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Reflections on Sustainable Fishery Development Based on the Conservation of the Weihai Sand Lance

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Abstract. The Weihai sand lance, Ammodytes personatus, is an important ecological species as well as a local livelihood-supporting species. In recent years, the population has structurally declined because juvenile fish are being overfished extensively. A meaningful analysis of the ecological and economic impacts of juvenile fishing is presented in this paper, based on recent catch data, interviews with fishers, and case studies. A sustainable framework for targeted conservation and fisher livelihood transition. The framework was developed using three basic principles, to introduce the optimization of current management measures to strengthen special protections for juveniles, and to actively guide fishers. The study seeks to reconcile interest in sand lance conservation with income opportunities for fishing communities, offering insights for local fisheries sustainable development and stimulating further discussions on this important balance.

Keywords: Weihai sand lance, juvenile overfishing, sustainable fisheries, ecological conservation, fishers' livelihood transition

1. Introduction

Weihai, a coastal city located in the eastern part of the Shandong Peninsula, is at the intersection of the Bohai-Yellow Sea Ecological Zone and the North Pacific Continental Shelf. In the marine economy system, fishery resources are not only a traditional pillar industry for the area but also an important carrier for maintaining the service function of the area's marine ecosystem as well as the livelihood resilience of coastal people. The sand lance (Ammodytes personatus), a common small pelagic forage fish of inshore waters of Weihai, is a primary consumer and key forage organism in its niche. The population of zoo planktons directly control the community structure of zooplankton which serves as an important food source for Chub mackerel (Scomberomorus niphonius), Silver pomfret (Pampus argenteus), etc., and the black-tailed gull (Larus crassirostris). For a long time, sand lance has supported the traditional fishing livelihoods of coastal fishers through their activities which consist mostly of small-scale fixed nets and bottom trawls. Sand lance inshore fish habitat is regarded as a critical link in maintaining the integrity of the inshore food chain and stability of the ecosystem. Thus, sand lance demonstrates a tight interconnection between resource-fishery-community.

In recent years, due to the mechanization upgrade of fishing gears (e.g. 30%~50% purse seine fishing efficiency increase) and the rigid growth of downstream market demand for aquatic feed and

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leisure food, Weihai sand lance resources have faced high pressure from fishing activities, this appears to show the overlapping characteristic of “growth overfishing” and “recruitment overfishing”. Juvenile fish (body length ≤ 50 mm) accounted for 25%~40% of the total catch, suggesting their frequent capture. This phenomenon directly contributed to the restoration of the age structural rejuvenation of the population, or in other words the continuous decline of recruitment stock, disrupting the natural cycle of 'adults reproduction-juveniles recruitment-population maintenance’. The level of fishing pressure being witnessed has surpassed the intrinsic growth rate (r) of the population of sand lance. This not only reduces the sustainable supply capacity of the resources but also affects the population recruitment of higher trophic level organisms through the “forage deficiency effect”, threatening the structural stability and service functions of the inshore fishery ecosystem in Weihai.

This study examines the ecological and socioeconomic impact of juvenile sand lance fishery in Weihai. The study includes publicly available catch data and interviews with fishers as well as cases to undertake the analysis. The study’s results are the foundation for recommendations and conservation measures. The goal of this research is to provide reference for protecting Weihai sand lance, and meanwhile highlight the balance of ecological protection and fisherman’s livelihood, to provide reference for the local fishery industry sustainable development.

2. Sand lance fisheries and juvenile fish protection in Weihai: status and imperatives

2.1. The dual ecological and economic value of the sand lance

The sand lance or the noodle fish (or “silver needle fish”) is a keystone species in the nearshore ecological chain of Weihai. In an ecological sense, the sand lance eats plankton and is the main source of food for higher predators, such as cod, sea bass, and mackerel, along with other marine life such as seabirds and seals. The size of the sand lance population impacts the nearshore ecosystem balance. The decline of the most common fish in the ocean may cause upper-level predators to go into decline due to lack of food but plankton will get a boost. According to Baker [1], this can lead to a eutrophication of the seawater.

Economically, the sand lance is important for the coastal fishermen at Weihai. Its meat is tender and rich in nutrition. A key ingredient in the local catering industry, it is also processed into dried fish and fish meal for export to Japan, Korea and the southern domestic market. This industry underpins the livelihoods of coastal fishermen and creates numerous jobs in processing, logistics, and sales, making it a vital pillar for regional economic stability.

2.2. The core issue in the fishing of the sand lance: overfishing of juvenile fish

The main problem of the sand lance fishery in Weihai is that juvenile fish are overfished, resulting in a structural decline of resources. The data on the juvenile fish share in the catch showed a range of 20% from 2019 to 2023. In 2020, juvenile fish accounted for 45 % of the catch, while the adult harvest totaled 1,760 tonnes, reflecting a 52 % decrease relative to 2019. Overexploitation is mainly caused using illegal fishing gear, like nets with very small mesh size (known locally as destructive nets) that catch a high volume of immature individuals (body length < 10 cm) and directly undermine stock recruitment [2]. This situation reveals that the presence of an excessive number of young fish brings long-term adverse effects on the fishery’s sustainability. Therefore, it is urgent to strengthen the supervision of gear as well as resources.

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2.3. Local cases: resource changes from the fishers' perspective

In the main production area of sand lance in Weihai, field visit was made and interviews were conducted with various local fishermen to obtain information to ground the research. Uncle Wang is a farmer who has been in this industry for 20 years and has report "Between 2018-2019, a sole net catch might obtain over 50 kg fish, whose body sizes are well-proportioned (12-15 cm) and whose market prices are high. After 2020, the fish have become smaller, and each catch has about half of juvenile fish, which has low prices that require more sorting and discarding, and the time and labor have been increased." Uncle Wang's wife said, "We used to be able to see fish schools often in May and June when they breed, and now it is the opposite. That year, in the same period, the catch was less, which is only half of five years ago". Various fishermen said that as resource levels have declined, they have had to fish for longer hours and extended fishing distances, while the gasoline cost has gone up and the income has gone down. Testimonies at the frontlines demonstrate that harvesting juvenile fish is bad for fisheries resources and fishermen's livelihoods.

3. Toward sustainable conservation and management strategies for the Weihai sand lance fishery

In view of the present condition of Weihai sand lance resources and based on its ecological characteristics and local fishery situation, this paper proposes optimization of existing management measures, special protection for juveniles, and participation of fishers as sustainable conservation measures from three perspectives.

3.1. Optimizing existing conservation measures: targeted adjustments based on reproductive behavior

Weihai's current fishing moratorium (1 May to 1 September) offers some baseline protection for the sand lance; however, the timing does not correspond well with the reproductive period of the resident population. According to one study, peak spawning for this stock runs from late May to early June. As the first wave of spawning is underway when the current moratorium starts date kicks in, it does not protect spawning adults effectively. Establish seasonal core no-take zones in important spawning grounds like Weihai Bay and Rongcheng Bay. The fishing ban in these zones should commence earlier, starting from April 15, to capture the full window for spawning and early juvenile development combined with a complete fishing ban. Patrol should be reinforced and complemented by electronic monitoring. The two-pronged plan, which combines a full seasonal closure and limited spatial management, will protect the biological baseline of sand lance.

Weihai's current stock enhancement program can be scientifically optimized to increase effectiveness of the resource restoration of sand lance. Even though the annual distribution of 4 to 5 million fry or seed could be said to be a sustained commitment, the provision of 1~2 cm fish larvae proportionately limit the actual recruitment benefit to that size. Upgrading the released stock to 3~5 cm, one-year-old juveniles (40% survival) will significantly increase survival and yield several times more ecological return on the same release volume [3]. It is also suggested to delay the release time from April till the end of July in synchronization with the period of maximum availability of natural plankton to encourage the early-stage growth of juveniles [4]. Establishment of a closed-loop "release-monitoring-assessment" mechanism will facilitate effective monitoring and assessment from scientific institutions. This will facilitate the evolution from a quantitative focus to an effectiveness-oriented approach and offer a solid foundation for future management decisions.

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3.2. Specialized protection measures for juveniles: a comprehensive strategy from gear management to law enforcement

To address the issue of juvenile fishing, various conservation measures targeting fishing gear specifications and regulatory mechanisms will be proposed. It is suggested that Weihai Fisheries Department should organize the "Compliant Fishing Gear Standard for Sand Lance" stipulating the mesh size of 3 cm and above so that juvenile fish under 10 cm of body length are not bycatch [5]. Subsidy schemes can be introduced to promote the use of compliant nets. Fishing ports need installation of inspection checkpoints to prevent use of non-compliant gear by vessels. In addition, fostering low-cost, compliant netting production by enterprises ensures that fishers can afford and use the mandated netting.

At the same time, clear warnings informing of closed seasons and penalties must be more common at breeding areas. There should be a collaborative patrol system "law enforcement + volunteer". This is done through official maritime patrols carried out 2 to 3 times a week to crack down on illegal fishing and reinforced by volunteers sourced from fishing communities. A rewarded reporting scheme can enhance this surveillance. In addition, drone aerial photography technology should be combined to form an "air-sea-land" monitoring network. The goal of this multi-tiered system is to achieve full coverage and eliminate regulatory gaps.

3.3. Preliminary concepts for fisher participation in conservation: transitioning fishers from 'beneficiaries' to 'guardians'

To improve fishers' involvement in fishery conservation, a participatory mechanism that combines ecological protection with income generation should be established. During the non-fishing period of sand lance, fishers could be mobilized to assist with ecological monitoring when these fish are relatively stable. Each participating fisher would collect important information like fish school distribution, density and body length while doing his/her work and send in regular monitoring reports. These fishers should be given suitable subsidies, which should be funded from an ecological conservation fund. This way, fishers get extra data to make scientific decisions. In addition, it also helps fishers earn from different ventures off-seasons.

At the same time, fishermen should be offered support for marine ecological restoration. Priority should be given to local fishermen in the construction process of furthering projects such as artificial reef deployment and the restoration of seagrass beds. This should include the placing of reefs. They must be given compensation equal to their income from fishing activities [6]. The fishermen can be trained as full-time marine conservation personnel with daily patrol and management works. It allows them to work and ensure that their livelihood and sense of purpose are secure. Through the model, the ecological restoration is made more efficient by strengthening the professional experience of the fisherman and by ensuring the benefit of the fisherman. This promotes changed mindsets through which people will actively participate in the protection of sustainable fisheries.

4. Insights into fishery protection from the perspective of fishermen's transformation

4.1. The core idea of the policy proposal: fishermen transform into "ecological guardians"

Changing fishermen's roles is an important strategy that helps provide ecological protection and security over livelihood. In the no-fishing season, the fishery department in collaboration with cooperatives manages fishermen organized to do 3 recycling jobs: 1) construction and maintenance

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of artificial fish reefs, disposal of reef body garbage clearance; 2) Seagrass bed restoration that is participating in scientists' seagrass planting and growth monitoring; 3) breeding young fish of the sand lance is participated in cleaning and feeding and health inclusion small seedling farm monitoring.

Fisherman's income consists of the basic salary, working bonus and ecological reward. The amount is equivalent to the fishing level, while your performance is dependent on the quality of work. More rewards will be given if the annual increase in the resources of the sand lance is significant. Fishery technicians and marine ecology experts come and offer subsidized training through this fund. The training includes ecological monitoring, fish reef construction, seagrass maintenance. This program seeks to train fishers to professionalize the sector. Thus, climate restoration and stable employment get into a feedback loop.

4.2. Thoughts on the fishery bureau's policies: scientific balance is the key to protection

The Fishery Bureau has highlighted the need for protection of sand lance resources through the establishment of a multi-party collaborative governance system characterized by "government leadership, fishermen participation, scientific research support and public involvement". In the framework, each stakeholder has its own responsibility with the government having policy and financial responsibilities, fishermen being the executors to undertake relevant ecological protection and restoration, research institutions providing science and technology support and technical guidance, and the public engaging in supervision and publicity environmental responsibility.

It is very essential for all parties to work together to achieve several objectives, such as enhanced environment, sustainable fishing which also uplifts fishermen's incomes. Striking the right balance between conservation and fishing will help. To develop ecological restoration behavior, it is necessary to link them with economic benefits through reasonable policy design, to form a virtuous mutual promotion mechanism between protection and income increase. Fishermen earn steady and stable labor income through ecological restoration and master professional restoration skills and finally transform from 'resource users' to 'ecological guardians' through these processes. As a result, they truly engage in conservation efforts both in mind and in action so that ecology and livelihood are developed in harmony.

5. Conclusion

The conservation efforts aimed at Weihai's sand lance serve as a microcosm for the sustainable development of the local fishery. The main contradiction is between short-term economic interests and long-term ecological security. Notably, the overfishing of juvenile fish is a concentrated expression of this contradiction. The sand lance acts as a key species in the ecological chain in nearshore areas. Furthermore, it is referred to as a "livelihood fish" for the fishing population. Thus, the resource status of the sand lance has a direct bearing on the marine ecological balance and long-term livelihood of fishermen. The safeguard plan, offered here, is drawn up on three dimensions: fine-tuning of existing measures, strengthening protection for juvenile fish and guiding participation of fishermen. The main logic is "precision conservation and fishermen transformation" The effect of protection should be scientifically adjusted for the fishing ban period and stocking plan. Recommended fishing gear should meet requirements. Supervision should be strengthened. Getting fishers involved in ecological work and providing them with stable income at the same time is a win-win situation. Pilot projects have shown that only if fishers benefit, they will participate, thereby ensuring the conservation measures are adopted for the long term.

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From a young people's view point, the preservation of the sand lance is merely a nature matter, in addition to the livelihoods of people and our major future. Appreciate all delicacies of the fish to lift the lifespan of the ecosystem for several generations. Three parties must emulate a commitment to sustainability, knowing that all efforts may likely intertwine and complement one another to create optimal outcomes. Collective efforts such as the well placed and clever brood source of the sand lance will finally bring a future of prosperity to the environment.

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