Measuring Productive Capacity Of Fish Habitats

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Outline

- Fish habitat management in Canada
- Productive capacity of fish habitats
- Measuring productive capacity
- Case studies
- Applying the principle of “no net loss”
- Management of habitat as a component of ecosystems
- Conclusions and next steps

Fish Habitat Management in Canada

- 1986 policy statement
- Implementation, procedures and practice

Policy for the Management of Fish Habitat in Canada (1986)

- Guiding principle: No Net Loss of Productive Capacity of Fish Habitats
- Conservation, Restoration, Creation
- Integrated Resource Management
- Still viewed as inspirational document
- NNL is a principle to which many environmental sectors aspire (Pollution Probe Feb 2004)

FHM Operational Statistics 2000-2007

Category	2000-2007
Fisheries Act:	
Referrals received by DFO	46950
Advice provided by DFO	50993
Operational Statements Sent of Notification Received	2618
Authorizations issued by DFO	3888
CEAA:	
Env. Assmt. Screenings and Comprehensive Studies	5250
EA Panels with DFO as RA	16

FHM Practice

- Net loss of productive capacity has continued
- Most decision-making is qualitative, although quantitative tools are available
- Largely stuck at the referral level with some attempts to move toward area management planning (e.g. AOC in the Great Lakes, CAs), and Ecosystem Based Management
- Small activities get too little attention even though their aggregate impacts (cumulative effects) may be significant

Productive Capacity of Fish Habitats

- What is productive capacity?
- Related concepts
- No net loss

Productive Capacity

- "The maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend"
- Economic concept originally
- Fish production is the key measure, but surrogates are usually used
- Qualities of production are also important
  - ➔Species, Diversity, Habitats

Related Concepts

- Maximum sustained or optimum yield (MSY or OY) – the yield taken under the maximum rate of production
  - ➔ MSY out of favour these days
  - ➔ Need something like ESY (ecologically sustainable yield)
- Carrying capacity (CC) – the "equilibrium" maximum abundance in the absence of exploitation
- Simple logistic/Lotka-Volterra models – bring the PC, CC, and MSY together
- Ecological Footprint neatly brings together PC and CC linking supply and demand (see Rees /Wackernagel)

The Basic Arithmetic

Category	Pre-Scenario			Post-Scenario		
	Area	unit pc	PC	Area	unit pc	PC
Loss	A_{LO}	$p_{LO\text{-}pre}$	$P_{LO\text{-}pre}$	-	-	-
Modified-Direct	A_{MD}	$p_{MD\text{-}pre}$	$P_{MD\text{-}pre}$	A_{MD}	$p_{MD\text{-}post}$	$P_{MD\text{-}post}$
Modified-Indirect	A_{MI}	$p_{MI\text{-}pre}$	$P_{MI\text{-}pre}$	A_{MI}	$p_{MI\text{-}post}$	$P_{MI\text{-}post}$
Compensatn. Mod	-	-	-	A_{CM}	$p_{CM\text{-}post}$	$P_{CM\text{-}post}$
Comp. Created	-	-	-	A_{CC}	$p_{CC\text{-}post}$	$P_{CC\text{-}post}$
Sum	$A_{T\text{-}pre}$	-	$P_{T\text{-}pre}$	$A_{T\text{-}post}$	-	$P_{T\text{-}post}$

- Productivity equals Area times unit productivity ($P = A*p$)
- While productivity is the ideal measure other surrogate metrics can be used. Suitability has been and will continue as the main approach

Measuring Productive Capacity

- Habitat-based methods
- Fish-based methods
  - ➔Population level
  - ➔Community level
  - ➔Individual level
- Lower Trophic Level methods
- Fish-Habitat and Ecosystem Models

Habitat-based Methods

Method	Features	Examples
Hydrologic metrics (Tennant, Median monthly Q50, 7Q10)	Only uses flow data, desk-top method	Tennant 1976 Caissie & El-Jabi 1995
Hydraulic rating curves (wetted perimeter, transect method)	Relates supply of habitat features to hydraulics	O'Shea 1995 Kilgour et al 2005
Habitat simulation (IFIM, PHABSIM, River 2D, MesoHabSim)	Focuses on depth, substrate, velocity, cover; simulated at different flows to give WUA of species of interest	Stalnaker et al 1995 Katopodis 2003 Parasiewicz 2001+
Defensible Methods/ HAAT	Not flow linked; computes net change of PC; multi-species; lakes and streams; uses WSA	Minns et al 2001

Fish-based Methods: Population

Method	Features	Examples
Abundance (CPUE, density, biomass, GLMs, GAMs)	Relates abundance (relative or absolute) to habitat types; assumes abundance is linked to habitat quality	Smokorowski et al 1998 Clarke & Scruton 2002 Quigley & Harper 2006
Population structure (age, body size, growth, P/B)	Component metrics, used as an estimate of production	Randall & Minns 2000 Jones et al 2003 Pratt 2004
Production (kg/ha/yr)	Integrated P across seasons, space, life stages	Smokorowski et al. 1998
Stock-recruitment (S-R) models	Identify carrying capacity (K)	Sharma & Hilborn 2001 Scheuerell et al 2006 Lobon-Cervia 2007

Fish-based Methods: Community

Method	Features	Examples
Biodiversity	Mainly in habitat conservation; species richness	Quigley & Harper 2006
IBI	Composite of fish community metrics; indicates habitat supply, water quality, exotic species & piscivores	Karr 1981 Minns et al 1994
Productivity /HPI	Seasonal biomass times P/B, all species, reflects habitat productive capacity	Randall & Minns 2000;2002 Roth et al 2007 Jones et al 2008
Productivity-Diversity-Habitat	A more ecosystem oriented approach; production and diversity often related	Gavaris 2009
Fish assemblage models	Mainly MPAs; mortality-habitat suitability links	Rodwell et al 2003

Fish-based Methods: Individual metrics

Method	Features	Examples
Body size and condition	habitat-dependent; linked to vital rates	Schlosser 1990 Harvey and Stewart 1991
Performance indices	Indicators of fish health; often measures water quality rather than habitat	Munkittrick & Dixon 1989 Adams et al. 1993
Behaviour / movements	Localized movements indicate frequency of habitat use and quality	Belanger & Rodriguez 2002 Dolinsek et al. 2007
Growth / survival	Vital rates; directly related to habitat quality	Jones & Tonn 2004 Rosenfeld & Taylor 2009
Fitness	Function of growth potential and morality risk	Railsback et al. 2003
Recruitment	Recruitment success as an indictor of habitat quality	Knapp et al. 1998 Johnson 2007

Lower Trophic Level Methods

Method	Features	Examples
Aquatic Insects	Biomonitoring – various taxonomic levels	Bonada et al. 2006
IBI: macrophytes, invertebrates, plankton & periphyton	Similar to Fish IBIs	Kerans & Karr 1994 Hill et al. 2000
CABIN/RIVPACS	Benthos and sediment composition Multivariate statistics Reference condition	Reynoldson
Regional and ecosystem level approaches	Integrative system measures/drivers	Bonada et al. 2006

Fish-Habitat Modelling Methods

Method	Features	Examples
Stage-structured, habitat supply models	Link habitat supply and quality features to vital rates	Minns et al 1996
Individual-based models	Spatial IBMs; movement important	Tyler & Rose 1994 Rose 2000 Hayes et al 2009
MEI and similar	Regional & site drivers	Ryder 1982; Minns 2009 Lester et al 2004 Christie & Regier
Mass-balance (Ecospace)	Spatial version of Ecopath with movements	Walters et al 1999 Pitcher et al 2002

Case Studies
(geography, issue, approach)

- Lakes
  - ⇨ Great Lakes and inland lake referrals: Habitat-based (HAAT)
  - ⇨ Management, assessment and research
  - ⇨ Challenges in northern Canada
- Rivers
  - ⇨ Athabasca River oil and gas: habitat methods (IFIM)
  - ⇨ Lower Churchill hydropower: habitat method (HEP with catch-based utilization indices)
  - ⇨ Romaine River hydropower: fish-based method (HPI)
- Marine
  - ⇨ NL and Maritimes small-craft harbours: ongoing research
  - ⇨ Temporal (BACI) and spatial scales
  - ⇨ Multi-trophic level (habitat, fish, macrobenthos)

Applying The “No Net Loss” Principle

- Elements of net change assessment
  - ➔Ten key elements readily identifiable
- Uncertainty and the precautionary principle
- Ecosystem-based approach to habitat management

Ten Elements of Net Change Assessment

1. Target selection
   - ➔ Spp., life stages
2. Habitat mapping
   - ➔ Patches, GIS
3. Assigning suitabilities
   - ➔ Spp by habitat matrices
4. Habitat supply
   - ➔ Project footprint
5. Productivity units
   - ➔ WUA, HUs, kg/ha/yr
6. Assigning weights
   - ➔ Valuing the components
7. Habitat co-factors
   - ➔ Changes in flow, temp, etc.
8. Biotic co-factors
   - ➔ Invasives, exploitation
9. Uncertainty
   - ➔ Function, variability, timing
10. Scenario comparisons
    - ➔ Pre vs Post

Uncertainty & the Precautionary Principle

- Uncertainty and Compensation Ratios
  - ➔Basic guideline is 1:1
  - ➔Considerable theoretical and practical evidence that ratios should be higher
  - ➔Probably > 4:1
- Precautionary Practice
  - ➔Principle is being applied to fisheries and habitat management
  - ➔Good frameworks have been developed, e.g. FAO
  - ➔Economics continues to trump ecology

Management of Habitat as a Component of Ecosystems

- Ecosystem-based approach to habitat management is becoming a priority
  - ➔Scope increases to include productivity, biodiversity and habitat as well as accommodating human wants and needs where sustainable
- Science-based approaches to NNL of productive capacity should fit well inside EBM
- Cumulative Effects Assessment & Management
  - ➔Impact of multiple stressors (CEAA)

Conclusions

1. Scope of potential surrogate metrics of PC has increased in recent years
2. Application of surrogate metrics need to address the 10 elements of net change assessment
3. Science needs to turn research-based metrics into operational management tools
4. Science needs to quantify the link between habitat suitability and absolute units of production
5. Surrogate metrics of PC need to be thoroughly evaluated, as surrogates will continue to be used
6. Larger-scale studies beyond individual sites are needed to fully calibrate tools for operational use

The Way Forward

- Strong communication between science and management is needed to facilitate the application and validation of measures of PC
- Continue to build dynamic models that integrate population responses to habitat characteristics
- Incorporate knowledge relevant to habitat science from other emerging issues that affect productivity and biodiversity (SAR, CC, CEAM)

Questions?