Optimization Analysis of Fishing Time and Feeding Strategy of Freshwater Fisheries Based on System Dynamics Model

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Abstract: Platform. As an important food supply industry, the healthy and sustainable development of freshwater fishery plays a role that cannot be ignored in terms of economic and ecological balance. In the face of limited resources and a volatile environment, scientifically formulating fishing time and feeding strategies has become the key to increasing yields and ensuring aquatic biodiversity. The application of system dynamics model provides strong theoretical support and technical tools for solving this problem.

1 INTRODUCTION

The system dynamics model has the unique advantage of simulating the interaction between various elements in the freshwater fishery ecosystem (Helena, 2024). By building models, we can clearly see the impact of different fishing pressures and feeding levels on fish stocks, so as to predict the long-term effects under different management measures (Fisheries Of The Northeastern United States, 2023). This dynamic simulation not only helps us assess the sustainability of existing policies, but also guides us in developing more efficient fishing plans and feeding strategies (Metcalfe, 2023).

2 ANALYSIS OF RATIONALITY AS THE BASIS OF QUANTIFICATION

2.1 Age Grouping and Promotion

Specifically, the choice of harvest time is a complex decision-making process that requires a trade-off between economic benefits and ecological health. Systematic dynamics models can accurately describe factors such as the growth cycle, breeding season (Urbina, 2023), and natural mortality of fish stocks, so that managers can harvest at the optimal time to maximize economic benefits and ensure the regeneration of fish stocks (Sara,2023). For example, fishing avoids the breeding season of fish not only helps to protect juvenile fish, but also maintains the population and enables the sustainable use of resources (Jun, 2023).

2.2 Catch Rate and Catch Rate

In addition, the optimization of feeding strategies is equally important. Overfeeding or underfeeding can have a negative impact on the water environment, leading to deterioration of water quality and even outbreaks of fish diseases (The Federal Register, 2023). The system dynamics model can simulate water quality trends and fish health status at different feeding frequencies and quantities to help managers find the best feeding spots. This not only improves feed utilization, reduces waste, but also contributes to the maintenance of a good ecological environment.

$$\frac{dx_k(t)}{dt} = -\lambda x(t) - v_k(t) \quad (1)$$

It is important to note that the system dynamics model emphasizes holism and interactivity. It does not look at fishing or feeding in isolation, but looks at it in the context of the ecosystem as a whole (The Federal Register, 2023). This holistic view allows us to identify non-intuitive causal chains, such as indirect effects of fishing intensity on water quality, or potential impacts of feeding strategies on other species, that are difficult to reach with traditional methods.

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$$\frac{Vx_k(t)}{b_t} \tag{2}$$

It's called catch rates. that's how we got it.

$$\frac{Vx_k(t)dt}{b_t x_k(t)} = \mu(t)d \tag{3}$$

In practice, applying system dynamics models requires us to have an in-depth understanding of ecosystems and accurate data support. This includes, but is not limited to, key information such as fish population dynamics, water quality parameters, food web structure, etc (Barrett, 2023). Through the detailed analysis of this data and the continuous adjustment of the model, we can gradually approximate the most reasonable harvest time and feeding strategy.

$$x_k(t) = x_k(a) \cdot e^{-\lambda} \tag{4}$$

In summary, the system dynamics model of freshwater fisheries is a powerful tool that can help us scientifically develop harvest timing and feeding strategies. By simulating different scenarios, we can better understand the complexity of fishery ecosystems and make more informed decisions based on them (Sin., 2023). This will not only increase yields, but also ensure ecological health and diversity, and promote the sustainable development of freshwater fisheries.

$$dN=1.5cx_3(t)dt+3cx_4(t)dt$$

Freshwater fisheries, as an important link in the global food supply chain, not only carry rich biodiversity, but also one of the food sources on which human beings depend.

$$N = \frac{x_3(a) \cdot 3c}{2x_4} \cdot 1 - e^{-\lambda} \tag{5}$$

However, in the development process of modern society, freshwater fishery systems are facing unprecedented challenges and changes. In this paper, we will delve into the dynamics of freshwater fishery systems and reveal the key variables and interaction mechanisms, in order to provide scientific basis and practical guidance for sustainable management in this field.:

$$x_1 = \frac{SN}{S+N} \tag{6}$$

System dynamics theory provides us with a methodology that combines macro and micro perspectives, enabling us to fully understand causal cycles in complex ecosystems. For freshwater fisheries, system dynamics analysis helps us identify key factors such as fish stock dynamics, water quality, ecological changes, fishing pressure, and climate change that shape the health and trends of freshwater fisheries systems.

Fishing strategies for sustainable production in a single year

Nonannual production means that the catch of fish in a fishing area is constant at the start of each year.

$$X4\ (1)= x4\ (0),\ k=1,2,3,4.$$

First, fish stock dynamics are a core component of freshwater fisheries systems. Fish catches are directly affected by the increase or decrease in stocks, and the growth potential of stocks is influenced by a combination of factors such as food availability, breeding conditions and natural mortality. For example, overfishing can lead to a sharp decline in the population of certain commercially valuable fish stocks, which in turn affects the balance of the entire ecosystem.

2.3 Fixed Rate Fishing Model

Water quality is then another key factor affecting the health of freshwater fisheries systems. The discharge of pollutants can reduce the oxygen content of the water body and increase the number of harmful bacteria, which is not conducive to the survival and reproduction of fish and other aquatic organisms. In addition, eutrophication often leads to blooms, which not only disrupt the process of underwater photosynthesis, but also directly poison aquatic life.

Then $v_4(t)=b\mu x_4(t)$, and the differential equation (1) is easily found.

$x_4(t)=x_4(0)e\text{-}(a+b,a)$

Let t=a be $x(a)=x_4(0)y_4e\text{-}a\hat{}$.

y=eb,n, and y is the damping factor for fishing, which is called the external damping factor.

Environmental and ecological changes should not be ignored, including changes in water connectivity, habitat destruction, and invasion of alien species.:

$$\begin{cases} x_1 = \dfrac{1}{s} + \dfrac{A}{x_3 + y_4} \\ x_2 = x_1 + x_1 \cdot y_1 \cdot e^{-\lambda} \\ x_3 = x_3 \cdot y_3 \end{cases} \tag{7}$$

These changes may pose a threat to native fish stocks, disrupt the original ecological competition and predation relationship, and ultimately lead to a decline in species diversity

$$\begin{cases} x_1 = s \cdot \frac{1}{s} + \frac{A \cdot e^{\lambda} e_2 - y_4}{x_{1,2,3} + y_{1,2,4}} \\ x_2 = x_1 + x_1 \cdot y_1 \cdot e^{-\lambda} \\ x_4 = \frac{x_3 \cdot y_3}{e^{\lambda} - y_4} \end{cases} \tag{8}$$

These changes may pose a threat to native fish stocks, disrupt the original ecological competition and predation

$$L_{x_1} = s \cdot \frac{1}{x_k} \int \frac{A \cdot e^{\lambda} e_2 - y_4}{x_{1,2,3} + y_{1,2,4}} dt \tag{9}$$

In the face of these complex system elements and their interactions, we must take a comprehensive management approach.

$$L_{x_1} = s \cdot \frac{b_k}{x_k} \cdot \mu t \cdot \frac{1}{\lambda + b_k \mu} \tag{10}$$

The total annual catch is as follows.

$$w = \sum_{k=1}^{4} p_k \cdot L_k \tag{11}$$

$b_1=b_2=0$, and $y_1=y_2=1, L_1=L_2=0$.
It's necessary:
$W=p_3L_3x_3+p_4L_4x$.

In addition, the impact of climate change cannot be underestimated. Rising temperatures and changing precipitation patterns can lead to changes in water temperature and water levels, which in turn affect fish growth, reproduction, and migration patterns. The frequency of extreme weather events can also cause sudden and sudden blows to freshwater fisheries.

2.4 Drop Fishing Model

First of all, it should be clear that the dynamics of the fishery system are not only reflected in the increase and decrease of biomass, but also involve the comprehensive effects of environmental factors, economic conditions, policies and regulations. From a biological point of view, biological parameters such as the regenerative ability, growth cycle, and reproductive habits of fish resources determine the change law of fish population, while the changes in the marine environment, such as increased water temperature and increased pollution, indirectly affect the structure of the food chain in the ecosystem.

In addition, the intervention of economic activities has brought profound changes to the fishing system. Problems such as resource depletion caused by overfishing, damage to the ecological environment by unsustainable fishing methods, and the impact of market supply and demand on the price of fishery products are all directly related to the healthy development of the entire industry.

$$l_{x_1} = b_k \cdot \mu_i \int \frac{x_k}{x_k} dt \tag{12}$$

Therefore, it is particularly important to formulate reasonable fisheries policies and management measures. For example, the establishment of closed seasons and areas, the limitation of net size, and the implementation of quota systems can all effectively reduce fishing pressure and create space for the natural recovery of fish stocks.

$$l_{ki} = \frac{E_{ki}}{E_{ki}} \cdot \frac{b_k \cdot \mu}{\lambda + b_k} \tag{13}$$

Furthermore, advances in science and technology have provided new tools and methods for the study of fishery system dynamics.

$$l_k = \sum_{i=1}^{m} l_{ki} \tag{14}$$

The application of remote sensing technology can monitor the environmental status of fishery in real time, GIS system can analyze the spatiotemporal pattern of fishery resource distribution, and biomarker technology can help track the migration path of fish, the combined application of these technologies has greatly improved the efficiency and accuracy of fishery management.

2.5 Case Calculation

Of course, the analysis of fishery system dynamics is inseparable from the support of mathematical models. By quantifying various biological, environmental, and economic parameters, the establishment of dynamic simulation models can help researchers and policymakers predict future resource change trends, evaluate the effects of different management strategies, and make more scientific and reasonable decisions..

Finally, the core purpose of fisheries system dynamics research is to achieve sustainable use of resources. In the face of the dual challenges of global climate change and human activities, how to balance economic benefits and ecological protection, and how to balance short-term interests and long-term well-being are all urgent questions to be answered in the current fishery development. Therefore, the exploration of multiple ways such as multidisciplinary integration, international cooperation and public participation is crucial to promote the development of the fishery system in a more stable, efficient and sustainable direction.

Table 1: The maximum yield of various fishing strategies.

Model Name	Maximum Harvest	tons of initial fish X_1～X_4	Decision Data
Fixed-rate fishing	387.7	119.5,53.70, 24.13,0.092	μ=17.02
Segment reduction rate(m=4)	402.0	121.1,54.44, 24.46,0.274	μ_i=25 q=0.580
Concentrated peak rate fishing	404.4	121.2,54.48, 24.48,0.310	μ=25 r=0.340

3 YEARS IS THE HDPE CHENGYE PACKAGE CAPTURE-UP STRATEGY

In summary, the overall analysis of fishery system dynamics reveals many interaction and feedback mechanisms in this complex system, which requires us to consider not only the internal laws of biology, but also the comprehensive effects of environmental changes, human intervention, and scientific and technological progress. Only by deeply understanding and scientifically managing these interrelated and dynamic processes can we truly achieve the sustainable use of fishery resources and ensure the long-term interests of human society and the healthy harmony of marine ecosystems.

The complexity and variability of fishery systems have always been the focus of research on the sustainable use of natural resources and ecosystem management in modern topics. In order to ensure that fishery resources can be supplied to human society in the long term, scientists have developed a powerful tool - the fishery system dynamics model. This mathematical model not only captures the intricate interactions within ecosystems, but also provides the scientific basis for predicting future trends and guiding decision-making.

Table 2: Shows the maximum yields for the five-year contract period.

Model name	Maximum number of changed into a solution to mushroom beginning ·		Decision data
	kiloton	x_1 (5)~x_4 (5)	
Fixed-rate capture up	1601	119.5,53.70, 24.15,0.093	μ=16.93
Fractional reduction rate fishing(m=4)	1655	121.2,54.44, 24.46,0.276	μ_1=25 q=0.577
Concentrated peak rate fishing	1664	121.3,54.48, 24.48,0.311	μ=25 r=0.339

Constructing an effective model of fishery system dynamics first requires an in-depth analysis and understanding of the ecosystem under study. This involves the quantitative description of the relationship between fish population growth, reproduction, mortality and predation, the consideration of environmental factors such as temperature, salinity, water current, etc., and the integrated analysis of human activities such as fishing intensity, fishing technology, policies and regulations. These elements are intertwined to form a complex and elaborate ecological web.

r_0=0.267,r_1=0.290,r_2=0.340,r_3=r_4=0.339,W=1667.

In this network, each population does not exist in isolation, they are connected to other populations through food chains and living spaces. For example, small plankton provide food for juvenile fish, and adult fish can become prey for large predators. As a result, when one link changes, the entire system can be affected. This is exactly what kinetic models must consider: how to model this chain reaction and its impact on fishery resources.

Models are usually constructed using differential equations or algebraic equations to represent the dynamic relationships between the various components in the system.

4 DIFFERENT FISHING STRATEGIES

In practical applications, the establishment of dynamic models is not achieved overnight. It requires the collection of a large amount of field data to support the estimation of model parameters. This includes information on catch records, stock surveys, environmental monitoring, and more. At the same time, the validation and adjustment of the model is also an essential step, and scientists need to constantly test and improve the model with new data to ensure the accuracy and reliability of its predictions.

The value of the fishery system dynamics model lies in its ability to predict the future, which provides a scientific basis for decision-makers. In the face of challenges such as overfishing, climate change, habitat destruction, and more, a well-constructed and validated model can demonstrate the potential long-term impact of various management measures. Such models can be used not only for resource management, but also for assessing economic benefits, ecological risks and social well-being, and providing direction for sustainable fisheries.

In conclusion, fisheries system dynamics models are powerful tools for understanding and managing complex ecosystems. Not only does it reflect the subtle relationship between populations and the environment in nature, but it also provides us with a window into the future. By continually researching and refining these models, we can better grasp the pulse of our fishery resources and ensure that the precious resources that the ocean has given us are sustainably harnessed, so that every corner of the blue planet is full of life and hope.

REFERENCES

Barrett.J. Post Release Survival Of Swordfish (Xiphias Gladius) Caught By A Recreational Fishery In Temperate Waters. Fisheries Research, 2023, 265

Fisheries Of The Northeastern United States; Northeast Multispecies Fishery; Gulf Of Maine Cod Possession And Trip Limit Adjustment For The Common Pool Fishery. The Federal Register / Find, 2023, 88 (196):

Fishing Capacity Reduction Program For The Southeast Alaska Purse Seine Salmon Fishery. The Federal Register / Find, 2023, 88 (105):

Helena T S S . How Covid-19 Pandemic Affected Fisheries (Catch Volume And Price): A Case Study In Europe. Marine Policy, 2024, 159

Jun. Estimating Fishing Effort In Small-Scale Fisheries Using High-Resolution Spatio-Temporal Tracking Data (An Implementation Framework Illustrated With Case Studies From Portugal). Ecological Indicators, 2023, 154

Metcalfe. Artisanal Fisheries Catch Highlights Hotspot For Threatened Sharks And Rays In The Republic Of The Congo. Conservation Science And Practice, 2023, 5 (11):

Urbina. Digital Classification Of Chilean Pelagic Species In Fishing Landing Lines. Sensors, 2023, 23 (19):

Sara.J. Predator Damaged Eel Caught In Coastal Fisheries Of The Baltic Sea. Fisheries Research, 2023, 267

Monitoring Requirements For Pot Catcher/Processors Participating In Bering Sea/Aleutian Islands Groundfish Fisheries. The Federal Register / Find, 2023, 88 (128):

Sin.J. Popular Solunar Tables Fail To Predict Fishing Success In North American Recreational Freshwater Trout Fisheries. Sn Applied Sciences, 2023, 5 (6):