GEF

UNDP/GEF PROJECT ENTITLED "REDUCING ENVIRONMENTAL STRESS IN THE YELLOW SEA LARGE MARINE ECOSYSTEM"

Development of joint regional stock assessment methodology

Comprehensive report on existing stock assessment methods and suggestions for a comprehensive strategy for joint-regional stock assessment

by

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1 GENERAL ISSUES

Based on the tasks listed in the Statement of Work issued by the Project Management Office (PMO) of UNDP/GEF project “Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem” (Contract Code: F-I-stockassess-JX-1201No), under the sub-objective A “Stock Assessment” of the Fisheries Component, the major tasks is to develop methods for joint regional stock assessment for the Yellow Sea Large Marine Ecosystem. [1]

1.1 Background

One of the problems common to each country highlighted by a Preliminary Transboundary Analysis of the Yellow Sea Large Marine Ecosystem (Feb, 2000) is the “inadequate capacity to assess the ecosystem and perform basin-scale assessments”. The approved Implementation Plan of the UNDP/GEF Yellow Sea Project, “Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem (YSLME),” lists one of the activities of the Fisheries Component as ‘developing a common methodology for joint-regional stock assessment for the Yellow Sea’ that will ultimately enable researchers to determine the condition of stocks and manage fisheries in the future.

The major objective of the task is to develop recommendations for future stock assessments of the Yellow Sea for integration into the YSLME Strategic Action Programme (SAP) and National Yellow Sea Action Plans (NYSAPs). It is hoped that this process of joint-regional stock assessment will contribute to: the continuation of the development of regionally agreed methods for observation, monitoring and sampling of the marine environment in the Yellow Sea; an enhanced co-operative mechanism for regional monitoring and observation; an upgrading of skills in basin-wide observation and monitoring; a better scientific understanding of the basin-wide marine environment/ecosystem status; and an increased mutual understanding and trust amongst the participating institutions.

The immediate objectives of this task are to collate information on methods currently used for assessing fisheries stocks in the Yellow Sea, comparing them with methods used in other regions and for different aquatic systems, where possible filling gaps, providing improvements and developing a set of best-practice guidelines for stock assessment using adequate tools for assessing the condition of stocks in the Yellow Sea.

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[1] Geographic Scope: The Yellow Sea Large Marine Ecosystem is defined in this Project Document as the body of water delineated at the south, by a line connecting the north bank of the mouth of the Chang Jiang (Yangtze River) to the south side of Cheju; at the east, by a line connecting Cheju Island to Jindo Island along the coast of the ROK; and to the north, a line connecting Dalian to Penglai (on the Shandong Peninsula).

1.2 Description of Activities

- Prepare a comprehensive summary of methods used for assessing fisheries stocks in the Yellow Sea. The summary should include:

  a. A description of the contemporary and historical techniques/methods used to assess and model stocks in this region.
  b. A description of methods used for regular, multi-species, stock assessment in other large marine ecosystems and/or in other aquatic systems.
  c. A description of the types of data and information collected, and used in the analysis, for all these methods.
  d. A description of the analytical and statistical methodology utilised in each model or technique.
  e. A description of the benefits, drawbacks and difficulties of each method.
  f. A description of the knowledge gaps in the current method of Yellow Sea stock assessment, and the barriers to obtaining data.
  g. Recommendations for the most practical and appropriate method for regular, multi-species, stocks assessment in the Yellow Sea with suggestions on how to fill knowledge/data/information gaps in the future.

- Prepare recommendations for a comprehensive guideline for annual, multi-species, joint-regional stock assessment for the Yellow Sea comprising of:

  a. Instructions for jointly-carrying out a reiterative series of multi-species stock assessments for the Yellow Sea;
  b. Recommendations for the acquisition of data – methodology, type, etc;
  c. Recommendations for the analysis of data – analytical and statistical models;
  d. Recommendations for outputs – charting and graphical display of resultant data;
  e. Recommendations on how data should be archived or managed; and
  f. Recommendations on where final results should be published, integrated into global databases and how the public can access these data and guidelines.

The guidelines should take into consideration: i) Existing national agreements; ii) Temporal changes in climatic regimes; and, iii) The geographic parameters of the Yellow Sea Project.

- A presentation of the results-to-date at a Meeting of the Regional Working Group - Fisheries, reviewing the preliminary results with all members of the RWG-F and the Project Management Office.
- Based on the comments of the RWG-F, revise the guidelines and provide a comprehensive proposal or list of recommendations for joint-regional stock assessment (highlighting the major barriers to stock assessment, and indicating the species to be assessed) to the next Regional Working Group – Fisheries meeting, for finalisation.

1.3 Expected Outputs/Results

The final product should be a set of reports as listed below:

i. A comprehensive report on the current techniques used to model carrying capacity both locally and internationally and comparing with other methodologies, describing data types, analytical methods, highlighting the differences, benefits, drawbacks and major barriers;

ii. A list of data and information sources to indicate the sources of the data and information collected in item (i), location of these data and information centres, conditions of access to data and information by different users;

iii. A recommendation for undertaking an regular, multi-species, joint-regional fisheries stock assessments in the Yellow Sea Large Marine Ecosystem, highlighting the suggested frequency of assessments, potential barriers and the species to be assessed;

iv. Project progress and final reports as requested by the PMO.

2 METHODOLOGY

Methods used to carry out assignment:

- Data and information collected during the YSLME initial data/information collection activities were referred to;
- Existing local and international data were accessed through internet searches, telephone interviews, library research, visits to/communication with national fisheries offices, research institutions, government agencies and related NGOs, compare methodologies and fill in gaps in knowledge.

2.1 Current methods of assessing fisheries stocks: Regional & International

The management objective of marine fisheries resources is the attainment of maximum sustainable yield (MSY) founded on scientific advice. This advice should be based on an evaluation of the state of the fish stock, as defined by fish abundance at a specific time, combined with the mortality and growth that control the stock development. It is often essential that advice should be given, with explicit statements of its reliability where necessary, especially when a fishery is developing rapidly. Stock assessment is presently based on two major sources of data: from fisheries and scientific surveys. Historical stock levels and the catch rate by fisheries are in most cases obtained from analyses of commercial fisheries data using Virtual Population Analysis (VPA) or alternative stock number at age based models. The present state of stocks is most commonly assessed by scientific surveys.

The stock assessment by scientific surveys is required at all stages of the development of a fishery, but the need for accuracy and precision is different. In an undeveloped fishery all that is generally required is a rough measure, but the requirement of accuracy and precision increases with the development of the fishery. In a very intense or overexploited fishery, estimates with high accuracy may be necessary to provide proper management advice.

The scientific survey is an important tool for assessing the present state of most commercially important stocks. The indices of abundance are used to tune a VPA or other types of catch at age models (Deriso *et al.*,1985; Hilborn and Walters, 1992, and Patterson and Melvin, 1995).

The results of fish stock assessment will provide:

- An estimate of the current stock status,

- A projection of the yield, total and spawning stock biomass and recruitment for specified scenarios of fishing mortalities, and
- The relationship between the stock status / projection and a number of biological reference points.

These parts are used to formulate biological advice on fishery management, and evaluate whether the stock is within safe biological limits, i.e. productivity (growth, recruitment) is not adversely affected by fishing.

The stock status is defined by the:

- Stock size, the number of fish by age group at a particular point in time,
- Stock productivity, growth, maturity, fecundity and recruitment, and
- Stock mortality, made up of fishing and natural mortality rates.

2.1.1 Population Dynamic Models

To describe population dynamics of fish stocks, many models have been developed and applied world wide, the main references are the books and/or manuals by Beverton and Holt (1957), Ricker (1958, 1975) and Gulland (1969, 1983). Among the most often used models are Virtual Population Analysis (VPA), simple production model (Schaefer model) and Yield per Recruit model (Beverton and Holt model). Multi-species modelling is highly multidisciplinary in nature, including fishery science, fish biology, ecology, hydrography, mathematics, statistics, economics, operations research and computer science, the more extensive the inclusion of such factors, the more complex the models. The three previously mentioned model types will be described briefly.

2.1.1.1 Virtual Population Analysis (VPA)

Although many mathematical models (including the original and corrected ones) are used to conduct stock assessment all over the world, the VPA method in fish stock assessment is widely accepted, and has become a standard assessment approach within many international communities and countries, for example, the International Council for the Exploration of the Sea (ICES), CCAMLR, CECAF, Northern Pacific stocks, Australia, New Zealand, South Africa, Argentina, Chile, Peru, etc.

Data requirement:

Age-structured data is required by VPA. Fisheries data may provide important information about catch-at-age data from fisheries statistics and biological samples taken from these catches. The state of the stock at a specific point in time is described by:

- Stock in numbers by age group (cohort)
- Mean weight per individual in the stock by age group
- Mean weight per individual in the catch by age
- Maturity proportion by age group, *F is* the fishing mortality, and *M* is the natural mortality, total mortality Z=F+M

Virtual population was originally defined by Fry (1957) as the sum of fish belonging to a given year class present in the water at any given time that are destined to be captured in the fishery. The VPA model is developed by Gulland (1965)

$$\frac{1}{N}\frac{dN}{dt} = F + M \qquad (1)$$

Where:

N is the number of fish in a year class

F is the fishing mortality, and

M is the natural mortality, which is normally assumed constant during the year. Solving equation (1) for catch gives

$$C = F\frac{N(1 - e^{-(F+M)})}{F + M} \qquad (2)$$

Where:

C is the catch in numbers during the year. This model also defines the demographic structure of the stock provided some additional weight at age and maturity at age are given.

The above formulas are general and not subject to any discussion on their validity for describing a fishable population of some species. The term VPA-analysis was developed using the assumption that when a year class (cohort) of fish is almost fished to extinction, an arbitrary value of F could be set to estimate the number of individuals at that age. Then, assuming a constant value of M, the numbers at any age could be calculated backwards in time by the following formula

$$C_t = F_t \frac{N_{t+1}(e^{(F_t+M)} - 1)}{F_t + M} \qquad (3)$$

Where:

t is the current year and t+1 is the next year and solving for F. Then the following version of formula (1)

$$N_t = N_{t+1} e^{(F_t+M)} \qquad (4)$$

Will give the current years population numbers and the process may be continued. The error introduced by the arbitrary choice of F at an old age would be negligible when estimating the number at age in the beginning of the life of the year class.

The problems arise when we want to calculate F. F has to be solved numerically either by reference to tables or by iteration. Either method makes the calculations somewhat laborious.

Pope (1972) proposed a method to overcome these problems by assuming that catch of each age group is taken exactly half way through each year.

$$N_2 = N_1 e^{-\frac{M}{2}} \rightarrow N_1 = N_2 e^{+\frac{M}{2}} \quad N_3 = N_2 - C \quad N_4 = N_3 e^{-\frac{M}{2}}$$

Therefore: $N_4 = N_1 e^{-M} - C * e^{-\frac{M}{2}}$ or $N_{t+1} = N_t e^{-M} + C_t e^{\frac{M}{2}}$

Then: $N_t = N_{t+1} e^{M} + C_t e^{\frac{M}{2}}$

When we take N_{t+1} as present. This means that we consider a year class from the last year it is present in the catches and work-out backwards in time. As in the Gulland's VPA, N_{t+1} has two possible forms. In the first form C_{t+1} refers to the catch in year t+1 only, in this case

$$N_{t+1} = \frac{C_{t+1} * Z_{t+1}}{F_{t+1}(1 - e^{-Z_{t+1}})}$$

The second form of N_{t+1} is when C_{t+1} refers to catch in year t+1 and subsequent years. This is usually the case with a completely fished year class. Then

$$N_{t+1} = \frac{C_{t+1} * Z_{t+1}}{F_{t+1}}$$

We also need a formula to calculate the F_t

We can use $N_{t+1} = N_t e^{-(F+M)}$ or $e^{-(F+M)} = \frac{N_{t+1}}{N_t}$

Therefore $-(F+M) = \ln \frac{N_{t+1}}{N_t}$ or $F = \ln \frac{N_t}{N_{t+1}} - M$

If we start at age 6 we can go backwards as follows:

$$N_5 = N_6 * e^M + C_5 * e^{\frac{M}{2}}$$

$$N_4 = N_5 * e^M + C_4 * e^{\frac{M}{2}}$$

$$N_3 = N_4 * e^M + C_3 * e^{\frac{M}{2}}$$

The VPA analytical model has been expanded to include multispecies interactions (Magnusson 1995, Sparre 1991) that assumed the natural mortality mainly caused by predation in the ecosystem. Therefore, multispecies VPA (MSVPA) includes estimation of the natural mortality from predator consumption. Natural mortality is separated into two components $M = M_p + M_o$, where M_o is a (small) constant while M_p is calculated from the estimated stock sizes and stomach contents. This method has only been used in a few areas due to data limitation.

2.1.1.2 Schaefer model

Assuming an equilibrium relation between catch and population biomass, the rate of change in biomass can be written

$$\frac{dB}{dt} = G(B)$$

The Schaefer model takes this function as

$$G(B) = Bk\frac{B_\infty - B}{B_\infty} = Bk(1 - \frac{B}{B_\infty})$$

Where:

B_∞ is the maximum biomass under equilibrium and k is a constant. This equation describes the logistic growth curve.

Data requirement:

- ✓ Catch data, *Y*
- ✓ Fishing effort, *f*
- ✓ Catchability coefficient, *q*

Since F = *f.q*, where F is instantaneous rate of fishing mortality, f is fishing effort and q is a catchability coefficient, when a fishery occurs, $Y = FB = fqB$, then

$$\frac{dB}{dt} = Bk(1 - \frac{B}{B_\infty}) - fqB$$

or $$\frac{1}{B}\frac{dB}{dt} = k(1 - \frac{B}{B_\infty}) - fq$$

Under conditions of equilibrium the growth is zero and the equation becomes

$$0 = (1 - \frac{B_e}{B_\infty}) - fq \quad \text{and} \quad B_e = \frac{B_\infty}{k}(k - fq)$$

Where: B_e is the equilibrium biomass.

The equilibrium yield is $Y_e = fqB_e$ or $Y_e = fq\frac{B_\infty}{k}(k - fq)$

Then, solving this equation, the maximum yield can be obtained.

$$Y_{e\max} = \frac{k}{4}B_\infty \quad \text{and} \quad f = \frac{k}{2q}$$

If we have an equilibrium situation, this can be fitted by plotting catch per unit effort (u) against *f* :

$$u = \frac{Y}{f} = qB_e$$

The model in non-equilibrium situations (Walter, 1975) is: $U_{i+1} = A - Cf_i$

$$Y_{\max} = \frac{k}{4} B_\infty = \frac{k^2}{4a} \text{ for } f = k/2q \text{ or } Y_{\max} = \frac{A^2}{4C} \text{ for } f = A/2C$$

Where:

$$a = \frac{k}{B_\infty} \text{ , } A = \frac{kq}{a} \text{ and } C = \frac{q^2}{a}$$

2.1.1.3 Beverton and Holt Model

Another popularly used prediction model is the *"Yield per Recruit"* model developed by Beverton and Holt (1957). The starting point of this type of model is the individual fish, compared to the Schaefer type of model which regards the total stocks as the basic unit.

The calculations are usually made in terms of the yield of a single year-class of fish throughout its life, which will be, in the steady state, the same as the yield from all year-classes in one year present in the fishery. In a stock the whole life span can be divided into periods. For each period the number alive, the number caught, the number dying of natural causes, and the number surviving to the beginning of next period can be calculated, and the yield in weight can be calculated if the number caught and mean weight of individual fish is know In.

Data requirement:

This process can be calculated mathematically. The parameters of the stock concerned are given below.

N_t = number of fish at age t

W_t = average weight of fish at age t

R = no. of recruits, or no. of fish alive at time t_r

M = instantaneous natural mortality coefficient

F = instantaneous fishing mortality coefficient

We first consider a time period before fishing operates. If

t_r = age at recruitment and t_c = age at capture

then $t_r < t < t_c$

The number (N$_t$) alive at time t, can be given as $N_t = \mathrm{Re}^{-M(t-t_r)}$

The number ($R^{'}$) alive at first capture, can be given as $R^{'} = \mathrm{Re}^{-M(t_c-t_r)}$

Therefore,

$$N_t = R^{'}e^{-(F+M)(t-t_c)}$$

$$N_t = \mathrm{Re}^{-M(t_c-t_r)-(F+M)(t-t_c)}$$

The yield in weight is proportional to fishing mortality (F), stock size in number (N$_t$) and mean weight of an individual at age t ($\overline{W_t}$).

The yield in weight caught in a short interval $\frac{dy_t}{dt} = FN_tW_t \quad dy_t = FN_tW_tdt$

The total weight caught throughout the life span of a cohort (t_c = age at first capture, t_λ = maximum age) is then $Y = \int_{t_c}^{t_\lambda} FN_tW_tdt$

W$_t$ can be expressed in the form of von Bertalanffy's growth equation $W_t = W_\infty(1-e^{-k(t-t_0)})^3$

Where *k* is the growth constant of the species concerned. This equation can be written as

$$W_t = 1-3e^{-k(t-t_0)} + 3e^{-2k(t-t_0)} - e^{-3k(t-t_0)} \qquad W_t = W_\infty\sum_{n=0}^{3}u_ne^{-nk(t-t_0)}$$

$$u_0 = 1, u_1 = -3, u_2 = 3, u_3 = -1$$

Therefore yield can be expressed

$$Y = \int_{t_c}^{t_\lambda} FR^{'}W_\infty e^{-(F+M)(t-t_c)} \sum_{n=0}^{3} u_n e^{-nk(t-t_0)} dt$$

writing $t - t_0 = (t - t_c) + (t_c - t_0)$ and rearranging

$$Y = FR^{'}W_\infty \sum_{n=0}^{3} u_n \int_{t}^{t_\lambda} e^{-(F+M+nk)(t-t_c)} e^{-nk(t_c-t_0)} dt$$

Integration gives $Y = FR^{'}W_\infty \sum_{n=0}^{3} \frac{u_n}{F+M+nk} e^{-nk(t_c-t_0)} (1 - e^{-(F+M+nk)(t-t_c)(t_\lambda - t_c)})$

If t_λ is sufficiently large, the last term can be neglected. The yield equation becomes

$$Y = F\,\mathrm{Re}^{-M(t_c-t_r)} W_\infty \sum_{n=0}^{3} \frac{u_n e^{-nk(t_c-t_0)}}{F+M+nk}$$

Because the recruitment is unknown and often variable, the yields etc. are normally calculated as yield etc. per recruit.

$$Y/R = Fe^{-M(t_c-t_r)} W_\infty \sum_{n=0}^{3} \frac{u_n e^{-nk(t_c-t_0)}}{F+M+nk}$$

This model assumes that the stock is in the steady state, or equilibrium condition, and that recruitment is independent of parent stock size.

2.1.2 Bottom Trawl Survey

For demersal fish, bottom trawl surveys may provide better indices of abundance than the CPUE indices from the commercial fishery. The bottom trawl survey is a traditional and most widely used method for the assessment of demersal fish stocks. Standard surveys are all built on simple equations where an observation parameter (d) is assumed to be directly related to the true density of fish (D). Currently, otter trawls and beam trawls are the two major types of bottom trawls used in scientific surveys. The density of fish is estimated by swept area method.

$$d = \frac{D}{a} q$$

Where:

a is the area swept by the survey trawl, is often assumed to be the area swept by the trawl's wings or doors during a standard tow, and

q is the catchability coefficient which is affected by target fish behaviour and gear operation.

Before surveying starts, sampling design should be well-defined that will increase the precision of the survey. For example, stratified sampling is usually employed, i.e. the area is divided into several strata of more uniform fish density and the mean and the variance for each stratum is separately estimated before combining them into a whole assessment.

Data requirement:

- ✓ fish behaviour
- ✓ gear specification
- ✓ width of wings or doors of the net

2.1.3 Acoustic Survey

The pelagic fish stocks are normally estimated using acoustic surveys, which usually give an absolute abundance/biomass. During the acoustic surveys, catches from bottom and pelagic trawl samplings are used to identify species in order to judge the acoustic recordings and to supply information on size composition that is needed for converting the reflected energy to actual fish densities.

The estimates of abundance obtained from the acoustic method rely on the recorded reflected energy from fish as a measure of biomass density (acoustic back scattering cross section). The basic acoustic relationship is usually formulated as.

$$s_A = \rho \cdot \sigma$$

Where:

s_A is the acoustic index (the area back scattering coefficient (m^2/n.mile^2), ρ is the area density of fish, and σ is the average back scattering cross section per fish (conversion factor).

For acoustic surveys, σ relates the acoustic signals to fish density and is correlated with the size composition of fish, which normally is established from trawling.

Instrumentation in acoustic surveys thus includes the electronic instruments as well as the gear used for sampling the recorded fish.

Data requirement：

- ✓ Target strength
- ✓ Biological characteristics
- ✓ Age, length and weight

2.1.4 Tagging – Recapture

Conventionally, the metal tags are implanted in the abdomen, dorsal fin etc. of the fish. Recaptures are obtained from scanning catches mostly from the commercial fleet. If the mortality caused by tagging is known or assumed and the tagged fish are evenly distributed in the stock, the tagged fish can be treated as a sub-population with the same population dynamics characteristics as the stock, e.g.

$$N : T = C : R$$

This implies that the relationship between total numbers caught in the fishery (C) and number of tags found in this catch (R) reflects the relationship between the total (N) and tagged (T) populations. The development of Jolly-Seber multiple mark-recapture models (Seber 1975) enables estimations of population number (with confidence intervals) and growth rates in open populations i.e. with recruitment into, and migration out of, the population.

With the develop of techniques, active acoustic tags or new data storage tags were used, a detailed picture of an individual fish's vertical and horizontal migration can be obtained, but this method need expensive equipment and manpower.

Data requirement:

- ✓ total numbers caught in the fishery
- ✓ number of tags found in catch

2.1.5 Egg and Larval Survey

Egg and larval surveys are another important method employed to conduct stock assessment. The total number of eggs and larvae produced per year is estimated by a survey, and divided by the number of eggs spawned per female to produce the number of fish in the spawning stock, then:

$$p = \frac{E}{FR}$$

Where:

p is size of spawning stock;

E is total annual egg and larva production in the survey area;

F is mean annual fecundity per adult female;

R is the sex ratio.

The accurate of the estimate is influenced by the mortality at egg and larval stages, and the fertilizing rate, except for the sampling problems.

Data requirement:

✓ total annual egg and larva production

✓ mean annual fecundity per adult female

✓ sex ratio

2.1.6 Ecosystem Model

Due to the complex marine ecosystem, many of the single species (stock) management strategies has been a failure, ecosystem-based fisheries management have been stressed recent years. As a result, more and more ecosystem models are being developed, among them, Ecopath with Ecosim (EwE) is probably the most widely used model (Christensen, et al, 2004), and is designed for straightforward construction, parameterization and analysis of mass-balance trophic models of aquatic and terrestrial ecosystems. Focus is on using the models for fisheries management, and a suite of tools are included for this aim.

EwE has three main components:

- Ecopath is a static, mass-balanced snapshot of the system, and is used to organize historical data on trophic interactions and population sizes;
- Ecosim is a time dynamic simulation module and builds dynamic predictions by combining the data with foraging arena theory;
- Ecospace – a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas.

The Ecopath software package can be used to

- Address ecological questions;
- Evaluate ecosystem effects of fishing;
- Explore management policy options;
- Evaluate impact and placement of marine protected areas;
- Evaluate effect of environmental changes.

The basic Ecopath equations are:

- Production = catches + predation mortality + biomass accumulation + net migration + other mortality
- Consumption = production+ unassimilated food+ respiration

Data requirement:

- ✓ Stomach contents
- ✓ Catches
- ✓ Biomass or density of major functional groups or species
- ✓ Migration

2.2 Location of data & info and access to each site by the public

- FAO Yearbooks of Fishery Statistics
- FAO Bulletins of Fishery Statistics
- FAO Fisheries Circulars
- FAO Handbook of fishery statistics
- FAO Fisheries Reports

- FAO Fisheries Technical Papers
- China Fisheries Yearbook
- China Ocean Yearbook
- Korean Yearbooks of Fishery Statistics
- http://www.fao.org/fi/
- http://www.cnfm.gov.cn/
- http://www.cafs.ac.cn/
- http://www.ysfri.ac.cn/
- http://www.eastfishery.ac.cn/
- http://www.china-fishery.net/
- http://www.ifishery.com.cn/
- http://www.china-fisheries.org/
- http://www.nmdis.gov.cn/
- http://www.ouc.edu.cn/
- http://www.qdio.ac.cn/
- http://www.momaf.go.kr/
- http://www.nfrdi.re.kr/
- http://kodc2.nfrdi.re.kr:8001/home/eng/main/index.php
- http://www.pknu.ac.kr/eng/

The data sources include: fisheries dependent data (fisheries), and independent data (scientific surveys).

The fisheries data may be extracted from fisheries statistics, mostly catch statistics by major species and total landings in whole country and total fishing effort, sometimes by fleets, the area fished is not usually specified. The large number of species caught and the many fleets operating in the Yellow Sea Large Marine Ecosystem create difficulties in getting accurate figures and sufficient fisheries data for stock assessment.

The survey data are not available to the public, and it is impossible to access to any kind of survey data on stock assessment. However, the final results from surveys can be found in publications from both countries and in international journals and books.

3 MAJOR ISSUES AND PRIORITIES

Currently, three countries (China, Republic of Korea, and DPR Korea) fish in the Yellow Sea region using multi-gears operated by different types of fishing boats. Japanese fishing boats also used to operate in this area in last century with high landings. It is a fact that there is no close cooperative work on stock assessment in this region, although a lot of signs indicate that many stocks are overexploited. Management measures have been taken by individual countries unsupported by strong scientific information.

The **major problems** in stock assessment in the Yellow Sea today are:

a. The lack of agreed methods such as those used by ICES who employs VPA tuned by survey data;

b. The availability of data at a regional level is limited, including insufficient fisheries data and survey data;

c. The different coverage of surveys resulting in insufficient knowledge of distribution and stock status of major species;

d. The different methods and gear used in scientific surveys without calibration leading to different results;

e. The different objectives of surveys leading to focus on different target species;

f. The different target species in catch statistics;

g. The different standards in catch statistics.

Data quality and the methods used to integrate them may result in imprecise and inconsistent stock assessments. Therefore, there is a lot of work to be done before conducting stock assessment for the whole ecosystem. To overcome these barriers, priorities are suggested as below.

First step is to establish several scientific working groups, such as

- Fisheries data WG, responsible for: collection of fisheries data; data standardization, etc.
- Survey methods WG, responsible for: comparison of survey methods used by the different countries; calibration to ensure consistent survey methods are used to estimate the biomass of stocks; development of better observation tools and survey strategies.
- Fisheries biology WG responsible for; collection of fisheries biology data; data standardization; biological characteristics of major species, e.g. growth, mortality, migration and distribution, spawning, feeding, wintering, etc.

- Stock assessment WG responsible for: selecting adequate mathematical models for the fish stocks in the Yellow Sea ecosystem; prediction of stock size of commercially important species; providing sound estimates of allowable biological catch (ABC) and total allowable catch (TAC) for fisheries management.

Second step is to establish a mechanism to exchange survey data and fisheries data.

Third step is to establish a joint survey mechanism based on analysis all the historical individual surveys performed by countries from the working groups.

4 RECOMMENDATIONS

Stock assessment is currently based on two methods, one is mathematic models dependent on fisheries data, and the other is fisheries-independent scientific surveys. Since many population dynamics models have been developed and used in different fisheries, the suitable models for specific fisheries are the best ones based on the available data. The quality of stock assessment depends on:

a. The quality of the assessment methods and the associated strategies;
b. An understanding of dynamics of the ecosystem, including species interaction, relationships between environment and biology;
c. Human activity effects;
d. Reliable data, both fisheries and survey data;
e. Reliability of the models chosen;
f. Knowledge of ecosystem uncertainties.

For stock assessment in the Yellow Sea region, many traditional models have been applied to analyze the population dynamics. The models listed above, including VPA, Schaefer model and yield per recruit model are more often based on the data available in the region, and these models are highly dependent on fisheries data and their precision. All methods are useful, relevant to the Yellow Sea specific fisheries in despite of the limitation of each method is suffered to the condition of assumption, data quality, and estimation of some parameters. The accuracy is highly dependent on the knowledge of fish stocks, the precision of fisheries data collected. Attempts at building an Ecopath model have been made in recent years.

The data and information collected during the past two years for the Yellow Sea LME are more general, and can’t directly fit these models without further specific fisheries data and careful processing and analyzing. However, the general trends of fisheries resources can be understood from this work.

The scientific surveys are more accurate, but costly. In the Yellow Sea region, both China and R. Korea have done some fisheries monitoring surveys, the main methods used are bottom trawl and acoustic surveys, egg and larval survey as a by-product. Tagging and recapture methods are now seldom used for stock assessment compared with past years. Those surveys data as shown in the dataset collected were insufficient for any stock assessment of the Yellow Sea LME due to the limited coverage, short period of the time series and all surveys were conducted by individual countries. However, the status of the local stocks may be estimated.

The stock assessment capacity in the Yellow Sea region needs to improve, to keep up with increasing exploitation rates in the fisheries. Although there are many scientists working with this field, capacity enhancement is required to reach equivalent standards to those employed in the northeast Pacific region and ICES regions, for example, the North Sea, the Barents, the Bering Sea, George Bank, etc. At present, due to the lack of data and capacity, the following methods for regional reiterative series of joint-regional stock assessment are as recommended below.

4.1 Collection of Fisheries and Survey Data

The data collected from fisheries and scientific surveys are used in various models to assess the state and trends in the development of stocks and to predict the catches and the development of the spawning stock in the short and medium terms.

As indicated from the models, fisheries data are important (necessary) for most models. Therefore, a collection system of accurate catch and effort and biological data should be implemented. A regularly undated fisheries database should be established that can provide a time series of stock abundance and composition.

Catch per unit effort (CPUE) is an index of stock abundance, used to support the prediction models, and may be obtained from either well-defined commercial fleets or from abundance surveys using research vessels. The CPUE values are expressed in numbers-by-age per effort unit. The effort unit can be days-at-sea, trawl hours, search time, etc. Commercial CPUE data are obtained through sampling the commercial fishery catches for biological information (for example, age composition data) and linking this information with catch and effort statistics. Abundance surveys using research vessels provide these data directly, often from bottom trawl surveys expressed as numbers caught per hour trawling. It should be noted that survey data differ from commercial CPUE data.

Biological information is the fundamental components required in the stock assessment, for example the age composition, growth, length-weight relationship, prey-predator relationships, migration, stomach contents etc.

There are large uncertainties in the ecosystem, therefore it is also necessary to collect data relating to the environment inhabited by the target fish, such as temperature, salinity, primary production, plankton, etc. Some of data is used to fit the ecosystem models.

4.2 Stock Assessment Modelling

The countries surrounding the Yellow Sea should:

- Jointly select an adequate model from the existing classical mathematical models for reiterative use in stock assessment of the fish stocks in the region after testing.
- Develop new models based on the classical and new models used in other regions.
- Agree on joint prediction of stock size of commercially important species in the region.

4.3 Jointly Scientific Survey

A regular scientific survey is suggested every year, to monitor the state of major stocks in the Yellow Sea. The sampling strategy and survey design should be well-defined. Acoustic-trawl survey is recommended, based on the availability of research vessels and equipment in the countries around the region. The frequency of cruise is completely dependent on the available budget due to the high cost of using research vessels. The coverage should be large enough to cover the whole distribution of the major stocks.

5 FINAL REMARKS

The purpose of stock assessment aims at fisheries management for sustainable development, and resources must be managed sustainably with a long-term view. Recently, ecosystem based fisheries management (EBFM) is being discussed in many areas of the world, particularly after the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem, held in Reykjavik, Iceland, October 2001. Fisheries not only reduce the exploited stock sizes, but also affect interrelated species, including predators, prey and species in competition with the target species for food resources. It is therefore important to monitor changes in the fish community as a whole, in conjunction with the exploited stock, to ensure the ecosystem is not damaged by the fishery.

Marine fishes do not respect political boundaries and fisheries science is very internationally oriented. Therefore, countries within the same region need co-operate with each other and work together to conduct stock assessments. When the objective of fisheries management is well defined, the method and strategy of stock assessment can be determined based on the currently available data and knowledge in relation to the Yellow Sea ecosystem.

Although there are many methods used in the world, in the Yellow Sea region, an increase stock assessment capacity is required to provide a more consistent and complete framework for sustainable management in the future. Cooperation can not flourish **without a formalized network** of institutions and scientists that maintain and share the data and knowledge. Firstly, as a result of these networks, Yellow Sea fisheries resources from different sources can be used to compare surveyed areas and assessed stocks, and all parties can directly exploit developments and improvements in assessment methodology. Secondly, effort at all levels must be encouraged to establish and to improve stock assessment in a coherent way. It is important that scientists with various areas of expertise form working groups to co-ordinate research projects.

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