Fish Conservation and Management
CONS 486

Fisheries OVERexploitation
Ludwig et al. 1993
Pauly et al. 2002
Post et al. 2002
Topics: Fisheries overexploitation

- Causes of commercial fishery overexploitation
- Can recreational fisheries be over-exploited?
Major theme: Linking science to conservation & management

- Harvest regulations
- Managing fisheries & habitats
- Protecting populations & habitats
- Restoring populations & habitats

- Fisheries exploitation data
- Applied life history data
- Human dimensions: socio-economic data

Basic science

Applied science

Conservation

Management

- Physiology
- Behaviour
- Population ecology
- Ecosystem ecology
- Habitat data (limnology, oceanography)
- Life history

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Ocean fisheries crisis: commercial harvest and widespread population declines (Jackson et al. 2001; Reynolds et al. 2001; Smith 2002; Christensen et al. 2003; Hilborn et al. 2003; Pauly et al. 2003; Watson et al. 2003)

Widespread ocean biodiversity losses (Worm et al. 2006)

- (A) Trajectories of collapsed fish and invertebrate taxa over the past 50 years (diamonds, collapses by year; triangles, cumulative collapses). Data are shown for all (black), species-poor (<500 species, blue), and species-rich (>500 species, red) large marine areas.

(B) Map of all 64 Large Marine Areas, color-coded according to their total fish species richness.
Introduction

- **Overexploitation**: harvest a resource to the point of diminishing returns
  - I.e., resource becomes unsustainable
- Most overexploitation research focuses on marine commercial fisheries
- 3 processes involved
  - Tend to occur in sequence
  - Overexploitation can occur with just the first two but the third is often observed
Causes of overexploitation

1) Tragedy of the commons

• Undesirable to conserve present resources because of the high uncertainty of future

• Personal restraint could mean lost income

• So, harvest as much as possible because if you don’t, your competitor will
Causes of overexploitation

2) Over-capitalization (over-investment)
   • Competition fuels over-capitalization
   • As resources get more limited (increased competition)
     – Pressure to increase capture efficiency
     – Better gear, bigger boats, increased effort
Causes of overexploitation

3) Ratchet effect (irrational fishing)

- Struggling fishers may opt for loans to make their vessels more efficient
  - Thus going into personal debt and having to compete even harder to pay back borrowed money
- Governments subsidize these loans, perpetuating the over-investment
iii) Ratchet effect cont’d

- Ratchet effect is overcapitalization followed by subsidization
  - And pressure to invest during good economic/fisheries periods
  - But no pressure to disinvest during bad periods (this fact makes humans act differently than natural predators)

- Termed **ratchet effect** because the outcomes are like turning a ‘ratchet’ leading to a ‘downward spiraling’ (in this case, on the fishery and fisher)
Ratchet effect: Canadian Atlantic cod fishery

- Federal government saw the fishery as a way to socially subsidize poor communities
Overexploitation/Ratchet effect consequences

• negative effects on fish populations
• can lead to illegal fishing in terms of violating regulations and non-reporting which leads to further negative effects
  – illegal gears (e.g., smaller mesh)
  – discarding (small bodied fish thrown away at sea so that total catch is made up of larger more valuable fish
Fisheries and Oceans Canada have Fisheries Officers to investigate potential illegal harvest and enforce regulations.
And they’re armed!
Evidence of Overexploitation

• Many fisheries cease because there are not enough fish to support the fishers' costs/wages
  – When primary fishery collapses, fishers turn to secondary species usually in a lower trophic level (top predators over exploited first)

• Over time, secondary species collapses

• Process called ‘fishing down the food web’
Fishing down the food web

• Fishing down the food web
  —Pauly et al. 1998; 2002

• Involves changing focus to different target species once focal species become hard to catch

• For several years it hid the problem of over-exploitation because fisheries were continuing
  —Industries still generating income
Fishing down the food web
A dip in the 1960s and early 1970s occurred because of extremely large catches [>12 × 10^6 metric tons (t) per year] of Peruvian anchoveta with a low trophic level of 2.2 (± 0.42). Since the collapse of the Peruvian anchoveta fishery in 1972–1973, the global trend in the trophic level of marine fisheries landings has been one of steady decline.
Recruitment vs growth overfishing

- **Recruitment overfishing**: occurs when removing excess mature fish leads to *selection for younger ages at maturation*, thus lower fecundities & sizes

- **Growth overfishing**: occurs when a target harvest biomass is achieved by *catching a lot of small fish* instead of fewer large fish
  - Smaller fish contribute less to population production
  - If a young age class is eliminated, it can make the population unstable

- Usually **R.O.** followed by **G.O.**
  - E.g. North Atlantic cod: will discuss this case study
Fisheries overexploitation: Freshwater Canadian example

Great Slave Lake, N.W.T.
Great Slave Lake, N.W.T. is serious about fishing too!
- Fisheries in these northern great lakes started in the mid 40s, target species Lake Trout with whitefish secondary target
- Lake Trout was rapidly overexploited as they have long generation time and slow recovery
- Whitefish harvested at about 2000 tonnes per year till mid 60s, then harvest rates started to decline (just like in Lesser Slave Lake for same artificial selection reasons)
Great Slave Lake Commercial Fisheries

- To help ensure Lake Trout quota could be met, gillnet mesh sizes were **REDUCED** (mid 1970s)
  - Note slight increase in harvest of both species but quota still not met
    - Harvest continues to decline so gillnet size reduced further
    - Doesn’t help get fisheries to quota but certainly pushed both species towards ‘commercial extinction’

**Classic overharvest Scenario**
- growth overfishing
- recruitment overfishing
Can recreational fisheries be overexploited?
Can recreational fisheries be overexploited?

- No economic incentives for overexploitation (unlike commercial fishery)
- When fish populations are low, anglers presumably would catch less and therefore spend less time/effort trying to catch them
- Thus recreational fisheries should be more sustainable?
Can recreational fisheries be overexploited?

- Recreational fisheries hold high economic value
  - Western world spends $76 billion US per year on rec fishing! (Arlinghaus et al. 2007)
  - In Canada, $4-7 billion annual direct expenditures from rec industry
    - 1.4X more revenue than value of all CDN commercial landings!

- Many commonalities between recreational and commercial sectors (Cooke and Cowx 2006)
  - Fishing effort and fisheries-induced selection
  - Trophic changes
  - Bycatch issues
Canada’s Recreational Fisheries: The Invisible Collapse?

John R. Post, Michael Sullivan, Sean Cox, Nigel P. Lester, Carl J. Walters, Eric A. Parkinson, Andrew J. Paul, Leyland Jackson, and Brian J. Shuter

Guest lecture ahead!
Recreational fisheries crisis?

- Post et al. 2002 suggest that there has been a collapse but it is ‘invisible’ to the average person and even to fisheries managers.

- Concerns over the ‘invisible’ collapse of recreational fisheries because:
  1. Diffuse fisheries
  2. Changing target species
  3. Masking through stocking
  4. Lack of compliance with regulations
  5. Data limited fisheries (but indirect data indicate a problem)
Why invisible collapse?

1. Diffuse Fisheries

- Tens of thousands of small lakes (and rivers) in Canada where fisheries occur
  - Different management systems & approaches at provincial and regional levels
- If small fisheries collapse in any small lake, it may not receive much media attention or public concern
Changes in the catches of species of fish at one family's fishing lodge at a large (20,000 ha) northern Saskatchewan lake illustrate the hidden decline in recreational fisheries. The young girl in this 1942 photograph is second-author M. Sullivan's mother, balancing a stringer of large walleye. At that time, the highly-desired lake trout fishery of her grandfather's time had collapsed through overfishing, and the family's guiding business had shifted to the large, abundant, and popular walleye. During the mid-1970s, lake trout were extirpated, walleye of the size and abundance in this photograph were unheard-of, and guiding was exclusively for large, but least-desired, northern pike. In recent years (1990s), pike remain abundant but small, a clear sign of growth overfishing. In spite of these spectacular collapses, sport fishermen have continued to travel to the lake (sustaining the guiding business), but with expectations that mirror the decline and change in species availability throughout lakes in this popular Canadian fishing area. In this manner, the collapse of highly-desired prey items such as trout and walleye is masked by the human predators' shift to other less-preferred species such as pike. If the pike fishery collapses (as has happened at lakes in nearby Alberta), the guiding business will also then collapse, because no sportfish species remain to be exploited. This will appear to be a "sudden" economic loss, but in reality it has been in progress for many decades and is only clearly understood when considering the changes spanning five generations of this family. This long-term and critical perspective is seldom available to fisheries managers.
• Many rec fisheries have numerous participants – tend to be open access fisheries, anyone can participate with no limits to numbers
• There are a few ‘private’ fisheries on private lakes/rivers in Europe
2. Changing target species

- Target species has been changing
  - E.g. Albertan lakes where fishing effort is highest anywhere in Canada
  - Lake trout to walleye to pike
    - If declining pike disappear, issue will get more visible

- Population declines of long-lived species
  - E.g. Lake Trout in Alberta lakes
  - Analogous to shifting baseline (fishing down the food web) phenomenon in commercial fisheries (Pauly 1995)
Why invisible collapse?

3. Masking declines through stocking

- Hatchery production has increased during the same period that fishing effort has been increasing.

Federal DFO fish hatchery
Chilliwack River BC
4. Non-compliance with regulations

- Analagous to commercial discards and illegal harvest
- Can be high non-compliance with regulations
  - Especially in overexploited lakes!
Figure 4. Non-compliance rate (percent of sub-legal sized fish caught that are not returned) as a function of angler catch rate (fish/8 hr) from Alberta walleye fisheries. The sample size in lake-years and standard errors are indicated for each catch rate class. Angler non-compliance with size-limits was determined for 20 walleye fisheries in Alberta that varied widely in walleye abundance, between 1992 and 1998, by contrasting size ratios of illegal-legal size ratios in a test fishery with ratios reported by anglers during creel surveys (data from Sullivan in press b).
Why invisible collapse?

5. Data limited fisheries

• Recreational fisheries managers have 1000s of populations and multiple systems to manage
  – Often lack even basic life history information on specific populations, so must rely on generalizations

• Indirect evidence suggests there is a problem
Lakes closer to Vancouver (short 3 hr vs long 6 hr drive) have twice as many angler days... but catch half as many fish!
Why invisible collapse?

• Easy lake access & poorer fishing

• Rainbow trout fishery in southern BC
  – One of the largest inland fisheries in Canada
  – Lakes closer to Vancouver have twice as many angler days but catch half as many fish
  – Analogous to commercial fishers in terms of ratchet effect
    • Fishing harder even though resource is harder to get
Look at it this way. You no longer have to worry about pollution, habitat loss, warming waters, fish nets or being devoured by a toxic whale...
Next lecture...

- Management ‘philo-fishies’
- Harvest regulations (and irregularities!)