more money than their parents or grandparents had ever dreamed of, and shoreside businesses were also profiting. Some boat owners ran two or more boats, captaining one and hiring a captain for the other, or staying ashore to run the office while hired crew did all the fishing. People without fishing experience began investing in boats as tax shelters. At least two larger firms operating in Portland and Rockland Maine in the 1980s had fleets of several very large trawlers, plus processing capacity.

3.4. New markets at the auction

The Portland Fish Exchange opened in 1986 after the city acquired federal funds from the US Economic Development Administration to buy a few older wharves and replace them with steel bulkheads, vessel berths, buildings, and ample space for parking and gear repair. The city then rented these to the new Exchange, fishing industry suppliers, fish processors, and fishing-related businesses offices. Fishers were actively involved in standardizing auction operations from inception, serving on its board of directors along with fish brokers, at large members, and a city council member. The board oversees the hiring of staff to manage the enterprise, including financial accounts, offloading and handling of fish, and facility maintenance. It ensures adherence to operational policies that enable transparency in market transactions and decision making, such as the public posting of sale prices in species and size groupings, including price averages, highs, and lows. This was the first fish display auction on the US east coast, and remains the only non-profit fish display auction in the US. In contrast, auctions in Boston and New Bedford sold fish unseen, often still in the boat hold (Peterson and Georgianna 1988; Kaplan 2000). More recent auctions adopting the display format, including in Gloucester, have been privately owned (Kaplan 2000; Stevenson 2000).

[4] Dayboats only stay out for one or two consecutive days per trip. Larger boats with bigger holds and rotating crew can fish farther from their home harbors, and can stay out for several days.

The Exchange is open to any boat wishing to land or truck product there. It will sell any fished species, but groundfish totals the highest annual value, and most other species have separate distribution chains. It keeps offloaded fish cold, packed in trays, until it is auctioned in lots of varying sizes, facilitating a variety of product streams. Originally, the board contracted an independent call-out auctioneer to run the sales in person, but eventually they switched to an online bidding system. The sale still takes place just once a day in real time, with on-site access available to both the auction floor where product is displayed, and to a bidding room with computer hook-ups. Although fishers can represent their own product at the auction, almost all choose to contract with seller representatives. These professionals can monitor prices closely and maintain frequent communications, ensuring that boats receive fair prices even after they have departed for home or another trip, and offering guidance to boats that routinely land fish in less than prime condition. They can refuse the final bid price and forward the lot to the next day's auction, but with an inevitable loss in quality. Fish buyers may employ an inspector on site, or contract with local inspectors who serve multiple buyers.

Some buyers are more concerned with quality, some with price. For instance, specialty buyers for high end restaurants and caterers pay top prices for small volumes of the freshest and most aesthetically attractive specimens. These fish might end up at sushi bars or catered black tie receptions. Small or medium sized flounders, haddock, and cod filet into plate-sized serving portions. Larger fish of round-bodied species like cod and haddock can be cut into steaks. Processors can take large volumes of medium quality fish, which might end up in supermarket frozen food aisles as packaged filets, breaded fish sticks, or microwaveable dinners, or in canned food aisles as chowder. Some brokers have outlets that will accept lower quality fish at a discounted price, such as for fish balls. As one auction worker put it, when inspectors "scratch and sniff" the fish:

> "It's like looking at a piece of art on the wall. One says, "That's beautiful." One says, "That's sh*t." They look at the eyes and the gills and the napes and the bellies and see what the quality is. They'll feel the fish to feel how firm it is. A lot of processors buy the best quality they can because it means shelf life and it means yield. Because when you're cutting fish, the higher the yield means the more meat that you get out of the fish... If you're buying fish that's a little abused, you may be getting a lot of chowder fish. So once you cut it, and you flip the fillet open it's all gapey, and you go, "Aw, sh*t, I can't sell that." So they want a filet that's firm and tight."

Gapey fish has gaps or holes between the flakes of meat. It may have an off colour or smell. It might have been at sea longer, or wasn't kept cold, or was handled roughly. The difference in wholesale to retail price for higher versus lower quality fish can reach a factor of more than ten. Though ex-vessel price differentials are smaller, on one auction day in early July of 2012 for example, cod were selling for $3.18 to $4.96 per pound, haddock for $2.08 to $3.82, grey sole for $1.73 to

$4.37, hake from $1.73 to $4.37, pollock for $.90 to $1.83 and monkfish from $1.99 to $5.06.

Like any site of intensive social interaction, the Exchange has suffered rumours and minor scandals, but harvesters generally have greater trust in auction staff and operations than at the privately owned or non-display auctions that have operated in Boston, New Bedford, and Gloucester (Peterson and Georgianna 1988; Kaplan 2000; Stevenson 2000). Buyers must pay the Exchange promptly for their purchases, fishers are guaranteed quick payment, and pricing is transparent. The fisherman describing the small trucking cooperative above offered a comparison:

> "When the Fish Exchange came on line, and there was guys [buying] there that owed me money, to see them at the auction playing by the rules, you know that was the best thing I ever saw. The auction is a wonderful thing."

An auction worker similarly commented:

> "This process has revolutionized how fish is brought to market. By culling the fish, by selling it by boat. And then the buyers able to maximize what they needed based on what's out there. Because say a boat comes in to one of the old podunk unloaders over here [before the auction opened]. The guy's, "I got this, this, this, this." The guy unloading goes, "You know, I don't have a market for this, and I don't have a market for that, so I'm just gonna send it out open and hope they give me some money for it." The guy goes, "Ok, you got me hostage." Here, someone brings a fish in, he's got 30 buyers, that all have little niche pieces of the market, so that maximizes his exposure to the marketplace, for all his fish. One guy's got a great market for haddock, and a lousy market for monk[fish]. But Joe Blow down here's got a great market for monk[fish]."

Within a few years, the Exchange was handling about 15–20 million pounds of fish annually. Following the rapid industry growth of the 1980s, by 1992 the Exchange was handling 30 million pounds per year. It attracted new groundfish processing capacity to Portland, outperforming the larger ports of Gloucester and New Bedford. Boats landing at the Exchange hailed from the entire Maine coast, as well as New Hampshire, Massachusetts, and farther south. The biggest seafood buyers from around New England kept staff on site in Portland. The auction achieved this success despite the 2–3 hour driving distance from Boston, 6–7 hour distance from New York, and farther distance from Georges Bank and other persistently productive fishing grounds. It also succeeded despite state regulations that prohibit landing trawled lobsters in Maine, reducing the profits on many groundfish trips by a few thousand dollars (Stevenson 2000).

4. Fleet boats and owner-operators

As the industry scaled up in the 1980s, and as the Exchange established new product markets, the experience of fish harvesting shifted in ways that precipitated

deeper changes in the rationale of some fishers, especially on smaller, owner-operated boats. As detailed in the following paragraphs (and elsewhere), logistical and social relations on a large, company-owned trawler are very different from a small owner-operated boat [blinded citation]. These differences drive significant variation in the collection, integration, and transmission of ecological observations among fishers.

Interview and participant observation data confirm that fixed and operating costs are higher for large boats than for small ones. Corporate owners of large boat fleets need predictable volume to pay vessel and equipment costs, maintenance, fuel, insurance, berthing, retain reliable personnel, and pay returns to investors. Those with processing facilities or contracts must also supply volume to cover those facility and payroll costs, and provide a consistent and standardized product stream for retail or institutional consumers who expect regularity. They cannot afford to have boats returning with disappointing catches. Their captains explain that once they catch large volumes of fish in a particular spot, they tend to fish that location routinely, as long as it continues to yield big hauls.

Compared to smaller boats, large boats have more crew and the captain spends more time in a glassed-in cabin placed well above the working deck. From there he pilots; monitors the navigational charts, sonar, and other electronics; and watches the deck below to make sure the large gear is deployed properly. He focuses on decisions about net and bottom roller choices, tow speed, and the depth and angle at which tow lines and weighted doors hold the net mouth open. With tons of metal and netting hovering over the irregular seafloor many fathoms below, controlled by a few chains wrapped around a massive roller mounted on deck, an error in judgment can cost tens or hundreds of thousands of dollars in equipment damage, and jeopardize a professional reputation.

Reports to the captain from the deck are often limited to catch information immediately relevant to marketability and trip planning, such as the volume of each commercial species and relative size of the fish. These are less likely to include other details, such as what non-marketable flora and fauna are also caught and dumped overboard, what condition the species are in, what reproductive status is apparent, or differences in colour, shape, or behaviour. Conversely, crew see and handle the entire catch, marketable or not, but may be unaware of gear settings, and have minimal knowledge of where the boat is positioned at the time of the haul. Most are focused on how many more days it might take to fill the hold, get paid, and return home without mishap. Social hierarchies separating captain from crew can further impede information exchange. Below deck, the captain has private quarters and head,[5] while deckhands bunk down a few feet from one another and share a head. Ashore, captain and crew often depart for homes in different towns or even different states.

[5] The head is the nautical term for a toilet facility, which can range from a bucket to a flush appliance in an enclosed compartment.

By contrast, a small boat operates with lower costs and in closer quarters, making for a rather different chain of social interaction and information flow. Fixed costs are not incidental, but it costs vastly less to maintain smaller expanses of metal, fibreglass, wood, rope, electronics, engines, and hardware, not to mention moorings, piers, and other shoreside infrastructure, all subject to constant physical strain and the corrosive force of salt water. Switching out gear types requires less time and shoreside infrastructure. Like other microenterprises, many owner-operators underpay themselves and exchange bartered labour with kin and neighbours, with the understanding that all are investing in long-term economic and social relationships that will produce some broader local benefit through diversified and sustained livelihoods. Experienced crew anticipate that incomes will vary seasonally, and with the expertise of the captain. Compared to fleet captains answering to investors, locally-based boats may therefore have more flexibility and risk tolerance in daily fishing strategies.

On board a small boat, the cabin generally sits on the same level as the working deck, so captain and crew easily step back and forth. After setting a course, the captain might ask any member of the small crew to steer the boat while he works through a gear or mechanical problem or inspects the catch. Most owner-operators are intimately familiar with every inch of the boat, having more independence than hired captains on fleet boats, and a more direct investment in every aspect of the enterprise. They make or authorize all decisions about gear, supplies, maintenance, repairs, mechanics, electronics, crew hires, and harvest strategies. The owner is often sufficiently present on deck to see everything hauled up: fish, crustaceans, sediment, seaweed, and invertebrates, including many species of little or no commercial value. On the smallest boats, without dedicated fish holds, catch is stored on deck in open boxes. Captain and crew may readily link these biological observations to spatial location. When plying grounds close to home, many know precisely where they are in relation to an array of shoreline and benthic features mapped within their minds as territory known first hand, or described in others' stories. Many of the inshore fish populations accessible to small boats are more migratory than those found on offshore, making for greater variation in catch volume over time, and requiring closer attention to fish behaviour at finer scales.

Social hierarchies are logistically hampered on a small boat, so transmission of information and knowledge is more likely. The smallest boats, intended for daytrips, have no bunks and only a bucket for a head, making it difficult to maintain interpersonal distance or formality. Crew must defer to captains, on the water and ashore, as each perceives the other to hold distinct class positions, but all live within driving distance of the harbour, if not in the same town. Especially in more remote harbours, they may share kinship or other social ties, patronize the same local businesses, send children to the same schools, and know each other's families for generations. They hear and tell fish stories as local entertainment around the waterfront, recounting the serendipity of big hauls in unexpected places, the tragedy of lives lost, and the glory of outperforming other boats in

skill and knowledge. Retired fishers often observe younger ones, offering running commentaries of wanted or unwanted advice on any number of subjects, including adjusting gear and finding fish, thereby building and shaping local knowledge in the course of daily routines.

5. Fill the boat or put 'em to bed?

In the 1980s and 1990s, chasing fish day after day, year after year, fishers began to notice that their boxes and holds were filling more slowly. Smaller vessels were seeing fewer fish close to shore, and had to take longer trips to deeper waters. Many believed the fish were just moving offshore temporarily, perhaps due to coastal pollution or normal predator-prey cycles. As inshore fish populations remained low, however, some fishers came to believe that groundfish populations were vulnerable to overharvesting, and that impacts were more acute using certain fishing practices at certain times and places, whether due to reproductive dynamics, gear impacts, habitat variation, or predator-prey interactions. Though not entirely oblivious to concerns of scientists and managers about possible fish population declines, fishers are like most people in giving greater credence to their own observations, and those of trusted peers and mentors. One gillnetter who switched to trawling and then lobster trapping as groundfish declined explained in 2000:

> "[W]e found that the fish were just getting farther and farther offshore. I was used to making a good living within 20 or 30 miles of the coast. But then we got off to 70 [miles]. And more nets, more nets. When I first started we had 24 nets and when I ended we had like 46. But now they fish 100 or 150."

One former captain who spent early and late years of his career on smaller boats described the large gear, high volume rationale as it impacted pollock populations, a generally abundant species used in fish sticks and other products for government, institutional food service, and supermarket chains because of its mild taste and low price.

> "[A] defining moment in my career was, when I worked for [one company], we had five 90 foot boats. We were really good at what we did… Cashes Ledge tapers down to a place called Parker Ridge, and the old guys never would have fished there. We learned how to tow it. We'd fill the boat with pollock in a day… A hundred and fifty thousand pounds, and they were all this big [indicating about 15"]… Between '83 and '85 we wiped out millions of pounds of pollock, between us and [one other company with several similar size boats], to the point where we couldn't catch any more. They were all 14, 16 inches long. Perfect for filleting machines. Perfect for the people hand cutting them, military contracts. We didn't make any money. We just was like, fun killing them. And finally in like 1985, scientists came out and said it took like a 19 inch pollock to reproduce. I have picture that I still have at my

> house. A hundred and fifty thousand pounds below the deck. The deck is full, the net is full, and I'm out on deck going like this [grinning]. Except none of those fish reproduced, and we caught millions of them... After having several years to stop and think about what we did...we wiped those frigging fish out. You couldn't make one there; you couldn't catch one there. We wiped them out [in] two years. [Those] boats were big. Five 90-footers catching 150,000 pounds every three days, day after day, after day, after day. Wiped them out."

While anecdotal evidence of fish population declines mounted, new markets at the Exchange provided impetus for more focused industry attention to gear-species interactions. The auction boosted boat profits by paying a premium for fish that were caught more selectively, handled more carefully, laid in with ice, and delivered more quickly to the dock. It created new markets, distribution chains, and processing opportunities for seafood of reliable quality. The old local buyers couldn't move enough volume to distinguish fish by quality, freshness, or handling. They sold fish into relatively undifferentiated product streams, even to the extent that cod and haddock were sometimes retailed interchangeably as "scrod." At the Exchange, fish was no longer a commodity, with a single price per pound determined by unknown players based on unknowable standards. Buyers representing a regional and international market spectrum viewed the catch in open boxes, and more attentive boats earned reputations for landing quality product. Knowledge and skill became more publicly recognizable assets. As one auction worker said, "When you drop your fish here, you're laying your soul out there."

It became profitable to land a small catch of fish, if harvested strategically, and not compressed in a long trawl tow or in a large hold. As a boat owner and auction board member explained:

> "…[T]he Fish Exchange played an important role, even though people didn't want to recognize it, that you didn't want to bring 5000 pounds up on the deck [in one haul] because it squished the heck out of your fish… I was adamant on my boat that we would brush their teeth, comb their hair, put 'em to bed, do things right. And we were ahead of the curve on that one."

Attention to trophic relationships and reproductive cycles also became more financially profitable. The same fisherman described how the handling of eviscerated fish on deck changed:

> "The fish eat this thing that all fishermen refer to as eye bait. They look like little shrimp but they're pink with little eyes... It burned the hell out of the fish. It ate their stomachs out… And so you're pulling the guts, and so the fish are laying in this guts. And so the meat would get burnt. Kinda like when fish are pregnant and they use all their energy to stay pregnant, and then after it's kinda like they're [floppy]. It took more ice. You needed to make shorter tows. You needed to get the fish taken care of, cleaned, washed, and iced. On my

> boat, we set up a whole separate process where we separated where the guts were going. And we had one of the crew members, after you pulled the guts out, we would put [the fish] in [a] box with ice and salt water, so it got chilled immediately before you put it in the fish hold. And that all was Fish Exchange stuff, that quality…"

Rising fuel prices compounded the reward for gear innovation and selectivity. Large hauls require more fuel and more crew to bring aboard, then undersized fish and more restricted species have to be thrown back as "regulatory discards," already dead after a long tow. The new markets rewarded smaller day boats, which fished inshore, landed fresher harvest, and used fuel more efficiently. It also rewarded fishers willing to discuss new ideas and compare notes. A small boat owner-operator said:

> "[T]he fish you buy from these [big boat] guys, it's two weeks old before you get it on your plate. But when you fillet out a fish that's caught from a day boat, you can see the iridescent, I mean it's like *pink* iridescent, colour. There's nothing better."

Innovative fishers experimented with gear modifications. One captain who eventually left his fleet boat job described the learning process, as innovation bred further innovation.

> "[Ninety foot boats] were becoming dinosaurs. You could see the writing on the wall… We fished for dollars. It wasn't about filling the boat all the time… I had [a guy] who could mend anything, could build a net with his eyes closed, and a good crew. We figured out how to just reconfigure things. Middle of February having 30,000 pounds of grey sole. It was unheard of [in a big boat company]. We made sh*tloads, sh*tloads, sh*tloads of money. Because back then your grey sole was a buck, pollock was a dime. And we didn't tear the net up. And we towed slower so it used less fuel."

He further explained that somewhat counter-intuitively, well-filled nets have a compact, rounded shape that can hover higher over irregular bottom while under way, to be hauled up undamaged. Lengthening and shortening tow lines traded off higher catch volume for reduced seafloor contact, altering the angle at which the gear travelled. Larger net meshes helped avoid undersized fish, allowing more to reproduce. Lighter ground gear left more fish on bottom, skimming a bit higher above the seafloor instead of churning up sediment to chase fish into nets. It left benthic habitat more intact, leaving fish refuges from predation. Inserting panels of less elastic square-shaped mesh in nets normally made of diamond-shaped mesh allowed more small cod to escape, since cod were particularly depleted. Compared to flat flounder bodies, cod are round, so undersized fish cannot slip through even larger diamond-shaped mesh once it is stretched taut by the drag of accumulating catch.

One extraordinarily hardworking, entrepreneurial, and conversational eastern Maine fisherman hauled his gillnets so often that he landed many fish still alive at the dock. Along with gillnets with meshes sized to meet the legal minimum, he kept others with larger mesh. Small mesh wouldn't catch larger fish, so when larger, higher value fish came around, he could switch nets, even if it meant an extra trip ashore to unload and reload at night. He commented, "[I]t was a lot of work for the crew, and the crew would tell you that, if they were here. But they made money doing it… And they see the results of it."

On the other hand, fishers who had not yet absorbed the reality that fish populations and markets had changed used only minimum sized mesh, and allowed fish caught in gillnets to dangle for days. Persistent draggers repeatedly towed areas where fish were already depleted, intent to fill the boat from grounds they had known to be flush with fish in the past. Anticipating the dynamics of net drag and momentum required careful field observation and continuous learning, not just rote repetition. For example, while under way, heavy nets with few fish in them can drag deep across rocky bottom features and tear, requiring intricate and laborious knotting to repair. As one innovator said:

> "Maybe a tenth to a third of the people got it. But there were guys who were old school, and they'd try to tow over that [spot] 10 times until they had to go home because they used up all their twine. And it was all about "I gotta fill the boat. I gotta fill the boat. I gotta fill the boat."

Certainly the auction was not the only impetus for the generation and sharing of industry knowledge. Many of the most experimentally inclined fishers were those who got to know boats and captains from other harbours. Some fished far enough from home to land fish elsewhere and make a stop at a waterfront bar. Some attended public regulatory hearings and got drawn into side conversations. Amid the commiseration about perceived regulatory absurdities, they also shared observations about fish behaviour, benthic ecology, and innovative ways to rig gear. The auction encouraged the repetition of such conversations over time, however, by providing common work spaces and points of experiential reference, attracting fishers from all around the region, even if only for a few hours between trips. Information changed hands not only on the auction premises, but at the growing supply, repair, and processing businesses a few steps away.

Not all impacts of the auction and its higher end markets were positive. Even as the auction achieved gains in technological and ecological attentiveness and fishing income, it did incur social costs, especially in more distant harbours. With the closing of so many local buying stations and trucking operations, most groundfishing harbours lost a few scarce shoreside jobs and a few larger ports likely lost a few dozen. Some of those jobs paid quite well by local standards, especially for non-fishing local residents with limited formal education. Particularly in eastern Maine, several hours drive from Portland and with few employment options, fishing industry members resent the auction to this day.

Many lament that it forced local businesses to close, reducing their sense of local autonomy. Even one mid-coast Maine resident who was groundfishing in the 1980s and lives an hour and a half drive from Portland expressed ambivalence about the auction in 2012, complaining that after it opened, there was nowhere else to sell but Portland. Buyers' trucks no longer stopped locally, and he didn't fish close enough to Portland to land there, so he had to send his fish to the auction by truck. He conceded that at the time he thought he was getting better prices for his fish at the auction, but he was never sure. He then grumbled that the displaced buyers "were all crooks anyways."

In recent years, a few other New England groundfish marketing innovations have joined the auction, though none yet compare in longevity or regional impact. A small, private wholesaling firm now specializes in similar niche markets, but concedes that regional prices are largely established at auction. Auctions at Gloucester and New Bedford have adopted some aspects of the Portland model, but with less transformative visions and outcomes. Small groups of fishers, food activists, and entrepreneurs have organized "community-supported fisheries," providing fresh, seasonal seafood directly to local consumers on regular delivery schedules at pre-established, non-species-specific prices. This bypasses most of the processing, distribution, and retail operations of conventional food systems, and introduces consumers to the variability of marine harvest, with high quality samples of unfamiliar species. Others are organizing similar sale agreements with restaurants, grocers, and institutional kitchens interested in facilitating the spread of public knowledge about sustainable food systems. These experiments draw on a number of marketing models, particularly the local foods movement initiated in agriculture, but the Portland Exchange clearly set the powerful precedent of collective action for information-rich pricing.

6. Discussion and conclusion

In this case we see that a marketing innovation, initiated and maintained through cooperation among small businesses and government, expanded a knowledge commons and increased the breadth and frequency of access to that commons. Resource users allied with government institutions to conceive and monitor a shift of market relations away from localist dependencies and toward regional and global competition with transparent information exchange. Previously existing knowledge accrued greater monetary value, and attracted increased intellectual entrepreneurship, investment, and dissemination.

Prior to the opening of the Portland Fish Exchange, local buyers mediated relationships between fishers and regional-to-global markets, based on long-term calculus of mutual interest, trust, and dependency. Opaque pricing mechanisms treated fish as a relatively undifferentiated and low-value commodity. Fishers' understanding of variation in the fished ecosystem informed their ability to compete by landing product volume, as migrations and spawning aggregations provided prime harvest opportunities. Broader development of practical knowledge beyond

immediate species abundance was limited, however, as was more active sharing of experimental results.

From the inception of the Portland auction, fishers became active agents in establishing transparent and differentiated markets, with refined quality standards and more opportunities to identify lucrative matches between sellers and buyers. With government assistance, fishers collectively undertook new relationships with a large number of prospective buyers on a regional basis. This advanced mutual interests, raising prices by creating new niche markets and rewarding biological selectivity in fishing operations. Success relied on the mediating role of broadly supported policies to ensure consistent fairness and transparency, and entrepreneurial experimentation, rather than interpersonal histories and the continuity of dependence.

Despite remaining incentives for fishers to garner the highest auction prices by keeping some information private, the sources and consequences of aggregated information became openly visible on the auction floor, readily accessible to all. By expanding the array of feasible market transactions for both buyers and sellers, a concomitant change took place in fishers' behaviour and understanding around the generation and use of local ecological knowledge. Assessment and assimilation of newly perceived information, the reframing and integration of observations into useful knowledge, were further enabled by the more public spaces in which burgeoning business activities transpired. Conversations that once took place only on small boats, and in private spaces of shoreside fish houses, homes, and pickup trucks expanded into largely public locales, enabling a much freer exchange. Competition still inhibited entirely open sharing of all industry knowledge, but secrecy was countered by recognition that collective action and more thoughtful harvest techniques were raising the overall value of the fishery across the region, and thereby benefitting the industry as a whole. The new markets attracted an influx of product and capital from boats, buyers, processors, and other businesses around Maine and New England. Higher prices paid for fresher and more gently handled fish, distinguished by species and size, rewarded industry attention to the origins, capture, and handling of smaller fish volumes. The financial payoff rose for fishers' acquisition and development of more nuanced knowledge of migrations and spawning aggregations, trophic and habitat relationships, seasonality, species life cycles, and gear-species interactions.

This transformation took place even while federal fishery policies actively encouraged high volume, commodity-based business strategies, and the conversion of small fishing businesses into large ones. It happened even as worldwide routes for seafood distribution became increasingly globalized and capitalized, and even as fish populations declined. The new business strategies were particularly beneficial for small boats, where the organization of labour is less hierarchical, technical and ecological information is shared more readily, trips are shorter, holds are smaller, and experimentation is less constrained. As the auction increased inter-firm competition, it encouraged a shift from a unitary

competitive logic premised on quantity to a broader range of more selective rationales premised on value, and active engagement in knowledge production.

One might suspect that the auction experience also shifted the rationales of some industry members toward more broadly collective and public problem solutions in general, particularly the prospect of integrating industry knowledge into management decision processes. Sufficient evidence to vigorously support such claims would require further investigation, however. The present research does not yet provide conclusive evidence that higher prices paid for thoughtfully harvested seafood engendered resource conservation per se, merely that it incentivized the abandonment of volume-driven rationales. Given the parallel decline of fish populations, more concerted attention to relationships between seafood markets and formal fisheries management arenas is in order. In particular, more explicit comparison of this case to the ostensible ideal of direct, local sales from fisher to consumer remains ripe for further inquiry. It might be possible to identify some number of overlapping knowledge commons associated with other, newer markets, each having differing levels of public access and conservation relevance.

Clearly, globalized food systems remain detrimental from any number of perspectives not covered here (transport-related greenhouse gas emissions not least among them). Nonetheless, we see in this case that collective action successfully strengthened and enriched a knowledge commons despite the primacy of globalized product distribution chains. It created a more transparent and informed pricing system in which seafood harvesters can mobilize and enhance ecological knowledge to refine public desire for specific seafood products, and in which that desire can then trace backwards from dinner plates through the distribution system, to the auction block, to the working decks of fishing boats, to the deployed fishing gear, and to the marine environment. It thus broadened public access to a more articulated and knowledge-rich food system. This is true at retail endpoints, where consumers (knowingly or not) purchase seafood that is more carefully selected to match their various preferences. It is true at the auction itself, where a greater number of harvesters benefit from more equitable, transparent, and informed transactions. It is also true in the marine depths, where fishers rely on vast stores of experience to navigate harvest technology through unseen ecosystems.

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