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Long-term Outcomes in the Tech Transfer of Scallop Spat Collection Techniques, from Aomori Prefecture, Japan to Maine, USA

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Abstract: Improved management, aquaculture and stock enhancement of the sea scallop (*Placopecten magellanicus*) in Maine are examples of long-term benefits from a technology transfer project. In 1999, a delegation from Maine traveled to their sister-state of Aomori Prefecture in Japan to gain a firsthand view of the world-famous scallop industry of Mutsu Bay. While the trip was informative from many perspectives, the detail with most immediate application was the use of so-called 'spat bags' to capture competent larvae for stock enhancement and intensive aquaculture, and the way in which rotational management could be used to maximize production.

In subsequent years, over 100 fishermen in Maine used spat bags to capture juveniles, and the current progress made in aquaculture of sea scallops is largely due to the excellent success in collecting spat as a reliable seed supply. Maine's fishery is currently managed in rotation and area closures - sometimes at the request of the fishermen. Fishermen are also involved in discussions of spat collection for the purposes of stock enhancement. In addition, spat collectors have provided an invaluable window for fishermen to observe details of this early life stage, observations that they would not otherwise make. Overall, spat bags have been useful both directly and indirectly for well over a decade.

Many of these outcomes were not foreseen during the visit of 1999. Technology transfer often aims for immediate impact, but it seems likely that the normal case is that impacts and benefits may take many years to be observed. It is important to keep this in mind both in reporting to funders of various tech transfer efforts, but to appropriately gauge the long-term value of contemporary efforts.

Keywords: aquaculture, enhancement, *Placopecten magellanicus*, technology transfer

Maine's fishery for the sea scallop (*Placopecten magellanicus*) has traditionally been an important option for the state's fishermen; it was an open-access fishery until recently, and provided much-needed wintertime income. Direct on-the-water employment in the 2012/2013 fishing year amounted to 547 mobile-gear licensees (draggers), and 84 divers (Trish DeGraaf, ME Dept. of Marine Resources, pers. comm.). Landings have varied widely, from a historic high of 3.8 million pounds in 1981, to a low of 33,000 pounds in 2005 (Fig. 1). Only the adductor muscle, or meat, is landed.

Prior to 2007, regulation of the fishery was fairly limited, with no limit on the number of licenses, and a 3.5" (88.9mm) minimum shell height. Prompted by low landings and stimulated by examples of better management - such as discussed below - the Maine Dept. of Marine Resources engaged fishermen and scientists in a process to improve the landings and value of the fishery. Since then, several measures have been adopted, such as a larger minimum shell height of 4" (101.6mm), limited fishing days, a daily landing limit, rotational management, and closed areas, and to date, landings have improved (Fig. 1).

The process of industry engagement and inclusion into the management process was not always

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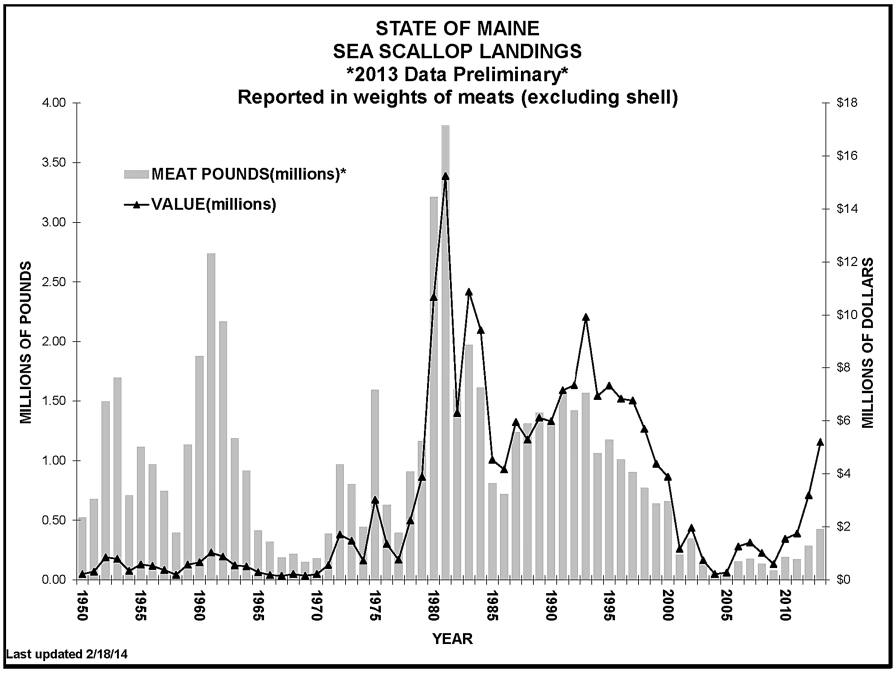

Fig. 1. Maine annual landings of scallop adductor muscles (meat).

smooth: the issues were highly contentious, and the bringing-together of industry with science and management meant that there was a good deal of learning to be done, toward and from one another. Conversely, it appears that these interactions have begun to pay dividends for all sides: management is more aware and responsive to industry perspectives, industry is more fluent in the science of scallop management and ecology, and science is being conducted on issues important both to fishermen and regulators.

Before the period reported in this document - 1999 and onward - engagement by fishermen and scientists in enhancement and aquaculture production was extremely limited and variable, with little in the way of planning or broader-scale thinking. Fishermen traditionally have experimented with enhancement through such actions as moving seed - meaning sublegal scallops, usually larger than 2" (5cm) - to a location they felt was protected or productive, or removing predators like crabs and starfish when they came up in the drag. Enhancement with seed smaller than 2" was very limited, and none performed in a structured fashion.

Scallop aquaculture has historically been opposed by many fishermen for two principle reasons: occupation of space that would normally be fished at one point of the year or other; and competition in the marketplace. A few small trials have yielded generally positive results though with several important caveats: work by Pottle and Hastings (2001) and Kuenstner (1996) - Maine polyculture study demonstrated that scallops would grow relatively quickly. The Pottle study also showed that whole scallops were a marketable item, but Kuenstner and Pottle both demonstrated the hurdles posed by algal toxins (saxitoxin, okadaic acid and domoic acid, principally) in selling products other than just adductor muscles.

Attitudes toward aquaculture have changed somewhat for many fishermen, however, with a major reason being the limited opportunities offered on the water in recent decades: limited access to licenses or resources have generally put fishermen 'in a box' where moving through several fisheries in the course of the year has been supplanted by access to only one or two fisheries, and therefore highly dependent upon them. The second reason concerns the subject of this paper: technology and information transfer becomes integrated in the knowledge, perspectives and ideas of the people who participate, and can support an adaptive stance toward current and future challenges.

Materials and Methods

Maine enjoys a sister-state relationship with the Prefecture of Aomori, Japan; the northernmost region of the island of Honshu. Delegations have passed with some regularity between Maine and Aomori, addressing such interests as energy, affordable housing, and fisheries. One such delegation traveled to Aomori in May of 1999, with the focus of learning about the highly-productive scallop industry there, one which has its' basis in aquaculture techniques, and one that has become a worldwide model of financial and social success. It was hoped that the group could identify aspects of the Japanese industry that would transfer well to the scallop fishery in Maine.

Between the 14th and 21st of May, ten representatives from Maine toured scientific facilities, processing plants, waterfront infrastructure, seafood markets, a fishermen's cooperative, and sea farms. Not unexpectedly, the delegation was impressed at the diversity, volume and vigor of the farming industry there. A brief list of conditions, opportunities and approaches that could potentially be beneficial to Maine ran as follows:

- A diverse suite of products from scallops would be beneficial for Maine, rather than just deriving income from the adductor muscle.
- Spat collection equipment and practices could be useful to stock enhancement and aquaculture in Maine. Techniques and equipment are directly transferrable.
- Collaboration with and support by scientists is beneficial to all involved; good monitoring for biotoxins is critical
- There is no difference between fisherman and sea-farmer in Japan: sea farmers are fishermen.

A full report was delivered to the Maine Aquaculture Innovation Center, detailing all aspects of the trip (Beal *et al.*, 1999).

In the years following the visit, several activities and projects were conducted in Maine, in an effort to build upon the knowledge gained.

Spat Collection: From 1999 to 2002 several meetings were held around the state, to familiarize fishermen with spat collection equipment and methodology. The emphasis was on searching for good spat collection areas, transferring captured seed to the wild, and educational connections with citizens and environmental groups (Fig. 2). As expected, fishermen quickly proved their expertise, and discovered that best spat collections were not done in the immediate coastal waters, but further offshore, near the limits of state jurisdiction (Fig 3). In these areas, counts were easily above 1,000 seed per collector, and frequently as high as 3,000. Many areas were found to result in collectors catching nearly exclusively scallops and with low fouling rates, whereas others yielded low scallop catch, high bycatch of other bivalves, and heavy fouling. It is estimated that between 1999 and 2002, over 100 fishermen had participated in some level of spat collection.

Fig. 2. Citizen environmental group aboard the F/V Lindsay Marie (Stonington, ME) to assist and learn about scallop spat collection and stock enhancement.

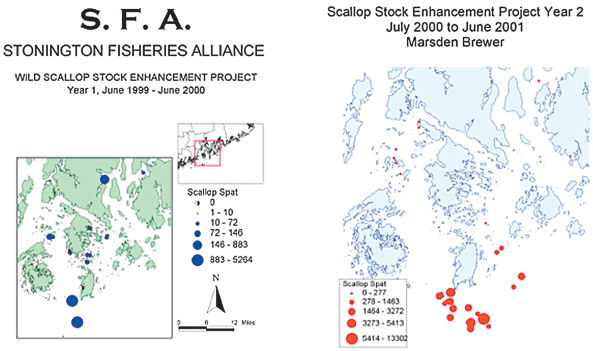

Fig. 3. Spat collections in 1999–2000 (left) and 2000–2001 in coastal Maine. Note that in the second year, most attempts were made further offshore because of prior success there: fishermen adapted rapidly to new knowledge.

Perhaps more importantly, fishermen found that spat collectors are most successful when they are observed regularly: the coast of Maine is heavily fished for lobster, and entanglements with lobster trap lines were common, unless the collector lines were tended. This was an important observation for the co-existence of spat collection with the lobster and other coastal fisheries. It was also during these years that the inclusion of spat collection, stock enhancement and aquaculture became better known to the state regulatory agency - the Maine Dept. of Marine Resources (DMR); this familiarity has proven to be very beneficial in the long run.

Stock Enhancement: Stock enhancement efforts in Maine can be generally characterized as haphazard, with a few exceptions. Efforts by the ME DMR and the Northwest Atlantic Marine Alliance (NAMA) were well coordinated, but of limited scope. Primary lessons from those efforts - which were both done with excellent collaboration between science and industry - were to reinforce the highly mobile nature of juvenile scallops, and the supposed high predation rates on seed less than 20mm or so (Schick and Feindel, 2005; Deese-Riordan, 2005). Unfortunately, these were general observations, and not thoroughly described in the detail desirable, due to limited ability to dive on the reseeded sites with the frequency necessary for such detail.

Other smaller efforts in stock enhancement were undertaken between 1999 and 2004; often amounting to a fishermen taking the spat from his collectors and deploying it in a favorite spot. The benefits of these activities have remained anecdotal and uncertain. The uncertainty over the success of stock enhancement led to the gradual decline of fishermen participating in spat collection. From roughly 2004 and onward, only a handful of fishermen per year participated; this area of study remains to this day one where industry interest would align well with scientific interest.

However, one area that has been of obvious benefit is the way in which spat collectors have allowed fishermen to observe and understand the earlier life phases of scallops; a subject that has been lightly discussed or considered previously. Spat collection led to conversations amongst fishermen and with scientists or managers about oceanography, predation, conservation, water quality and other topics, all of which entered the ensuing discussions about management of the fishery and the scallop resource. Similarly, spat collectors also spurred fishermen's interest in aquaculture: seeing 2000 small scallops in a spat collector immediately led them to consider what it would be like to raise them in cages. Both of these phenomena have played a large role over time in the evolution of scallop management in Maine, and the beginnings of an aquaculture sector.

Aquaculture: The investigation of sea scallops as a candidate for aquaculture in Maine has been a story of stops and starts. From 1999 to 2000, a trial of cage culture for scallops was undertaken by Tom Pottle, who was one of the delegates from the 1999 trip, and a fisherman from the Cobscook Bay region. His project successfully demonstrated reasonable growth rates, useful equipment and husbandry practices, and positive feedback from test sales into the marketplace (Pottle, 2001). It also underscored the importance of thorough testing for toxic algae, and presence of algal toxins in scallop tissues. Mr. Pottle did not continue his project past the funded time frame, though has remained optimistic about the chances for scallop aquaculture in Maine.

From 2000 through approximately 2010, scallop aquaculture was at a virtual standstill in Maine; the risks associated with sales of live or roe-on product were prohibitive for state regulators. In recent years however, conversations between industry and the regulatory community have increased, with both sides joining in an effort to explore the possibility for sales of roe-on or live/whole product. A current project involves five pilot scallop farms, with excellent growth observed thus far (up to 0.19mm/day), and low mortality (Fig. 4). Conversations continue regarding the protocols necessary to guarantee product and public safety - but they are occurring and all parties have felt optimistic for future development.

To date, first sales of live scallops are anticipated in 2014, accompanied by sales of seed from spat collectors to new growers. Project details located at: http://www.seagrant.umaine.edu/research/projects/dv/scallop-trials

Fig. 4. Scallops growing in a cage during the pilot project; Blue Hill, ME

Results and Discussion

Technology transfer clearly yields both short-term and long-term results. While it may be possible to anticipate or predict the near-term benefits and activities that stem from a technology transfer activity, real predictions over the longer term are much less achievable, other than to say that they will exist. Documenting such developments is a worthwhile endeavor however, because of the local relevance but also because of the larger implications for future efforts: funding for travel is usually difficult, and when good documentation is available on the value of such travel, it improves the rationale for proposals involving travel to support technology transfer. Therefore, while it's very difficult to anticipate long-range outcomes, it is of value to note them as they do become apparent.

In the case of the 1999 trip to Aomori, three principal areas of impact can be easily identified. These topics - which are closely linked - are: biology and ecology, management, and production.

In the category of Biology and Ecology, several items come to mind. The Aomori visit supported an improved understanding of biology and ecology of scallops, compared to the level of understanding prior, particularly by industry. By focusing on the deployment of spat collectors and observing the catches, fishermen started to better understand important factors such as proximity of spawners to one another, the influences of oceanographic conditions (currents, tides, temperatures, etc) on larval dispersal and settlement, and in particular, the challenges faced by very young post-set scallops. In fact, the simple identification of young scallops improved a good deal: fishermen have often mistaken so-called 'jingle shells' (*Anomia simplex*) as young scallops; spat collectors have allowed fishermen access to the very smallest sizes, such that identification is now much more accurate - and questions have naturally followed those observations.

The concepts of rotational management have been reinforced; many had focused on the management of offshore scallops on George's Bank as the primary example, but the Japanese example has figured into management discussion. Today, Maine's inshore scallop fishery is managed in rotation, in some measure due to a changed way of thinking by fishermen, scientists and managers resulting from the Aomori visit (Fig. 5). Other issues such as mandatory stock enhancement and creation of spawner sanctuaries have been included in the management discussion and although not included in regulations, have been a noteworthy step about how fishermen and managers have discussed the responsibilities and possibilities in supporting a healthy resource and fishery.

Production remains an area where the Aomori visit has had a profound influence, all starting with the technology of spat collection. Stock enhancement continues to gather support from fishermen when the subject arises, and it's likely that more work will be done in this area, and with greater scientific scrutiny than before, which would permit a better evaluation of effectiveness. An aquaculture industry has begun to develop in the state as well with small sales of the first crop (and scallop seed from collectors) expected later in 2014. Moreover, the tenuousness of the lobster, shrimp and groundfish industries have made commercial fishermen more

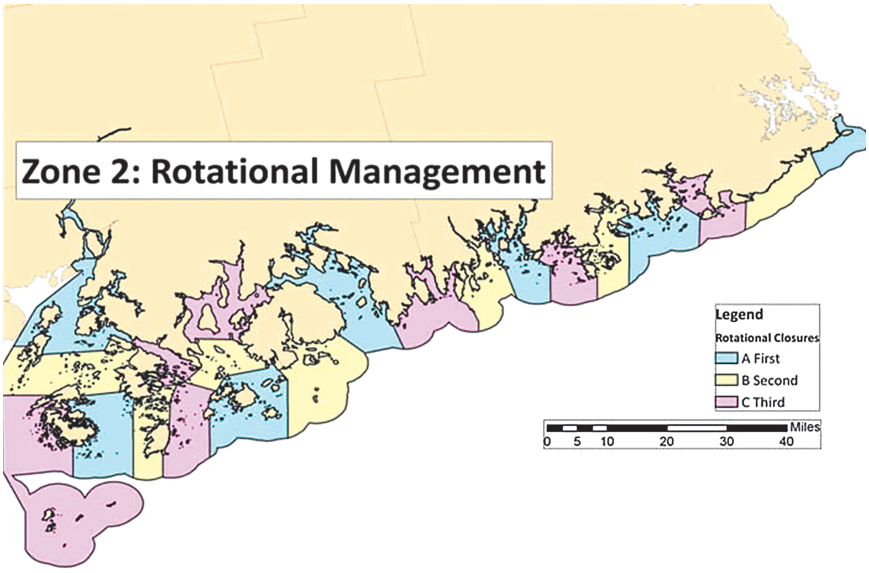

Fig. 5. Ten-year rotational management plan for the Maine scallop fishery; in this case the eastern zone.

open to the possibility of aquaculture as a way to generate income, and thus the integration of the fishing and aquaculture industries has a pathway for progress, through the culture of sea scallops.

The quantification of impacts is more difficult, though not impossible. Landings for scallops have increased in recent years, and surveys of the areas closed as part of the rotational management approach have provided strong indications that management plays a large role in the improvements. Therefore, landings and licenses are two metrics that can be easily identified. As the aquaculture industry continues to advance, it is straightforward to record economic activity and the number of farmers as measures of success. These data are important in the sense of tracking the influence of the original information.

The natural complement to the numbers themselves (sales, licenses, leases, etc) is the use of anecdotes to tell the story of what happened over time. When taken together, the quantifiable data and the qualitative assessments, the stories can create an understandable and informative landscape of the value of technology transfer in both the short and long terms. In fact, both are necessary to fully understand the impacts. In the case of the Aomori trip of 1999, the payoffs became apparent rapidly, and it appears that benefits will continue well into the future.

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