Biological Assessment Theme

Assessment of Inland Fish Populations and Fisheries: Foundation for Demonstrating Value and Sustainable Management

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Outline

• Status of inland fisheries to global food security and livelihoods

• Need for stock assessment

• Current assessment approaches

• Novel assessment approaches

• Challenges and the way forward
  – How to improve and what is reasonable?
Status of inland fisheries
Trends in global fisheries and aquaculture production – FAO FishstatJ

![Graph showing trends in global fisheries and aquaculture production from 1950 to 2010. The graph displays nominal catch in tonnes x 10^6 for aquaculture, capture - marine, and capture - inland. The data shows an increase in all categories over time.](image-url)
Increase mainly due to improved reporting and stock enhancement
Species contribution to global inland catches

FAO FishstatJ

Production (t x million)

- Freshwater crustaceans
- Freshwater molluscs
- Tilapias and other cichlids
- Carps, barbels and other cyprinids

Graph showing the production of each species from 1970 to 2012.
Importance of “freshwater production to human nutrition and incomes is much greater than gross national production figures suggest”. (Dugan et. al. 2007., Inland Fisheries and Aquaculture)
Example: Lower Mekong Basin
FAO reporting - 0.9 million tonnes

Fisheries production based on household surveys

Lower Mekong
1-1.3 million tonnes

Middle Mekong
0.9-1.2 million tonnes

Upper Mekong
60,000 tonnes

Yield = 2.6 - 3 million tonnes

Source: MRC 2007
Recreational fisheries

Global participation in recreational fisheries
(Arlinhaus and Cooke 2009)

- Estimated 47.1 billion fish caught annually - about 17 billion retained
- Global value in excess of US$ 200 billion
- Becoming important in developing countries

(Cooke and Cowx 2004)
Stocking enhancement – special concern for reporting production

- No special FAO category for culture based fisheries:
  - culture or capture;
  - confusion in reporting, e.g. Mexico reporting of carp production.

![Graph showing Mexican carp production and change in reporting stocked](image)
Objectives of stock assessment

• Evaluation of the status of fish stocks for exploitation (commercial, subsistence, recreational), conservation and enhancement.

• Assessment (detection) of long-term population change in response to environmental change/degradation.

• Predication of future changes.

• Evaluation of management activities:
  - fishery regulations
  - stocking and introductions
  - habitat improvements
  - water quality improvements

• Environmental impact assessments.
Relationship between fisheries stock assessment and aquatic resource management

**OBJECTIVES**
- Law, policy, events, users, finance

**Assessment & evaluation**
- Processes & models

**Fishery assessment**
- Data collection and monitoring

**Design & indicators**

**Uncertainty**

**Management choices**

**OUTCOMES:**
- Users, stocks, catches, economics, ecosystems

**Management policy formulation and decision making**
- Optimise best practice in multiuser environment
Stock assessment approaches

Fisheries independent assessment
- Area catch
- Mark recapture & Depletion
- Catch per unit effort and stock index
- Fish counters
- Stocking
- Remote sensing
- Licence returns
- Statistical surveys

Fisheries dependent assessment
- Catch returns/log books
- Creel surveys

Environmental correlation methods

Biomass assessment
- Assessment of extant fisheries
- Prediction of fisheries yield
Assessment approaches: fishery independent

**Sampling methods**

- Experimental gears similar to commercial gears but without restrictions on mesh sizes etc.
- Electric fishing
- Hydroacoustics
- Counters
- Larval and juvenile sampling

**Sampling strategies**

- Catch effort relative abundance
- Depletion / removal methods
- Mark – recapture
- Calibrated gear methods
Assessment approaches: fishery dependent

**Sampling strategies**

- Catch assessment survey and frame surveys.
  - Stratified or random stratified sampling
- Recreational fisheries
  - intercept methods
  - roving creel methods
  - Questionnaires
- Market surveys
- Rapid rural appraisal
- (Household surveys)
Assessment approaches: fishery dependent

Assessment outputs – production models

**Single Species Fishery**
- Moderate fishing gives maximum catch
- Too much fishing causes extinction or depletion

**Multi-Species Fishery**
- Total catch approximately constant
- Valuable species become extinct or depleted first
Assessment approaches: fishery dependent

Sub-sampling / Random stratified sampling

Complexities of multi-gear multi-species fisheries e.g. Lake Kyoga (Orach-Meza 1996)

Fishermen

- Full time
- Part time

Fishing boats

- Planked canoes, with or without outboard motors
- Dug-out canoes

Fishing gear

- Gill net, variable mesh size and materials
- Long lines, variable hook number and sizes
- Seine nets, variable length and mesh size
- Cast nets
- Traps
- Hand lines

Fish landing

- Number of boat landings
- Ecological zone of the fishery
The fishing down process (Welcomme pers comm)

need for indicators of exploitation or status of stocks

Large, long-lived species and individual fish

Small, short-lived species and individual fish

Effort

Catch
Assessment approaches: habitat & environmental correlation

Correlate fish catches to river, lake and reservoir ecosystem characteristics and drivers, e.g.

Morpho Edaphic Index:
\[ \text{catch kg/ha} = 14.3136 \text{ MEI}^{0.4681} \]

Area model:
\[ \text{catch kg/ha} = 160.\text{lake area}^{0.24} \]
Novel methods for assessment

- Mobile technologies
- Remote sensing
- Hydro-acoustics
- eDNA
Mobile technologies

Cell phones, smartphones, tablet computers and other hand-held devices are emerging as important fisheries assessment tools.

Technologies are attractive to researchers and agencies because they:

• often combine global positioning, wireless capabilities, accelerometers, gyroscopes, and high resolution cameras in a single unit (that can accommodate additional attachments);
• can quickly capture, store, and upload a great deal of information;
• reduce data recording and transcription errors.
Remote sensing

GIS approach:
- \( \text{Catch} = \text{Area} \times \text{Catch per Unit of Area} \)
- CPUA and AREA for different type of water bodies
- WWF supported the development of global water database, coverage all water bodies larger than 10 ha
Modelling in GIS (after de Graaf et al 2015)

• Multi linear regression between spatial layers

\[ \text{Catch (kg/ha)} = a + b_1 X_1 + b_2 X_2 + \ldots + b_p X_p \]

Once model developed, total global/regional inland fisheries catch estimated by applying the model in GIS software over all water bodies.
• Only work if data from large number of water bodies obtained.
Hydroacoustics

Evolving science used to estimate stock biomass using propagation of sound waves:

- Non invasive
- constrained by environmental and morphological considerations
- need to be validated at each site prior to implementation
- New levels of sophistication - DIDSON

“Vertical” Acoustics

“Horizontal” Acoustics
eDNA

- Evolving science mainly used to detect Presence-Absence:
  - detecting distribution of endangered species (Jerde et al. 2011)
  - assessing biodiversity (Lodge et al. 2012; Thomsen et al. 2012)
  - detecting invaders (Great Lakes)
- Estimate biomass and distribution of carp in a natural freshwater lagoon (Takahara et al. (2012)).
- Determine the effects of oestrogenic effluents on genetic structure and effective population sizes of roach populations in rivers in England (Hamilton et al. 2014).
Challenges

Biological and production assessment essential for science-based, sustainable fisheries management and to demonstrate the full value (economic and otherwise) of inland fisheries resources.
Challenges

Inland fisheries assessment pose challenges that differ from marine environment:

• fishery-dependent data difficult to generate because many freshwater fisheries are subsistence, informal, unregulated with no monitoring schemes;
• sheer number and diversity of fisheries;
• high levels of ecological and environmental variation;
• lack of institutional capacity and financial and human resources for assessment;
• anthropogenic impacts other than fishing;
• frequent use of active enhancement and restoration measures such as stocking affect stock dynamics.
Challenges: Issues with data

- Fishing pressure - role of ‘unknown’ change effort
- Environmental change
- Nutrient loading
- Flow modification
- Lake levels

Missing importance of fish and fisheries to livelihoods and food security – not ‘capturing’ real-time consumption and use.

Do we need to know the volume, value or some other measure of importance of inland fisheries and how do we disseminate the information.
Way forward

- Identify **practical solutions** for improving:
  - UN FAO global assessments of inland fisheries production
  - local/regional/national fisheries assessment, valuation and management.

- **Accounting for IUU fishing**
  - Improve sampling frame/CAS (resource constraints)
  - Household and Government, export statistical surveys

- **Inclusion of economic and social information**

- **Account for stock enhancement and culture based production**
Way forward

• Explore use of novel fisheries assessment methods
  – Mobile technology, GIS tools, remote sensing, eDNA

• Standardization of assessment methodologies

• Provide solutions to inform fisheries management,
  – develop and validate a variety of biological assessment tools (fishery-dependent and -independent) that are flexible, robust and can be operationalized at the appropriate scale
  – be integrated within multiple resource management scenarios.
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Brief (3 min!) Panel Perspectives

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