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- Community – Plant and animal assemblages that live together in a common area

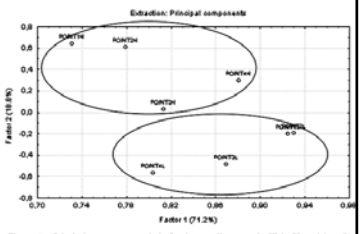

Figure 4 - Principal components analysis for the sampling spots in High (H) and low (L) temperatures for the fish comunity of the Fortaleza lagoon during November 1998 to October 1999.

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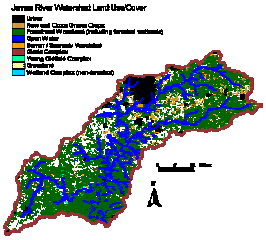
- Spatial Scale = Watersheds
- Landscapes – interactions and linkages among ecosystems and human influences on linkages



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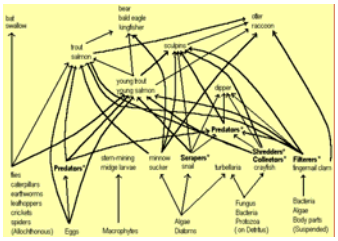
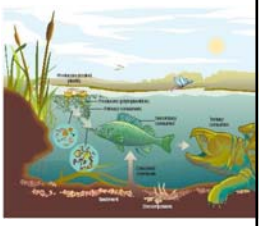
- Ecosystems – biotic and abiotic interactions





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- 1) Community interactions between fish and other taxonomic groups?
- **Type of interaction**
  - Mutualism +/+ both species benefit from interaction
  - Commensalism +/0 one species benefits, one unaffected
  - Competition -/- each species affected negatively
  - Predation, parasitism, herbivory +/- one species benefits, one is disadvantaged

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- 1) Community interactions between fish and other taxonomic groups?
- Competition - primarily for food and space; complex mix commensalisms – e.g. bluefish and terns that feed for anchovies – bluefish drive fish up - terns drive down.

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- 1) Community interactions between fish and other taxonomic groups?
- Parasitism – isopods and snappers and tongue by Brusca

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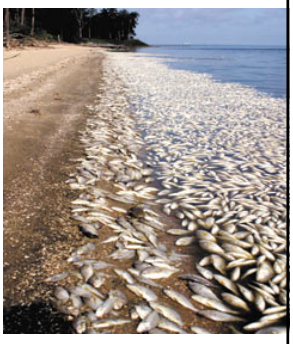
- 1) Community interactions between fish and other taxonomic groups?
- Predation – many species feed on fish and impacts on fish populations can be substantial;
- Au Sable River in MI – brook – brown trout – 70-90% mortality.
- Many things kill fish - Birds, Inverts (marine), mammals etc even dinoflagellate blooms (Pfiesteria) – over 1 billion menhaden in Neuse River in 1991.



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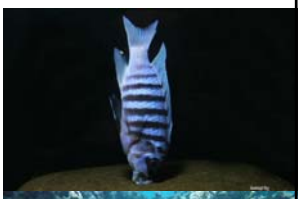
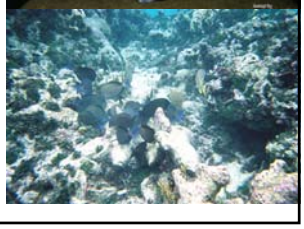
2) Effects of fish on plants

- Browsing – removing parts of plants
- Grazing – removing plant at the substrate





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2) Effects of fish on plants

- Latitude greatest correlate with herbivore diversity – above/below 40 degrees N/S rare or lacking (depends definition herbivore – 25-50% of diet).
- Tropical Communities – minnows, characins, cichlids and (lesser degree) catfish, livebearers, gouramis.
- Significant effects on abundance and diversity macrophytes - Panama streams, Costa Rica,
- Seed Dispersal – Pacu – Colossoma sp.
- Tropical Lakes – filter feeders, grazers, etc.
- Coral Reefs – Caging, zonation, secondary defense, food preferences, Damselfish (cichlids) and algal gardens = keystone species.

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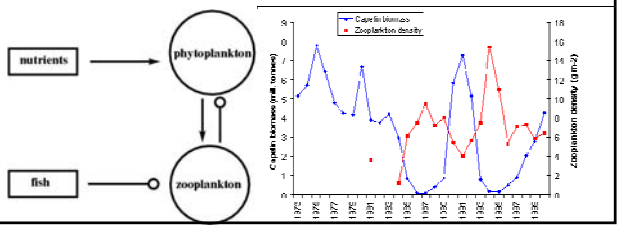
- 3) Fish effects on Invertebrate Activity, Distribution and Abundance
- Effects on Zooplankton – Size-selective predation - fish like to eat large zooplankton; Herring in CT Lake – small individuals and smaller size. Strong and direct influences;



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2) Effects of fish on plants

- Temperate Communities – minnows, catfish, suckers and pupfish – few exclusive but can effect biomass, species composition, increase growth rates.
- Many omnivores eat large amounts of plants esp. when preferred not available.
- Lakes – same as rivers more phytoplanktivory e.g. gizzard shad
- Marine – species diversity much lower
- Temperate – herbivory by inverts more important than fish

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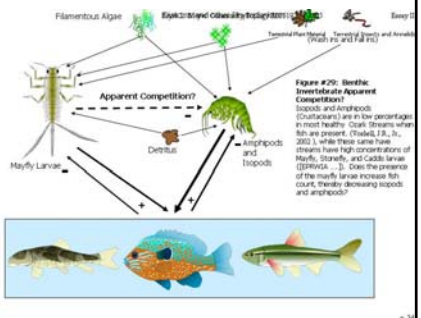
- 3) Fish effects on Invertebrate Activity, Distribution and Abundance
- Effects on Benthic Invertebrates – much less of an effect



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- 3) Fish effects on Invertebrate Activity, Distribution and Abundance
- Biomass (mass per unit area) vs. Turnover rates (production/standing crop biomass – P/B in g/m2/yr – Biomass tells little.
- What happens when fish biomass exceeds standing? Inverts can go through several generations etc. Production usually 3 to 10 times greater than biomass.

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- Fish in Ecosystems
- Indirect Effects and Trophic Cascades
- Top Down vs. Bottom Up Effects
- Nutrient Cycling and Transport
  - P excretion for algal growth,

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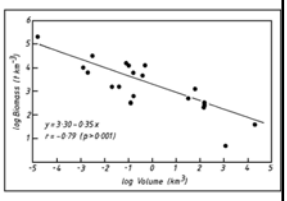

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- Fish in Ecosystems
- Indirect Effects and Trophic Cascades
- Top Down vs. Bottom Up Effects
- Nutrient Cycling and Transport
  - Benthic fishes increase transport from sediment to water column,
  - Large amounts of nutrients tied up in fish – released by defecations, through gills and death.

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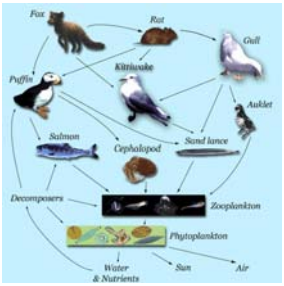
- Fish in Ecosystems
- Indirect Effects and Trophic Cascades
- Top Down vs. Bottom Up Effects
- Nutrient Cycling and Transport
  - grind coral etc (parrotfish)
  - Vertical and horizontal migrations;
  - Fish in Food Webs – linkages between distinct ecosystems - salmon

FOOD CHAINS AND WEBS
I. Food chains

- A. Conceptual: light -- primary producers -- primary consumers – secondary consumers, etc.
- Associated with trophic level



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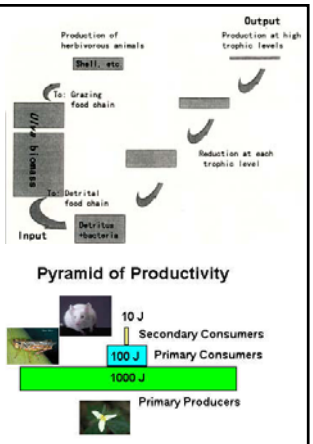
- Fish in Ecosystems –
- Influence of Physical Factors and Disturbance
- Temperature, Oxygen and Water Flow – O2 greatest effect – drought, ice cover reduce O2; Water flow – increased river and stream discharge – Desert fishes??? Temperature and lake turnovers and fish kills, stratification of lakes.
- Extreme Weather – hurricanes

I. Food chains

- B. Ecological efficiency -- energy content of trophic level
- N = energy income, from N-1 minus losses

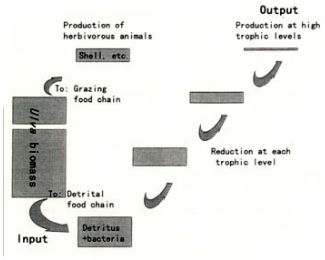


I. Food chains

- C. Currency
  - 1.calories
  - 2.C or N
  - 3.dry mass (as a proxy for C and N)
  - 4.ash-free dry weight
  - 5. Limitations of currency measures - vitamins, nutrients, lignin

II. Food webs

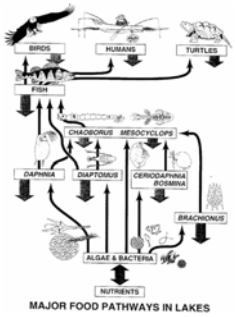
- B. Detrital food webs and pools - biogeochemical processes



II. Food webs

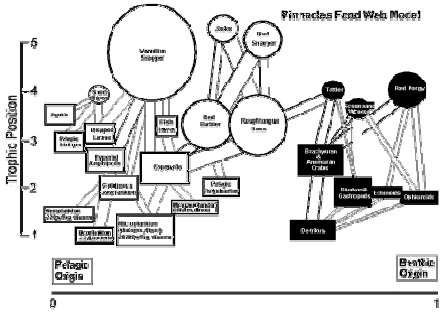
A. Food chain transformed to web due to:

- 1.Omnivory
- 2.Ontogeny
- 3.Temporal shifts in diet



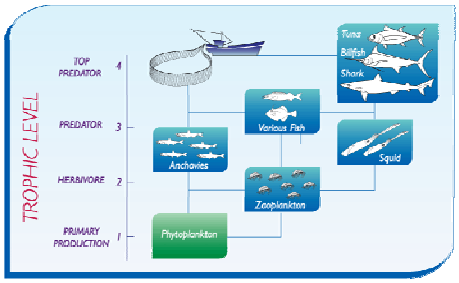
II. Food webs

- C. Mathematical descriptions of food webs - stability, connectance, diversity. Limited by not knowing true trophic positions.



II. Food webs

- D. Bottom-up control – nutrient driven

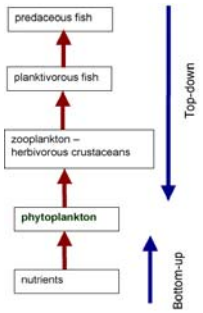


II. Food Webs

- 1. Need to take into account ontogeny
- 2. Need to study predator-prey cycles and transitory effects
- 3. Rearrangement of trophic structure during perturbation
- 4. Variability of diet, plasticity in feeding

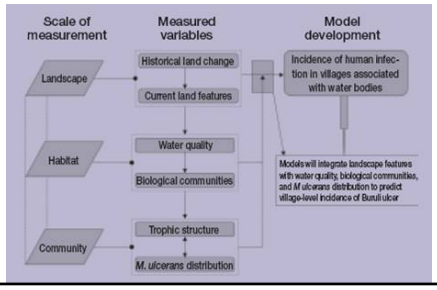
II. Food webs

- E. Top-down control - cascading trophic interactions



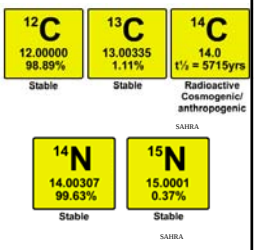
II. Food Webs

- F. Food web controls
- 1. Depend on trophic condition and time period

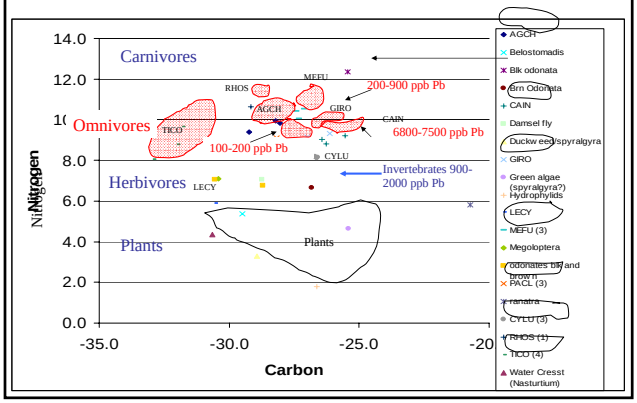


Stable Isotopes and Food Webs

- Stable isotopes - C, N, S
  - Heavy versus light – extra neutrons
  - Isotopes discimination or Fractionation
  - Notation - "del" values; isotope ratios compared to standard
- Concepts and rules
  - For C and S, "you are what you eat". Can be used to determine sources of food.
  - For N, "you are what you eat plus 3o/oo per trophic level". Assign trophic level by 15N contents.



Carbon and Nitrogen Isotopes "Trophic Levels"



Isotopes vs. Gut Contents

- Advantages of Isotopes
  - Potential versus realized trophic structure
  - Small Organisms - Difficult to determine feeding relationships with gut-content
  - Gut contents give "snapshot" in time of diet. Isotopes integrate diet over scale of tissue turnover
  - What ingested not always assimilated – detritus in grayling
- Lots of Aravaipa Gut - Schreiber 1978; Schreiber & Minckley 1981; Barber & Minckley 1983; Abarca 1989; Marsh et al. 1989; Clarkson 1982; Clarkson & Minckley 1988

III. Stable Isotopes and Food Webs

- D. Testing hypotheses - importance of different foods – i.e. use terrestrial detritus vs algae by zooplankton in Lake N2, Alaska
- 1. Label algae with 15NH4; terrestrial detritus unlabeled.
- 2. Most zooplankton became labeled with 15N; detritus use unimportant.
- 3. Cyclops not labeled - evidence of feeding on microbial food web.
- 4. Benthic animals labeled slowly - time lag in incorporation of new algal production
- 5. Clam labeled strongly, lost label over winter when feed on unlabeled bacteria in sediments

III. Stable Isotopes and Food Webs

- E. Summary
- 1. Isotopes give food source and trophic level information
- 2. Whole lake experiments with isotopes are feasible
- 3. Multiple isotopes (C plus N) give more information
- 4. Oxygen, Pb, etc.