Measuring Productive Capacity Of Fish Habitats: A Progress Report

Dr. Ken Minns
Adj. Prof., Ecol. Evol. Biol, Univ. Toronto
Scientist Emeritus, Fisheries & Oceans, Burlington

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Outline

- Fish habitat management in Canada
- Productive capacity of fish habitats
- Measuring productive capacity
- Applying the principle of "no net loss"
- Management of habitats and ecosystems
- Next Steps

Fish Habitat Management in Canada

- 1986 policy statement
- Implementation guidelines and procedures
- Practice

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

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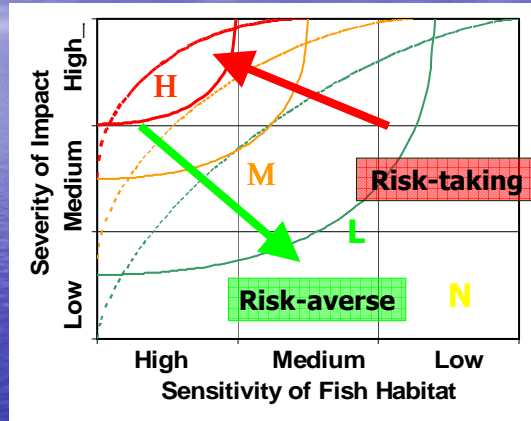
Guidelines and Procedures

- Numerous guidance documents issued since 1986
- Most lack operational methods thereby limiting their utility
- Risk management has assumed increase importance although the guidance on that is seriously flawed

Risk Management Framework

- **Current guideline is risk-taking BUT should be risk-averse**
- **Lacks operational definitions for sensitivity and severity**
- **No consideration of cumulative impacts (past & future)**

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 qualitative, subjective despite the availability of science-based tools
- FHM managers tend to be asking for more tools while practitioners remain reluctant to use them or prefer their own judgement
- Largely stuck at the referral level with some attempts to move toward area management planning (AOCs)
- Small activities get too little attention even though their aggregate impacts may exceed those of large ones
    - ➔ 'Sweat the small stuff'/ 'Zero tolerance' approaches needed

Productive Capacity of Fish Habitats

- What is productive capacity
- Related concepts
- Doing the sums

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 –
  - "income generating capacity be it of a factory, land, patent or the labour skills of an individual"
  - "the volume of products that can be generated by a production plant or enterprise in a given period of time by using current resources"
  - "the productive resources, entrepreneurial capabilities and production linkages which together determine the capacity of a country to produce goods and services"
- 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 (see Ricker)
- Ecological Footprint neatly brings together PC and CC linking supply and demand (see Rees /Wackernagel)

Doing the Sums

- Often use of quantification to support decision-making is resisted in HM (and elsewhere!)
- Often confusion about PC and how to use it pragmatically
- Net change equations (Minns 1997) provided a cost-benefit framework using productivity units NOT $$
- Based on HEP/HSI with HEA (Habitat Equivalency Analysis) as a new manifestation
- Analyses are not difficult to do and there are tools available to help
- The science base has grown as I hope to demonstrate

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
- Non-monetary cost-benefit analyses

Measuring Productive Capacity

- Habitat only methods
- Fish only methods
  - Population level
  - Community level
  - Individual level
- Non-fish biotic methods
- Fish and habitat methods

Habitat-only 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; with spp suitabilities gives WUA	Stalnaker et al 1995 Katopodis 2003 Parasiewicz 2001+
Defensible Methods/ HAAT	Not flow linked; Computes net change of PC; multi-spp; lakes and streams; uses WSA	Minns et al 2001

Fish-only Individual Methods (incomplete)

Method	Features	Examples
Growth rates	Key to estimating P or P:B	Jones et al
Survival/Mortality rates	ditto	Pauly
Performance indices	Allied to EEM techniques Condition, GSI	Munkittrick/Dixon
Recruitment rates		?
Movement	Stay or go?	?

Fish-only Population Methods

Method	Features	Examples
Abundance (CPUE, Density, biomass, GLMs, GAMs)	Relates abundance to habitat areas	Smokorowski et al 1998 Clarke & Scruton 2002 Quigley & Harper 2006
Population structure (age, body size, growth, P/B)	Component metrics of production seasonally	Randall & Minns 2000 Jones et al 2003 Pratt 2004
Production	Integrated P across seasons, space, life stages	Scruton et al
Stock-recruitment (S-R) models	Identify carrying capacity (K)	Sharma & Hilborn 2001 Sheuerell et al 2006 Honea et al 2009

Fish-only Community Methods

Method	Features	Examples
Biodiversity	Mainly in habitat conservation; species richness	Quigley & Harper 2006
IBI	Composite of fish community metrics; indicates habitat suppy, WQ, exotic spp & piscivores	Karr Minns et al 1994
Productivity-Diversity-Habitat	A more ecosystem oriented approach; P and D often related	Randall & Minns 2000;2002 Roth et al 2007 Jones et al 2008
Fish assemblage models	Mainly MPAs; mortality-habitat suitability links	

Non-fish Biotic Methods (incomplete)

Method	Features	Examples
Benthic/Planktonic/ Vegetation IBIs	Similar to Fish IBIs	Angermeier Chow-Fraser and others in GLs
CABIN/RIVPACS	Benthos and sediment composition Multivariate statistics	Reynoldson
Limnological (Primary production, Oxygen depletion, WQ params) ?	Integrative system measures	Peters, Rigler, Dillon

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		Ryder 1982; Minns 2009 Lester et al 2004 (TOHA) Christie & Regier
Mass-balance (Ecospace)	Spatial version of Ecopath with movements	Walters et al 1999 Pitcher et al 2002

Applying The "No Net Loss" Principle

- Elements of net change assessment
  - Ten key elements readily identifiable
- Uncertainty and the precautionary principle
  - The 'unknown unknowns'

Elements of Net Change Assessment

- Target selection
  - Spp., life stages
- Habitat mapping
  - Patches, GIS
- Assigning suitabilities
  - Spp by habitat matrices
- Habitat supply
  - Project footprint
- Productivity units
  - WUA, HUs, kg/ha/yr

- Assigning weights
  - Valuing the components
- Habitat co-factors
  - Changes in flow, temp, etc.
- Biotic co-factors
  - Invasives, exploitation
- Uncertainty
  - Function, variability, timing
- Scenario comparisons
  - Pre vs Post always

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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 much talked about but little practice
  - Good frameworks have been developed, e.g. FAO
  - Economics continues to trump ecology

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Cumulative Impacts

- Beyond immediate, local activities, we are doing a poor job on long-term, large-scale perturbations.
  - → Land use change, invasive ecological engineers, climate change, fishing-induced habitat damage
- Habitat management generally not seen as a forum for addressing those perturbations.
- Yet, FHM referrals often become CIAs

Management of Habitats and Ecosystems

- Ecosystem-based management (EBM) is becoming a priority
  - → Scope increases to include productivity, biodiversity (incl. SAR), 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
- HOWEVER, as the power of NNL methods is steadily increasing, EBM methods are becoming more nebulous, subjective, user-dominated
- EBM methods should also be science-based less another set of good ideas becomes debased and survival only as catch-phrases

Conclusions

- Often it might seem as if developers' consultants want to use minimal methods that ensure an apparent positive outcome while research staff want exhaustive science-based investigations: The former is inadequate and the latter unreasonable
- Fish habitat managers need to pay more attention to the middle ground if they are to turn the tide from accumulating losses to making gains.
- This review shows there are a wide array of methodologies amenable to assessing net change of productive capacity
- It is not rocket science!

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Recommendations

- Increase the use of available, science-based tools and methods in the practice of fish habitat management
- Don't expect perfection or easy answers
- Press on with the development of habitat-population and ecosystem models

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- Thank you for being here and listening
- Any questions or comments?
- To contact me:
  - Email ken@minns.ca
  - Web www.minns.ca/ck

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