Lab Notes FW 300

Class Agnatha

No jaws, no paired appendages. The class Agnatha represents the most primitive vertebrates. Fossils are known from Ordovician times, almost 500,000,000 years ago. After jaws and paired fins were evolved (Placoderm stage of evolution) the placoderms and their derivatives, the class Osteichthyes and the class Chondrichthes essentially replaced agnathan fishes during Devonian times, except for the two living groups of Agnatha, the lampreys (order Petromyzontiformes), and the hagfishes (order Myxiniformes). The earliest fossil Agnatha had a covering of bony plates. Thus the origin of bone is very ancient, but the living lampreys and hagfishes have no bone and it is not known if they represent a primitive divergence before the origin of bone or if the absence of bone is a secondary character as it is in Chondrichthyes where the bone present in ancestral species has been lost.

To attain the Placoderm level of evolution, the more advanced Agnatha evolved three semi-circular canals in the inner ear, paired nostrils and gill arches in place of gill pouches, allowing for the evolution of jaws.

Characters shared in common by Petromyzontiformes and Myxiniformes: No bone, single nostril, eel-like body.

Characters differentiating:

Petromyontiformes	Myxiniformes
7 pr. gill pouches each with separate openings.	6-15 pr. gill pouches, some species with one pr. of openings.
Two semi-circular canals.	One semi-circular canal.
Nasal sac closed.	Nasal sac open to mouth (internal nares).
Ammocoete larvae.	No larval stage.
Freshwater, anadromous (euryhaline).	Stenohaline marine (blood isotonic).

About 25-30 species of lampreys inhabit freshwaters of the Northern Hemisphere: North America, Europe and Asia and the Southern Hemisphere: Australia, New Zealand, western South America. The largest species, the sea lamprey may attain a length of about three feet.

Although esteemed as food in Europe and Asia, the lamprey is generally despised in North America. Because of its predation on valuable fishes of the Great Lakes, enormous sums of money and effort has been expended in attempts to control the sea lamprey, Petromyzon marinus. The sea lamprey has caused a drastic change in the fish fauna of the Great Lakes. Hagfishes, although of biological significance as the most primitive living vertebrate, have a negative economic significance by destroying fish captured in nets. Hagfish, probably because of the chemical composition of their mucous secretion have no known predators (including man).

Class Chondrichthyes

No bone, no air bladder, internal fertilization. The subclass Elasmobranchii (sharks and rays) is differentiated from the subclass Holocephali (chimaeras) by the presence of separate gill slits in Elasmobranchii and a common gill covering (operculum) in Holocephali.

The Chondrichthyes solve the osmoregulatory problem in the ocean by concentrating urea in the blood until the osmotic pressure slightly exceeds sea water (hypertonic blood).

Only about 25-30 living species remain of the subclass Holocephali. They are entirely marine, typically deepwater (to 10,000 ft.) Placoid scales are essentially lost and the spiracle is lost in adults. The tail is diphicercal. Besides the pelvic fin claspers for internal fertilization, male chimaeras have tentaculums, small clasping appendages on the base of the pelvic fins and on the snout. Chimaeras have rodent-like, crushing teeth fused to the cranium (autostylic-like jaws). The largest chimaeras may reach six ft. but have little commercial importance, although they are eaten in some areas.

The Elasmobranchii are typically large, predaceous fishes. The whole shark and basking shark (45-50 ft. and to 70,000-50,000 lbs.) are the largest of all fishes. We will divide the subclass Elasmobranchii into two superorders--Selachii for the sharks (note Selachii is used for class Chondrichthyes in Encyclopedia article) and Batoidei for the skates and rays.

The most diagnostic character to separate all sharks from all rays is the opening of the gill slits--lateral on sharks and ventral on skates and rays. Fertilization is always internal. The pelvic fins of all male Chondrichthyes are modified as intromittant organs called claspers. Reproduction may be oviparous, ovoviparous or viviparous (maternal food supply to embryo). The intestine of all Chondrichthyes is of the typical spiral valve type.

There are about 225 living species of sharks which can be classified into the following major groups (orders or suborders) to which we will not assign formal taxa or nomenclature.

Group 1. The primitive 6 or 7 gill sharks and those with primitive dentition pattern. A relatively few, uncommon species such as the Port Jackson, frill and cow sharks.

Group 2. Galeoid sharks: the largest and most common sharks including the white, mako, tiger, basking, whale, thresher and hammerhead sharks. Galeoid sharks are distinguished by the presence of an anal fin, absence of spines in the dorsal fins and a reduced spiracle.

Group 3. Squaliod sharks: spiney dogfish and spiny sharks. Anal fin absent, dorsal fins with spines, spiracle well developed.

Two other sharks, the sawshark (which resembles the sawfish--a true ray) and the angel shark (also resembling Batoidei) are often classified in separate orders or suborders.

About 25 species of sharks are known to attack man, but the most dangerous by far is the white shark, Carcharodon carcharinus (the star of Jaws).

Batoidei consists of about 325-350 living species of skates and rays (the term skate is typically used for the suborder Rajoidei) including the sawfish and guitarfish (shark-like rays). Being specialized for benthic life, the spiracle is well developed for respiration. Although generally specialized for feeding on molluscs and benthic invertebrates some batoids have strange adaptations for other methods of obtaining food such as the rostrum of the sawfish, the electric organs of the torpedo rays, and the plankton straining mouth of the manta ray which is the only fish to "fly" through the water by flapping its "wings". The "wings" of skates and rays are formed from the greatly expanded pectoral fins (the fin elements without fin rays). The largest of all batoids is the manta ray which may have a wing spread of 18-20 ft. and weigh over a ton. The defensive action of torpedo rays (electricity) and sting rays (venom) are dangerous to man, but skates and rays are not known to unprovoked attack on man.

Completely freshwater species of rays are known in South America, Africa and Asia. In a South American freshwater species studied, urea is not present in the blood.

Primitive endolymphatic ducts are present in Chondrichthyes (external tube to inner ear).

Chondrichthyes make up about 3% of all fish species of the world but only about 1% of the world's commercial catch of fish. Although considered as good food in many parts of the world sharks and rays have never been a popular food fish in North America. The contribution of Chondrichthyes to the world's protein supply could be greatly increased. Other commercial shark and ray products, now largely replaced by synthetics, include liver oil, sandpaper (Shagreen), leather and sharkfin soup.

Class Osteichthyes

True bone, air bladder (or lung), upper jaw of pre-maxillary and maxillary. Subclass Dipnoi and subclass Crossopterygii are sometimes considered together as subclass Sarcopterygii. Both phylogenies (Dipnoi and Crossopterygii) were already separated by the early Devonian period. The only consistent difference between Dipnoi and Crossopterygii is in the structure of the skull. The evolutionary impetus stimulating the early radiation of lungfishes and coelacanths evidently resulted in specializations to utilize atmospheric air for respiration and to move about out of water during the Devonian period when bodies of water were drying up and stagnating.

The ability to convert nitrogenous wastes into urea is retained in these subclasses (lost in Octinopterygii). The jaw is autostylic and the caudal skeleton diphicercal in living species. Lungfishes and fossil Crossopterygii have internal nares but the single living coelacanth has closed nostrils. All living lungfishes are primary freshwater species (salinity not tolerated) and have a primitive distribution: Africa (4 species), South America (1 species) and Australia (1 species). The living coelacanth is marine, evidently a deepwater species restricted to a relatively small area off of Southern Africa in the Indian Ocean.

The primitive type of scale in these subclasses was cosmoid, but the scales are highly modified in living species.

The African and South American lungfish can aestivate in the mud for more than a year if their habitat drys. All lungfish can respire with both gills and lungs. The living coelacanth has lost its lungs and has instead, a fat-filled organ. The rhipidistian group of Crossopterygii is generally believed to have given rise to the Amphibia during Devonian times. The Dipnoi and Crossopterygii were common in later Paleozoic and early Mesozoic times but their numbers dwindled during the Mesozoic as the Actinopterygii (Chondrostei and Holostei) became dominant. The Crossopterygii disappeared from the fossil record in the Cretaceous--not to be heard from again until the discovery of a living species in 1938.

The subclass Actinopterygii appears in the fossil record of mid-Devonian times as paleoniscoid fishes. Urea retention is lost in the Actinopterygii and changes in the skull occur leading to a transition from an autosylic to a hyostylic jaw.

From the early paleoniscoids, two phylogenies have persisted to the present--the order Polypteriformes, a group of about 10 species of African primary freshwater fish, which resemble the fossil paleoniscoids.

Polypteriformes (often considered a subclass Brachyopterygii) have typical ganoid scales, a functional lung, lobed fins and a diphicercal tail.

The other paleoniscoid derivative is the superorder Chondrostei including the Acipenseriformes (sturgeons) and Polyodontiformes (paddlefish). The living Chondrostei are highly modified from the ancestral paleoniscoids but still retain the basic features of a cartilaginous notochord, three elements in the opercle, a clavicle in the pectoral girdle, each pterygiophore supporting more than one dorsal and anal fin ray, a typical heterocercal tail and a spiracle (although much reduced). About 25 species of freshwater and anadromous sturgeons are indigenous to the Northern Hemisphere. Huso huso, the beluga of the Caspian Sea, is the largest species, known to reach more than 2000 lbs. at one time. The great value of caviar has helped to save the sturgeons where their spawning runs have been blocked.

Two species of paddlefish are known. One (Polyodon) is native to the Mississippi-Missouri basin and the other (Psepherus) is indigenous to the Yangtze River of China. Paddlefish are characterized by a greatly elongated rostrum and are filter feeders with a tremendous development of gillrakers.

During the early Mesozoic period, a progressive evolutionary trend produced the Holostei from Chondrostean ancestors. These trends include replacement of the notochord by ossified vertebrae, four bones in the opercle, branchiostegal rays predominant over gular plates, loss of the spiracle (retained as a pseudobranch into the teleosts), one to one ration of dorsal and anal rays to pterygiophores, loss of clavicle, trend in freeing upper jaw from cranium, reduction in heterocercal tail.

During the Mesozoic, Holostei became the dominant fishes of the world, but beginning in the Cretaceous, they were largely replaced by the Teleostei.

All that is left of Holostei are the gars (hepisosteiformes or Semonotiformes)--10 species native to eastern North America and Central America, and the bowfin, a single species, Amia calva, in the order Amiiformes, or eastern North America. The gars retain typical ganoid scales, typical hetercercal tail and an air bladder used for atmospheric respiration (gars will drown if denied access to the surface). The alligator gar has been known to reach a weight of 300 lbs.

The bowfin has lost the ganoid layer on its scales, the heterocercal tail is reduced (abbreviated) but the air bladder can still be used for respiration to allow existence in stagnant waters. Both gars and bowfins are predators and generally considered as pest or trash fish. These few relics of the once dominant Holostei, however, are abundant and flourishing, often to the consternation of fishery managers.

During the mid-Mesozoic period, a group of Holostei--the Pholidophoriformes--evolved advanced characters and gave rise to the Teleostei which rapidly radiated during Cretaceous times to become the dominant fishes in all waters of the world--presently making up more than 95% of all living species. The major teleost trends include hyostylic jaws, homocercal tail, hydrostatic air bladder and small size.

Supplementary Notes FW 300

The Teleostean Fishes

In the mid-Mesozoic period, the order Pholidophoriformes of the Holostei evolved several advanced characters providing the basis for the origin of the most speciose vertebrate taxon (probably about 25,000 living species of teleostean fishes exist).

There is no clear-cut separation between Holostei and Teleostei. The major differences concern the caudal skeleton (fewer, vertebral centra involved in the support of the fin rays; that is, going from heterocercal to homocercal), the loss of ganoine on the scales (ganoid to cycloid scale), fewer separate bones in the skull and jaws and a further "freeing" of the maxillary from the head.

The phylogenetic progression within Teleostei concerns several characters such as: 1. Jaws. Premaxillary becomes dominant over the maxillary allowing the upper jaw to be protrusible. 2. Fins. Pelvic fins move anterior with basipterygium in contact with pectoral girdle. Pectoral fins move dorsally and positioned (when fanned out) in a more vertical rather than horizontal plane. 3. Air bladder. Duct lost (physostomous to physoclistic) so any respiratory function is lost. 4. Caudal skeleton. Progressing from 2-4 vertebral centra involved in caudal fin support in primitive state to one centrum (urostyle). 5. Spines. True spines (unsegmented) develop in fins in advanced teleosts. 6. Scales. Cycloid to Ctenoid.

There is a transitional series of diverse groups of fishes before the fully advanced stage of "spiny rayed" fishes is reached. According to the classification of teleostean fishes by Greenwood, Rosen, Weitzman and Myers, three phylogenetic side branches of living teleosts arise before the main stem form (Salmoniformes) is reached. These three early divergences are represented by the Elopomorpha (including the orders Elopiformes and Anguilliformes), the Osteoglossomorpha (orders Osteoglossiformes and Mormyriformes) and the Clupeomorpha (only order Clupeiformes). At the base of the evolutionary line leading to Salmoniformes, two new phylogenies appear - the Ostariophysi (Cypriniformes and Siluriformes) and the Myctophiformes. After evolutionary advancement beyond the Salmoniform level, the advanced, spiny-rayed fishes occur in the fossil record of the upper Cretaceous. The spiny-rayed fishes are divided into two major phylogenies - the Paracanthopterygii, with about 5 orders, and the Acanthopterygii, with about 12 orders, including the Perciformes, the largest order of Vertebrates with over 8,000 species.

Elopomorpha fishes with leptocephalus larvae.

Order Elopiformes. Vestige of heterocercal tail, gular plate in some species, air bladder may be used in respiration. Marine, world-wide distribution. Mainly littoral, estuarine (euryhaline) species. Twelve species arranged in 4 families, includes ladyfish, ten pounder, tarpon and bonefish.

Order Anguilliformes. True eels. About 500+ species arranged in 20 families. Marine species, except for family Anguillidae which are catadromous. World-wide distribution.

Osteoglossomorpha. Some primitive skeletal features.

Order Osteoglossiformes. Primary freshwater fishes, largely replaced throughout the world by Ostariophysi. About 15 living species arranged in 4 families. Family Osteoglossidae has species in Africa, South America, Australia and Southeast Asia--the most ancient distribution of any family.

The arapaima, an osteoglossid of South America may attain a weight of more than 400 lbs. and is one of the largest of primary freshwater fishes.

The family Hiodontidae consists of two species endemic to North America.

order Mormyriformes. Electrical sensory primary freshwater fishes of Africa. The family Mormyridae has 130+ species and the family Gymnarchidae has only one known species. Note the relatively greater success (in number of living species) of the Mormyriformes in relation to the Osteoglossiformes. Evidently the electro-orientation system allows for a highly specialized coexistence with Ostariophysi (there are only 4 species of Osteoglossiformes in Africa).

Clupeomorpha. order Clupeiformes. Many peculiar features such as an air bladder directly in contact with inner ear capsule and a posterior duct from air bladder, sets Clupeiformes off from other teleosts. In the former classification of Regan and Berg, the Clupeiformes (Isospondyli of Regan) included just about all teleostean fishes up to the present level of Paracanthopterygii and Acanthopterygii. The present classification of Clupeiformes includes about 400 species in 4 families. Almost all species, however, belong to the herring family (Clupeidae) and the anchovy family (Engraullidae). Typically, Clupeiform fishes are pelagic plankton feeders, and form tremendous aggregations. About one third or more of the total world's fish catch consists of Clupeiformes - and only a relatively few species of herrings and anchovies make up this catch.

Order Salmoniformes. Contains diverse groups of uncertain relationships, but sharing, rather generalized, primitive characters.

Suborder Salmonoidei includes Northern Hemisphere freshwater and anadromous species (secondary freshwater fish) of the families Salmonidae and Osmeridae plus two families in the Far East.

The family Salmonidae consists of three subfamilies: Salmoninae for the trouts, salmons and chars (*Salmo*, *Oncorhynchus* and *Salvelinus*); Coregoninae for the whitefishes and Thymallinae for the graylings.

The subfamily Salmoninae contains species of trout and salmon whose value in the water greatly exceeds their value as food. That is, anglers are willing to make huge investments merely for the opportunity to try to catch these beautiful and sporting fishes.

Suborder Esocoidei contains 10 species in two families distributed in Europe, Asia and North America. All species are primary freshwater fishes. The pike family *Esocidae* contains 5 species in the genus *Esox*. All are specialized predators. The mudminnows and Alaskan blackfish comprise 5 species of small, sluggish fish specialized to live in stagnant waters with low oxygen tensions.

The Southern Hemisphere freshwater salmoniform fishes (secondary freshwater) are classified in the suborder Galaxoidei and are native to Australia, New Zealand, South America and Africa (one species of *Galaxias*).

The other salmoniform fishes are all deep sea marine species in the suborders Stomiatoidei, Argentinoidei and Alepocephaloidei. These are typically small fish with weird adaptations such as large teeth, large eyes and photophores. Along with the order Myctophiformes they total more than 1000 species and are the dominant fishes of the ocean depths (below level of light penetration).

The Ostariophysi are fishes with a Weberrian apparatus and includes about 6200+ species in the orders Cypriniformes and Siluriformes. Except for two marine families of Siluriformes, virtually all Ostariophysi can be considered as primary freshwater fishes. They dominate the freshwater fish fauna of the world (about 93% of all primary freshwater fishes).

Siluriformes are grouped into 31 families indigenous to South America, Africa, Europe, Asia and North America. The family Ictaluridae is endemic to North America. Catfishes are amazingly diverse in size, shape and ecology. Species range in size from about 1-2 inches to 1200 lbs.

Cypriniformes are divided into three suborders. Cyprinoidei, lack teeth in jaws and mouth, the pre-maxillary is dominant and the jaws may be protrusible, the adipose fin is absent. The family Cyprinidae is the largest family of Vertebrates with more than 2000 species in Africa, Europe, Asia and North America.

The Catostomidae (suckers) are predominantly North American species with two species in Asia--the longnose sucker, a recent immigrant to Siberia, crossing the Bering land bridge as recently as 11,000-12,000 years ago, and an ancient (Miocene) relic in central China (note similarity in this distribution with the paddlefishes). Much convergence for sucker-like mouths and body shape occurs in Cyprinidae of Europe and Asia to fill a similar niche in areas where Catostomidae are absent.

The family Cobitidae, the loaches, are typically small, eel-like fish with numerous barbels found in Africa, Asia and Europe. Some utilize atmospheric oxygen through respiration in the intestine.

The suborder Characoidei consists of 16 families of characin fishes native to South America and Africa. One species occurs in the U.S.A. in the lower Rio Grande. The isthmus of Panama has been virtually a complete block to passage of primary freshwater fishes between North and South America. The zoogeography of Ostariophysi is nicely correlated with their phylogeny. The more primitive lines (Siluriformes and Characoidei occur in both Africa and South America and evidently gained this distribution prior to the complete separation of the continents. Characters such as teeth in jaws, non-protrusible jaws, and adipose fin reveals that characins are a more ancient lineage than the cyprinoid fishes.

The other cypriniform suborder consists of 4 families of electrical fishes (Gymnotoidei) of South and Central America. Only the electric eel produces high voltage discharges. The other species specialize in low voltage electrical fields for orientation and sensing their environment. Note the convergence between the suborder Gymnotoidei and the order Momyriformes.

The advanced, spiny-rayed teleost fishes are divided into two major evolutionary groups, the Paracanthopterygii and the Acanthopterygii. The Paracanthopterygii consists of 5 orders with about 1000 species.

The order Percopsiformes is the most primitive order. It consists of about 10 species of small, primary freshwater fishes, all endemic to North America. The cave fish family, Amblyopsidae has about 7 species in the eastern U.S. The trout perch family, Percopsidae, has two species. Trout perches have true spines, ctenoid scales and an adipose fin. No other true spiny-rayed fish have adipose fins. The pirate perch family, Apherododeridae has but a single living species. Evidently the Percopsiformes have been almost entirely replaced by other groups.

The Gadiformes is the largest and most important order of Paracanthopterygii, because of the abundance and commercial significance of the codfishes. The only strictly freshwater species of Gadiformes is the burbot, Lota lota, of the Holarctic region. The Gadiformes also contains some deep-sea families. The suborders Ophidoidei (brotulas, cusk eels) and Zoarcoidei (eel-pouts) inhabit the greatest depths of the oceans. These suborders were placed in Gadiformes by Greenwood, et. al., but they are most likely derived from the order Perciformes of the acanthopterygian phylogeny.

The order Batrachoidiformes (about 45 species of toadfishes) and the order Gobiesociformes (about 100 species of clingfishes) are both mainly marine, littoral fishes of the temperate and tropical seas. A group of Pacific toadfishes - the "midshipmen" - have photophores. The clingfishes modify the pectoral and pelvic fins into a sucking disc. They are euryhaline and have given rise to some freshwater species in rivers in Central America (where a depauperate primary freshwater fauna exists).

The Lophiiformes is an order of about 200 species of anglerfishes, with some bizarre, deep sea fishes with photophores and parasitic males. A dorsal fin ray is modified as a "fishing pole with a bait" to lure prey. Lophiiformes are almost entirely marine but some species are known from freshwater, despite lack of glomeruli development for pumping out water. Evidently diffusion into the body must be greatly reduced.

NAME ____________________________

FW300 Test II

February 16, 1973

1. (40) Concisely characterize the following groups of fishes, giving their distribution, typical habitat (with any notable exceptions), approximate number of species comprising the group, certain characters that place this group in a phylogenetic sequence of fish evolution and any significant notes on life history and reproduction you deem important.

A. order Percopsiformes:

B. order Siluriformes:

C. family Salmonidae:

D. suborder Esocoidei

2. (10) State the problem of maintaining the salt and water balance in fish in freshwater and in the ocean. How is osmo-regulation handled by (a) teleosts (b) elasmobranchs?

3. (6) Cite three examples where fins are modified for a unique function. Name the function, the fin involved and fishes exemplifying the example.

4. (9) Briefly define:

a. stenohaline:

b. primary freshwater fish:

c. relict:

d. endemic:

e. stannius corpuscles:

f. gynogenetic:

g. protandrous hermaphrodite:

h. ultimobranchial:

i. species flock:

5. (6) List 6 families of fishes that are endemic to the freshwaters of North America.

6. (5) List 5 families of fishes that are endemic to the Northern Hemisphere; that is indigenous to North America and Asia and/or Europe.

7. (4) List 4 familis of fishes that consist of mainly marine species but have freshwater species (vicarious freshwater fishes).

NAME ______________________________

8. (10) Indicate which of the following species are native (N) and which are introduced (I) to Colorado. If neither term is applicable, mark an (X).

Bowfin, *Amia calva*	( )
Gizzard shad, *Dorosoma cepedianam*	( )
Mountain whitefish, *Prosopium williamsoni*	( )
Cutthroat trout, *Salmo clarki*	( )
Grayling, *Thymallus arcticus*	( )
Muskelunge, *Esox masquinongy*	( )
Bonytail chub, *Gila elegans*	( )
Humpback sucker, *Xyrauchen texanus*	( )
Grass carp, *Ctenopharynogodon idella*	( )
Burbot, *Lota lota*	( )

9. (5) Compare and contrast specific stages in the life histories of the eel, *Anguilla rostrata* and sea lamprey, *Petromyzon marinus*. Include the terms elvers, ammocete, leptocephalus, anadramous and catadromus.

10. (10) Construct a dichotomous key, using diagnostic characteristics serving to separate the following: *Squalus acanthias* (Elasmobranchi) *Catostomus catostomus* (Catostamidae), *Cyprinus carpio* (Cyprinidae), *Oncorhynchus nerka* (Salmonidae), *Ictalurus punctatus* (Ictaluridae).

NAME____________________

Ichthyology Exam
Feb. 18, 1974

1 (12) The following three titles appeared in recent publications. From these titles, tell what you think the article is all about.

A. Upper Cretaceous ostariophysine (Vorhisia) redescribed from unique association of utricular and lagenar otoliths (lapillus and asteriscers).

B. Hybrid zones and reproductive isolation.

C. Cytogenetic studies of Poecilia. Persistence of triploid genomes in the unisexual progeny of triploid females associated with Peocilia formosa.

2 (10) Within a class or an order of fishes, what kind of evidence is used and how is it interpreted to evaluate the relative phylogenetic position of a family (or genus) in relation to its primitive or advanced state.

3 (6) Describe two different evolutionary statergies allowing fishes to utilize temporary habitat (alternating flooding and desiccation).

 NAME____

4 (26) Define or describe:

a. Protogynous hermaphroditism

b. Gynogensis

c. Diadromous

d. Leptocephalus larvae

e. Basibranchial teeth

f. Pholidophoroid Holostei

g. Gaeleoid elasmobranch

h. Acanthopterygii

i. Existing families of Actinopterygii with spiracle

j. Mesocoracoid

k. Endemic species

NAME ____________________

l. Relict species

m. Gular plate

5 (15) State the geographical distribution (continents) of existing species of:

a. Dipnoi

b. Polyodontidae

c. Catostomidae

d. Cyprinidae

e. Esox

6 (10) What factors lead to convergent evolution? Cite an example of convergent evolution, naming the fishes and the niche involved.

NAME ______________________________

7 (6) List the major diagnostic character differentiating all existing species of:

a. Sharks from rays:

b. Chondrostei from Holostei:

c. Holostei from Teleostei

8 (15) Construct a key which functions to separate: Amiidae, Anguillidae, Clupeidae, Salmonidae, Characidae, Gadidae, Cyprinidae, Salmo, Coregonus, Salvelinus, Cyprinus (carp), Tinca (tench).

NAME ______________________________

FINAL EXAM
MARCH 14, 1974
200 Points

1. (25) What orders, super orders, subclasses and classes of fishes possess the following characters:

   a. One semi circular canal ______________________________

   b. Two semi circular canals ______________________________

   c. Clavicle ______________________________

   d. Mesocoracoid ______________________________

   e. Gular plate ______________________________

   f. Rectal gland ______________________________

   g. Spiracle ______________________________

   h. Endolymphatic ducts ______________________________

   i. Autostylic jaws ______________________________

   j. True heterocercal tail ______________________________

   k. True Diphicercal tail ______________________________

   l. Tenaculum ______________________________

   m. Spiral valve intestine ______________________________

   n. Ganoid scales ______________________________

2. (20) Indicate by an arrow the evolutionary trend from primitive to advanced condition of the following pairs of characters:

a.	Maxillary dominant	premaxillary
b.	Air bladder hydrostatic	air bladder respiratory
c.	mesocoracoid	clavicle
d.	mesocoracoid present	mesocoracoid absent
e.	pelvic fins abdominal	pelvic fins jugular
f.	homocercal tail	heterocercal tail
g.	hyostylic jaws	autostylic jaws
h.	stapes	hyomandibula
i.	gular plate	branchiostegal rays
j.	Many fin rays per pterygiophore	1:1 ratio

3. (40) Define:

a. Synonym

b. Homonym

c. Type specimen

d. Type locality

e. First reviser

f. Polytypic species

g. Homology

h. Codon

i. Karyotype

j. Amino acid sequence

k. Taxonomy

l. Systematics

m. *Salmo* *clarki* Richardson 1836

n. *Salmo* *clarki* *lewisi* (Girard 1856)

NAME ________________________________

o. Monophyletic

p. Rule of priority

q. Cytosine

r. Allele

s. Gene

t. Polypeptide

4. (15) Although more than 90% of the water on earth is in the oceans (Marine environment), about 1/3 of all fish species live in freshwater. How might this be explained?

5. (10) A recent television program presented in documentary style, suggested that because the insects are such a successful group, they will inherit the earth, and eventually all animal life will be of the class Insecta. From our discussions in class of natural selection, niches and how evolution works--why would you consider this TV show to be in the realm of science fiction rather than scientific documentary?

NAME ______________________________

6. (15) How might a very condensed abstract for the following titles read?

   a. Taximetric analysis of selected groups of western North American <u>Salmo</u> with respect to phylogenetic divergences.

   b. The application of cytogenetic and biochemical systematics to phylogenetic problems in the family Salmonidae.

   c. Cytotaxonomic studies of the coregonine fishes of the Great Lakes, USA: DNA and karyotype analysis

7. (15) Why might the typological approach lead to erroneous conclusion for:

   a. Orthodox taxonomy

   b. Biochemical taxonomy

   c. Fisheries management

NAME ______________________________

8. (20) Match the most correct letters from column 2 to column 1 (More than one may be correct).

Atrium ____________________ A. Respiratory

Pyloric caeca ______________ B. Circulatory

Hemibranch ________________ C. Excretory

Centrum ___________________ D. Vision

Weberian apparatus _________ E. Skeletal

Sacculus __________________ F. Digestive

Basipterygium ______________ G. Reproductive

Epaxial ___________________ H. Auditory

Pseudobranch _______________ I. Orientation

Gonopodium ________________ J. Musculature

Hypurals __________________ K. Pressure receptor

Bowmans Capsule ___________ L Electro receptor

Neuronost _________________

Choroid gland ______________

Ampullia Lorenzini __________

Spiracle __________________

9. (25) Match one or more from column 2 to column 1.

1. Polypterus (bichirs) __________ A. Endemic North America
2. Lepisosteus (gars) __________ B. North America & Asia
3. Ptychocheilus (squawfish) ____ C. Endemic Africa
4. Salvelinus namaycush ________ D. Viviparous
5. Gadus ____________________ E. East of Rocky Mountains
6. Catostomidae ______________ F. West of Rocky Mountains
7. Salmo clarki _______________ G. Mainly marine
8. Archoplites interruptus ______ (Sacramento perch) H. Native to Colorado

. [illegible] __________

NAME ______________________________

9. Hiodon (goldeye) ______________

10. Embiotocidae ______________

11. Polyodontidae ______________

10. (15) Fill in the name of the taxon or the diagnostic characters to complete this key.

1 (A) One semicircular canal ______________________________

(B) Three semicircular canals - 2

2 (A) Placoid scales present ______________________________

(B) Placoid scales absent (3)

3 (A) Gular plate present (4)

(B) Gular plate absent (5)

4 (A) Superorder of North American freshwater fishes ______________

(B) Family of marine fishes ______________________________

5. (A) Pelvic fins absent (6)

(B) Pelvic fins present (7)

6 (A) ______________________________ Balistidae

(B) ______________________________ Anguillidae

7 (A) Adipose fin present (8)

8 (A) ______________________________ Salmonidae (9)

(B) ______________________________ Osmeridae

9 (A) Maxillary toothed, scales small. Subfamily ______________ (10)

(B) Maxillary toothless, scales large. Subfamily ______________

NAME ______________________________

10 (A) Anal rays less than 14 - (11)

(B) Anal rays 14 or more ______________________________

11 (A) Teeth on shaft of vomer; genus ______________________________

(B) Vomer shaft toothless; genus ______________________________

FW 300 Exam I
20 February 1976
100 points

NAME ____________________________

1. (18) Sketch a phylogenetic arrangement of fishes starting with the Agnatha indicating the positions of Chondrichthyes, Osteichthyes, Dipnoi, Crossopterygii, Actinopterygii, Chondrostei, Holostei and Teleostei. Note on your phylogeny where the following structures first appear: jaws, paired fins, hyostylic jaws, homocercal tail, placoid scale, ctenoid scale, spiracle. Also indicate which evolutionary lines are associated with 1) ammocoete larvae, 2) single nostril, 3) internal nares and 4) urea in blood for osmoregulation.

2. (10) Briefly identify:

John Ray

Peter Artedi

Linnaeus

Lamark

D. S. Jordan

3. (12) What are the major premises on which Darwin based his theory of evolution? In what way was Darwin's theory "Lamarkian" in explaining the cause of change?

4. (16) What morphological, anatomical and sensory system specializations might be expected in: 1) a typical day time predator, 2) a typical nocturnal benthic feeder, 3) a pelagic plankton feeder.

5. (14) Fill in terms which best describe an evolutionary trend going from a primitive to an advanced condition in fishes.

1. Pelvic fins abdominal to ________________________________ position.
2. Air bladder physostomus to ______________________________.
3. Ganoid scales to ________________________ scales.
4. Autostylic jaws to _______________________________ jaws.
5. Spiracle to ___________________________.
6. Heterocercal tail to ___________________________________ tail.
7. Maxillary dominant to ___________________________________ dominant.

6. (30) Briefly define:

1. Basipterygium
2. Clavicle
3. Cosmoid scale
4. Otolith
5. Weberian apparatus
6. Typology
7. Hyomandibula
8. Choroid gland
9. Neuromast
10. Gular plate
11. Dorsal fin X-10
12. Epipleural
13. Cleithrum
14. Binomial nomenclature
15. Pterygiophore

FISH PHYSIOLOGY LABORATORY PUBLICATIONS AND INVESTIGATIONS

Publ. No.

65-1 Norris, D. O., and A. Gorbman. Radiothyroidectomy of larval steelhead trout. Proc. Soc. Exp. Biol. & Med., 119: 1205-1207.

65-2 Norris, D. O. The effect of radiothyroidectomy on growth rates of juvenile steelhead trout (Salmo gairdneri) and chinook salmon (Oncorhynchus tshawytscha). Amer. Zool., 5: 79.

66-3 Windell, J. T. Rate of digestion in the bluegill sunfish. Invest. Ind. Lakes & Streams, 7: 185-214.

67-4 Windell, J. T. Rates of digestion in fishes. In Gerking, S. D., ed., The Biological Basis of Freshwater Fish Production. Blackwell Scientific Publications, Oxford. 495 pp.

67-5 Windell, J. T. The 24-hour feeding chronology of the bluegill sunfish (Lepomis macrochirus). J. Colo.-Wyo. Acad. Sci., 5(8): 10-11.

68-6 Kitchell, J. F., and J. T. Windell. Rate of gastric digestion in pumpkinseed sunfish, Lepomis gibbosus. Trans. Amer. Fish. Soc., 97(4): 489-492.

68-7 Windell, J. T., and D. O. Norris. Gastric digestion and evacuation in rainbow trout (Salmo gairdneri). Prog. Fish-Culturist. In press.

67-8 Windell, J. T. Starvation and rate of digestion for the bluegill sunfish (_Lepomis macrochirus_). J. Colo.-Wyo. Acad. Sci., 5(8): 11-12.

68-9 Norris, D. O. Depression of growth following radiothyroidectomy of larval chinook salmon and steelhead trout. Trans. Amer. Fish. Soc., In press.

67-10 Norris, D. O. Examination of thyroidal autoimmune response in radioiodide-treated steelhead trout. J. Colo.-Wyo. Acad. Sci., 5(8): 18.

67-11 Norris, D. O. Migratory behavior of normal and radiothyroidectomized steelhead trout in Fern Lake, Washington. Abstracts of Regional Symposium on Comparative Endocrinology, Reed College, February, 1967.

68-12 Windell, J. T. Food analysis and digestion rates. _In_ Ricker, W. E., ed., Methods for Assessment of Fish Production in Fresh Waters, IBP Handbook No. 3, Blackwell Scientific Publications, Oxford. 313 pp.

68-13 Windell, J. T. Rates of digestion for rainbow trout. Abstracts, Colo.-Wyo. Division, Amer. Fish. Soc..

68-14 Windell, J. T., and D. O. Norris. Gastric evacuation of natural and unnatural foods in rainbow trout (_Salmo gairdneri_). J. Colo.-Wyo. Acad. Sci., 5(9): In press.

68-15 Kitchell, J. F., and J. T. Windell. Effects of fat and food volume on gastric evacuation in the pumpkin-seed sunfish, Lepomis gibbosus. J. Colo.-Wyo. Acad. Sci., 5(9): In press.

68-16 Norris, D. O. Effect of radiothyroidectomy and thyroxine replacement on the growth rates of salmonid fry. J. Colo.-Wyo. Acad. Sci., 5(9): In press.

Manuscripts in Preparation

1. Windell, J. T., J. F. Kitchell, J. S. Norris and D. O. Norris. Digestibility of food components by rainbow trout (Salmo gairdneri).
2. Windell, J. T., J. F. Kitchell, J. S. Norris and D. O. Norris. Food progression in rainbow trout (Salmo gairdneri).
3. Windell, J. T. Estimation of food consumption rates in bluegill sunfish (Lepomis macrochirus).
4. Kitchell, J. F., J. S. Norris, J. T. Windell and D. O. Norris. A comparison of the rates of gastric evacuation in large and small sunfishes; Lepomis cyanellus, L. macrochirus and L. gibbosus.
5. Windell, J. T. Return of digestion to normal after fasting.

Investigations in Progress

1. Windell, J. T., and J. F. Kitchell. Nutritional value of algae to bluegill sunfish.
2. Kitchell, J. F. Effect of temperature on gastric evacuation in bluegill sunfish.
3. Windell, J. T., D. O. Norris, J. F. Kitchell and J. S. Norris. Effect of temperature on the digestive physiology of rainbow trout.
4. Kitchell, J. F. Ph.D. Thesis. The daily ration approach to the study of food consumption by a population of bluegill sunfish.
5. Norris, J. S. Ph.D. Thesis. A radioisotopic method for measuring pepsin secretion in the bluegill sunfish.

Other Publications

E-67-1 Norris, D. O., ed., Report on the Second Colorado-Wyoming Conference on Undergraduate Education in Biology, April, 1968. 23pp.

E-69-2 Norris, D. O. Mutation and drug resistance in bacteria; a laboratory experience. The Science Teacher. In Press.

E-69-3 Windell, J. T., and D. O. Norris. General Biology Laboratory I.

E-69-4 Norris, D. O., J. T. Windell and J. S. Smith. General Biology Laboratory II.

R-67-1 Kitchell, J. F. Body temperatures of snakes in a thermal gradient. J. Colo.-Wyo. Acad. Sci., 5(8): 99.

R-69-2 Kitchell, J. F., Thermophilic and thermophobic responses of snakes in a thermal gradient. Copeia. In press.

FW501

1. The Journal of Wildlife Management, 55(4), contains an article by H. C. Romesburg, "On improving the natural resource and environmental sciences." Natural resource science, according to Romesburg's definition concerns commodity issues (such as wood, meat, hunting, fishing, recreation) and environmental science deals with noncommodity issues such as conservation biology, endangered species, etc. His point is that we have had poor success in managing natural resources--the professions lack credibility. His solution is to attract better students to the natural resources-environmental professions. To attract the best and the brightest by methods used by top sport teams to attract the superstars that make for winning teams. He also sees a need to change our system of education.

   Obviously, this is a most important issue for the future. We would all agree on the need to "improve the natural resource and environmental sciences," but by what means? Because virtually all natural resource management and research is controlled by government agencies and universities, typically funded by these agencies, the matter of administrative structure (bureaucracy) of government agencies which may suppress innovative and creative ideas in favor of committee consensus and status quo must be considered.

   Delineate your thoughts on the matter of how the natural resource and environmental sciences can be improved -- raise IQ of people, changes in education, changes in administrative structure, etc.

2. Explain how you can use the concept of macroniches to provide insights to predict the consequences of the introduction of a new species into an ecosystem. Discuss the pheasant as a successful introduction (a "good" introduction) and the successful (but "bad") introductions of such species as English sparrow, starling, Mysis shrimp, and carp. What basic information was lacking at the time the "bad" species were introduced?

FW501 Essay Exam

We have discussed problems of natural resource, environmental, conservation, and particularly fisheries management and research - how to do a better job, gain reliable knowledge, how to be more effective at problem and conflict resolution; how to improve credibility. Various remedies have been proposed - better students, improved education, proper experimental design, communications (human dimension), agency structure, etc.

Write a "proposal" as if for funding, to convince me that your "project" would make a useful contribution towards improvement in one of the above mentioned areas. Be aware of problems of moving from generalities (good intentions) to specific implementation, necessary to achieve success.

Chas.
... Re. problems - most ... Fish Mgt. - Activities - use Paradigms, experience, personal expertise : time frame : New reservoir what to stock --- Romesburg
long term - food web disturb
- energetics -
- - -
what do - "research"
- zebra mussel
- uncertainties, unpredictabilities
when completed - no dif.
NAPAP - regional model
- grazing - long term res
- vs. fencing -
- when rigorous sci. mgt necessary?
- solution? - - -

- Rachel Carson
- Darwin - Agassiz
- Luther Burbank - gen. strains - hatch - Wis. Calif.

- lesson for reading - brown bag - ex
- energetics - L. Mendota -
- natural phenomenon
- hot, dry (10-25 yr)
O2 - temp - - bluegreen
coincide w/ cisco - zoopl. - phyto.
- ...
- self-adjusting - die-off.

Name:____________________

FW555

October 1990

1. A major point of contention of the Endangered Species Act concerns the unit of diversity protected under the Act. In seeking a rational basis for resolution of this controversy, a basic assumption is that to adequately protect biodiversity, protection must extend to below the species level (intraspecific diversity), but protection of intraspecific diversity, expecially "nontaxa" diversity opens a "can of worms", and threatens to weaken the E.S.A. Provide your rational basis for criteria that might serve to define, prioritize, and select units (parts of a species) that would qualify for protection. Discuss the pros and cons of a taxa approach, a nontaxa approach, and methods which might be useful to characterize units that would receive priority for protection.

2. Define endemism. Why would you expect a higher degree of endemism in an area long isolated from "core" mainland areas. Why is endemic island fauna and flora more susceptible to extinction from the establishment of non-native species than mainland (continental) species? How do you explain the fact that the Colorado River Basin has the highest degress of endemism of freshwater fishes of any Nearctic river basin, but essentially has no endemism (perhaps a few dubious subspecies) of birds and mammals?

Presently, the Endangered Species Act defines "species" to include subspecies and populations (one population of the nonendangered chinook salmon species is currently listed and protected under the ESA and several more have been recommended for listing). The ESA comes up for reauthorization in 1992. There will be a strong effort to revise the definition of "species," probably along the lines recommended in the January 1979 Harper's magazine article (The Sinking Ark). That is, there is no biological justification for preserving intraspecific diversity or even diversity among a group of closely-related species---150 species of darters, including the snail darter, could be lumped at the genus level and the ESA would not be invoked until virtually all diversity within the genus has been lost.

What advice and recommendations would you give to a congressional committee reviewing the species definition of ESA? Keep in mind that the present trend under the present definition is likely to lead to a backlash and result in a severe weakening of ESA. Assume that the general public and many, if not most, congressmen share, or are susceptible to the points emphasized in the Harper's magazine article--"red squirrel, black squirrel, what's the difference?"--"must we save all species or all diversity just because it exists?" --"What good is it?"

Can you perceive a resolution to the dilemma of preserving biodiversity in the face of sentiment that believes it is simply not feasible nor morally, biologically, or economically justifiable or defensible to preserve all existing diversity? How might a species definition using the concept of SEV be helpful?

COURSE OUTLINE

FW 555 03(2-0-1). Conservation Biology. F. Robert J. Behnke
15 Wagar 5320

FW 555 reflects a gradual evolution (since 1985) from Ecological Zoogeography to Conservation Biology emphasizing the theories and principles of Island Biogeography to develop an understanding of the patterns of biodiversity, the values of biodiversity, and a rationale for the preservation of biodiversity. The goal of the course is to produce students informed on the issues of conservation biology.

I. Introduction
   A. Historical and Phylogenetic Factors
      1. Phylogeny of vertebrates
      2. History of the earth
      3. Interpretation of distribution of diversity
   B. Ecological Factors
      1. Principles of habitat classification: biomes, life zones
      2. Biotic and abiotic factors
      3. Niches, niche shifts

II. Vertebrate Classes: Distributions, macro niches, roles in ecosystem, ectothermy, endothermy
   A. Fishes
   B. Amphibians
   C. Reptiles
   D. Birds
   E. Mammals

III. Evolution
   A. Coevolution, coadaptation
   B. Origin of species, of intraspecific diversity
   C. Evolution by natural selection as an adaptive process
   D. Conflicts among theories and ramifications regarding values of biodiversity

IV. Extinctions
   A. Types of extinction: Natural, accelerated, anagenetic, dead-end, catastrophic
   B. Implications regarding values of biodiversity

V. Rationale for Preservation of Biodiversity
   A. Conservation Biology and Natural Resource Management
   B. Implications for Fisheries and Wildlife Management
   C. Implications for changing ecosystems
   D. Non-native (introduced) species

TEXT: Biodiversity Wilson, E.O. editor. 1988. National Academy Press Washington, D.C. 521 pp.

PREREQUISITE: BY 220

FW 555 CONSERVATION BIOLOGY

Text: Principles of Conservation Biology
Lectures: Mon. Wed. 1:10 - 2:00 NR 115
Recitation Fri. as above, for student
presentations and makeup lectures
(later in semester).

Grading: Two take home exams (200), term paper (300); participation, attendance, seminar presentation (100).

The course consists of lecture and text, independent study (term paper), and seminar presentation. The term paper will be a topic you select to develop an in-depth knowledge of a particular subject relevant to conservation biology. The first take home exam is designed to gain familiarity with the text and an understanding of the basic principles and issues of conservation biology. "Participation" concerns class discussion and calling attention to pertinent current events from the media or journals.

We follow "adaptive management" for flexibility to address contemporary issues as they come up. Thus, there is no fixed schedule for reading assignments. Become familiar with the subject matter of each chapter of the text. Handouts that further elaborate on certain points will be distributed throughout the semester.

Conservation Biology covers a wide range of subjects from theoretical ecology to economics and philosophy. There are many definitions of conservation biology (see chapter 1). Most simply, it concerns preservation of biodiversity. A real challenge is to develop a logical rationale that would convince most people of why we want to preserve biodiversity. What good is it?

There is nothing in the methods, math, or models that is unique to conservation biology--it is eclectic. Several separate disciplines such as conservation genetics, conservation education, landscape ecology, restoration ecology, natural resource (or ecological) economics, philosophy, and ethics all contribute to conservation biology (see contents of an issue of the journal Conservation Biology).

How "scientific" is conservation biology? In most instances, the magnitude and complexity of problems and urgency for resolution, makes hypothesis testing with control and test replication an impossibility. Therefore, most successes are the result of critical thinking and professional judgement based on knowledge and experience with an understanding of the "uncertainty principle" inherent in natural biological systems.

FW 555 CONSERVATION BIOLOGY

Text: Principles of Conservation Biology

Lectures: M. W. 1:10 - 2:00 NR 115
Student Presentations F. (later in semester)

Grading: Three take home exams (300); term paper (300);
participation, attendance, presentation (100).

Course Structure and Goals

The course has elements of a formal lecture with text, independent study (term paper) and seminar presentation. Issues of conservation biology are highly contemporary (especially in an election year.) Students are encouraged to bring news clippings or notes from the media pertaining to current conservation issues. The text book is comprehensive and serves as a source of information for the various topics discussed in lectures. To be contemporary, we follow principles of "adaptive management." That is, there are no set rules or strict schedule in regards to assignments and testing. Your term paper topic should be selected to develop an in-depth knowledge of a particular area of conservation biology of your interest.

There are numerous definitions and descriptions of conservation biology (see chapter 1.) Most basically, it concerns the preservation of biodiversity. A perceptive student should ask: What is biodiversity? Why should we preserve it? The main anthropocentric (self-interest) rationale is based on evolution by natural selection and all it implies concerning co-evolution and co-adaptation (other reasons, based on intrinsic values of nature, are dealt with in philosophy courses.)

What are similarities and differences between conservation biology and other natural resource fields? for example, why isn't conservation biology a special section of the Wildlife Society? What is the influence of conservation biology on traditional natural resource uses such as hunting, fishing, logging, mining, grazing? An obvious difference concerns the number of species considered and a more holistic integration of organisms and environment. What conflicts might arise from different perspectives on how natural resources should be managed?

There is nothing in the methods, math, modeling, or genetic techniques that is unique to conservation biology. It assimilates and adapts from many disciplines--it is eclectic. Several associated disciplines have their own societies, books and journal. The fields of conservation genetics, conservation education, landscape ecology, restoration ecology, ecological (or natural resource) economics, philosophy and ethics all contribute to the body of knowledge making up conservation biology.

How scientifically rigorous is conservation biology? It must be recognized that in many instances, the magnitude of a problem and urgency for resolution, makes hypothesis testing with control and test replicates infeasible or impossible and political resolution is imposed. Much of the success of conservation biology is dependent on critical thinking and professional judgement based on knowledge and experience that fully understands the uncertainty principle of nature.

It must be recognized that in a democracy, public policy must have public support to be successful. Besides "scientific" limitations, conservation biology is confronted with political and institutional constraints and limitations in regards to implementation of the best conceived plans and programs. Public resource agencies can be faced with severe limitations for implementing conservation or restoration programs. (for ex. introductions of wolves and grizzly bears in Colorado.)

constraints
DOW biol. – supervisor – Director Comm. – Gov. Legisl.
– trapping / an. control.
ballot (biocentric)

The first take home exam will introduce you to the text and many of the issues and problems dealt with by conservation biology. The goal of the course is improved management of natural resources by producing better educated future professionals. These professionals should fully understand that simplistic solutions to complex problems are rarely achieved because uncertainty (stochastic events) limits accuracy of predictions. Slavishly following rules, standard methods, or simplistic models is no substitute for creative thinking based on knowledge. This illustrates the difference between a university education and technical training.

technol. fix
IFIM – fisheries – Bur. seek under standards

SECOND TAKE HOME EXAM
FW 555

How would you describe what conservation biology is all about? Why is "formalization" of the subject matter into a society a recent phenomenon — the journal, conservation Biology is in eleventh year. Why not conservation biology subsections of other natural resource societies (compare subject matter in journals — what distinctions can be drawn)? Are there any methods or techniques unique to conservation biology? How have principles of conservation biology influenced federal agencies in regards to multiple use management? Why hasn't this influence extended to the general public as reflected in local, state, and national elections? Can a middle ground be reached between extreme anthropocentric, utilitarian values of nature and extreme ecocentric, intrinsic values?

hand back — A — salmonid genetics — fragmented — lack connectedness

1 why not subsection — 2 gen-public — media — between TV — public informed — highly biased — polarized view vs. in-depth — politicians

Karen 94 1st, 97 2nd ecol. — citations — text, others, lectures, handouts

wed 29 — Fri 31

how much learn - cumulative 2 ...

— synthesizing, analyzing, condensing, interpreting, Critical Thinking

Alar apples, Hg Teeth, Erie — Ontario, Collegian, ESA

— Concern for loss biodiversity: E. O. Wilson - MacArthur Wilson

30 yrs 1960 Island Biogeography: extinctions, species richness.. math. models (PVA, MVP)

math models PVA MVP Soule - ... Cons. Biol. - first ord 1987 first issue Jrn. - why not ...

TWS / AFS / For. / Range - — Techniques, methods. (what expect? -- Ecol. Econom., Envir. Law

FW 371 - wildlf. Techniques .. sampling, design -- synthesis, eclectic, -

*Chapt. 6 Conserv - genetics, landscape ecol., restoration ecol. ... Let nature

take course - " " bombing NV - Cotton Co. - polarized extreme wise-Use - ignorance but

→ extremes - mid. ground -- black-white hard-line -- Ex. Winter Park - environmentalists

push agenda - block future expansion --- coalition - T. U. - support - protest

(-Sci. Adv.) - sound science? -- I'm not with them - then against:

— L. Powell Sierra Club - from draining - ? -

— Livestock grazing - NV - 40 yrs. vast impoundment BLM -- Earth First,

Defenders Au. Wildlife - 'cattle free by 93' - no compromise - but useful! -

— take, eat trout Au Sable - no-kill, Gov. - Comm. - count - 'traitor'

like dog eating dogs-cats - European phil. - sport

— TV - 20 yrs grazing BLM lands - doesn't have to be - improve mgt. --

— if 'believe' evidence supports. stick with it - catch from both sides.

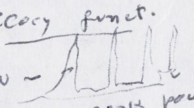
N.W

w/ team pop.

Ann Longhn heath - plan - 1967 - douse big area w/
Toxic pesticide
w/ concern for ramifications
DDT New Brunswick
gypsy moth → salmon R. juvenile
aquatic [illegible] it volunteer

achieving
ecol. integrity
- no standard score / index

- % native sp. occurring
but one person's ecol. integrity
may drastically differ fr another
esp. nonnative sp. in natural ec.

ex. tailwater
anoxic, ammonia
H_2SO_4
toxic - disrupts
ecosys funct.
flow ~

peak power
very limiting.

phosphorus [illegible]
st. bass L. Powell
wale
s. ~ b.
trout tailwater

NOVEMBER TAKEHOME

Choose one of the following topics for analysis, discussion (give citations of sources of information).

1. Example(s) of application of principles of conservation biology to achieve goal(s) of preservation-enhancement of biodiversity, ecological integrity, sustainability, etc. Examples might concern reserve design, watershed restoration, multiple use management, etc. Discuss elements of planning, strategy, and implementation that can determine success or failure to achieve a goal.

2. Analyze results of the November election in terms of role played by environmental issues influencing the outcome. What is your opinion on the depth of understanding of issues by most politicians and voters? In view of this, what strategies and propaganda appeared to be most effective?

3. Environmental problems in underdeveloped, overpopulated countries. Conflicts generated by resource exploitation and overpopulation in relation to short term benefits and long term losses. Irreversible losses. Recommendations?

Take home exam for September, 1997
FW 555

Give brief definition, clarification, implications of following:

1. Biodiversity (intra and intraspecific).

2. Significant Evolutionary Units (SEU for prioritizing units of biodiversity for protection)

3. Species (what is a species? How many species are there? What phylum and class dominates biodiversity?)

4. Nonnative and exotic species.

5. Why do we want to preserve biodiversity?
   A. Anthropocentric, utilitarian (instrumental values), and
   B. Ecocentric and biocentric (intrinsic values) points of view.

6. Charismatic megafauna ("flagship" species.)

7. Keystone species.

8. Dynamic or nonequilibrium paradigm of ecology (vs. balance, stability of nature and implications for predictions).

9. Landscape Ecology (a matter of scale, metapopulations, habitat fragmentation, reserve design).

10. Ecosystem management (to restore or maintain ecosystem health, ecological integrity, sustainability).

Chapt. 2

(*) - Historical basis for C.B. Values on nature & ecosystem — intrinsic — systematic

Ancient history — modern times
most recent 20 yrs
in contemporary debates

Chapt. 1 & 2

— 1. - Denver Post - Sierra Club - Dave Brower

Cong. hearing

early 1950s - DNM -
- first major victory -
+ Bur Rec. - water develop
seeked - utilitarian use
Use of water
- farm - on west

1922 basin compact

Lees Ferry

East - Calif.

Colo. R. storage

Paul Brower
n. 84
Earth First

Anthro — Eco
idealist
conservation
preservation

Breadth of the Spectrum
the most — in tune

Tragedy of Commons
role over
sustainable

— extreme eccentric point views - Sierra Club? - mediator
- Ecol. integrity, - ... — high profile — going ambitious

- most people?
— reservoir - ... 2 mil
... overp. of Yosemite NP
- fishing, boating -
$ $

Col. R.
technol. fix
ill. technique

- flood control, electricity.
- 1996 - flood:
tailwater - trout -
restore ecosystem health? - how people perceive nature

advocacy group
- sportsman?
-

- John Wesley Powell
1869 - barren flood zone
>100,000 cfr.
now - Tamarisk birds
rafting fishing - loss of ...

$ 2 weeks
3 mil in flood

2. 50,000 acre Ranch - CSU / UWY - (Nat. Conserv.)
Range Mgt. Dept. - fl. good rte ...:
$25 yrs. ago - max. AUM - red meat
— inventory - biodiversity
- compatibility - showcase ??

An. Rights
(individual)
- sp. rights

Conflicts control, extermination

- chem. treatment

- Coyotes - Kit fox
- Bl. foot. ferret

- Red fox - S.F. Bay plovers

Is Coyote Control an Effective Management Technique for the Recovery of Endangered Species?

** Use of Coyote Control in the Past

Can Coyotes be controlled?

Has Coyote control increased numbers of Endangered Species?

** Coyote control is an inneffective management technique because:

Coyote predation is not the main limiting factor

The ecosystems in question are unhealthy

The relationship between the coyote and the endangered species is more complex than managers are willing to admit.

1. Intraguild Predation Theory
2. Interference Competition and Niche Theory

Implications on future management

**The San Joaquin Kit Fox (*Vulpes macrotis*)

Elk Hills Naval Petroleum reserve, California

Carrizo Plain Natural Area, California

**The Swift Fox (*Vulpes velox*)

Conservation Strategy for the Swift Fox on the Great Plains

Mayo Call

SECOND TAKE HOME EXAM
FW 555

How would you describe what conservation biology is all about? Why is "formalization" of the subject matter into a society a recent phenomenon — the journal, conservation Biology is in eleventh year. Why not conservation biology subsections of other natural resource societies (compare subject matter in journals — what distinctions can be drawn)? Are there any methods or techniques unique to conservation biology? How have principles of conservation biology influenced federal agencies in regards to multiple use management? Why hasn't this influence extended to the general public as reflected in local, state, and national elections? Can a middle ground be reached between extreme anthropocentric, utilitarian values of nature and extreme ecocentric, intrinsic values?

Citations
sources of info. – reflect reading, understand, synthesis text
+ outside ref. – Given Aldo Leopold

October Take Home Exam

– Discussion leaders
participants

FW 555

Obvious problems and conflicts can arise when given broad generalities as stated in a goal, such as to preserve biodiversity (by practicing ecosystem management), and how to achieve the goal by implementation of an action program. That is, moving from generalities to specifics, from policy to practice. Einstein said that we can't expect to solve today's problems with the same level of thinking that caused them. With this in mind, choose one of the following topics to explain what you would recommend to achieve a goal.

– traditional – Bur Rec., CE, BPA, TVA.
– CWA – water quality / air goal.

E.M. federal lands, role humans, anthro – eco centric, politically correct ("dams & fish too") Einstein 1950.

1. A natural resource agency with traditional commodity, utilitarian values (such as BLM, USFS) has a goal to maintain "ecological integrity" on the lands it manages. How might this be achieved in light of traditional exploitive uses--grazing, logging, mining? What might a be policy for non-native species? What methods or indicators might be used to assess progress toward success?

1994 C.B. Grumbine
role of humans? anthrop. – ecocentric
conflicts Leopold –

Karra, Dudley, Biotic Int, IBI, Colo. St. F.S., Fiona, Shane Copeland, water, air

(350)

2. If 100 million dollars were made available for environmental protection, restoration, enhancement (a broad goal), how could this money be distributed and spent to maximize success? What kinds of checks, oversight, direction would be needed to make the money well-spent?

– private enterprise – competition
costs –

* Nature Conserv. – review grant
– Klamath basin restoration ecosyst. goals

Alison: 1980s Acid Rain, power plants, 600 mil $, Ecol. Appl. 1992

3. The endangered species set provides a legal basis to preserve biodiversity but the complexity of intraspecific diversity and lack of consensus on what constitutes a species creates problems for defining and identifying what should be protected. How might we prioritize "significance" of evolutionary significant units? Recognize that by identifying "significant" units of biodiversity, we imply other units to be "insignificant," yet we can't list everything. Do you see a way out of this dilemma?

Malenna

FWS 1. monotypic genus
Preserve Biodiversity 2. sp. (in polytypic genus)
3. subsp. – Univ., museums – birds, mammals
? undescribed – intrasp. diversity – salmon

– Chapt. 6 – genetic heirarchy
avoid listing – Conserv. agreements – Utah

How div. distri.
– Sp. structure
w/in – among diversity
H.s. – cutthroat
gene flow 98% each strm. 50%

– Chinook salmon – Range adaptation
homing – Calif. – AK – Asia
local races
– Anguilla – catadromous – selection – fecundity each generation
Carribean Fla. – Greenland.

FW 555 Second Take-Home

Building on the first take-home, familiarization with text, lectures, handouts, and other sources, choose one of the following interrelated topics.

1. What is conservation biology all about? Why should we want to preserve biodiversity? What elements or factors determine successes or failures of conservation efforts (scientific-biological vs. sociopolitical and institutional factors).

2. What methods, models, concepts, theories, and principles are used in Conservation Biology? The diversity of disciplines involved (nothing unique to C.B. except overall synthesis from many fields). Note limitations for unanimous consensus of any of above.

3. How has conservation biology influenced the development of various fields of Natural Resource management during the past 30-50 years? For example, the transition from the Pinchot Utilitarian view toward the Leopold ecocentric land ethic. How do you explain "lag time"?

A - Coloradoan -

FW 555 Second Take-Home

Building on the first take-home, familiarization with text, lectures, handouts, and other sources, choose one of the following interrelated topics.

1. What is conservation biology all about? Why should we want to preserve biodiversity? What elements or factors determine successes or failures of conservation efforts (scientific-biological vs. sociopolitical and institutional factors).

re. public perception West - handout stakeholders -

Babbitt Ecosyst. Mgt. Avoid train wrecks - Code word Elko Co

2. What methods, models, concepts, theories, and principles are used in Conservation Biology? The diversity of disciplines involved (nothing unique to C.B. except overall synthesis from many fields). Note limitations for unanimous consensus of any of above. - Sustainab. Uncertainty

IS, Biogeography - philosophy - intrinsic

sp.? why Biodiv. Function adaptive

Economics Conserv. G. Z.E. - Law

Model. HSI IBI Environmental Law 30 ft. Goshawk MVP PVA Conserv. Genetics

3. How has conservation biology influenced the development of various fields of Natural Resource management during the past 30-50 years? For example, the transition from the Pinchot Utilitarian view toward the Leopold ecocentric land ethic. How do you explain "lag time"?

Forest, Range, Fish/wildlife

CSU Coll. Nat. Res. Water Dept. Watershed (Earth Resources) Civil Engineers

old guard die, retire - new generation

re 1 between 2 colleagues

beneficiaries water - 1900s - 1960s - benefits use

fish, wildlife ... Women more less consumptive oriented

Questions, comments

do only 1, but if done nice could ... all 3

(2) - Elko Co. NV - I-80 People of the West Mining (1872 Act)

1000s jobs good pay - Barrick & Newmont cyanide leach - gold 2 great holes "200/oz"

Elko Spring Creek Ranches T & S Ellison - now prop... Range ... (educator in E.M.) ... ranger

very good ... , organ. ...

$ for E.S.A. Lahontan cutt

Return CLN... Eiseman's - response

- 1995 - BLM local exposition - Wash. D.C. - Babbitt - hold up pressure to reform 1872 - does mean justify end politician

BLM USFWS

250 ... adaptive

Reno: fill ...

November Take Home Exam

(3)

FW 555

Prepare a plan based on principles of conservation biology. The plan can be based on a real example, such as recovery of an endangered species, or a hypothetical example such as design for urban open space or greenbelt. Cite sources of information used in plan development. Anticipate conflicts between anthropocentric-utilitarian values and ecocentric-intrinsic values that indicate constraints and limitations for successful implementation. Especially in the case where several federal and state agencies and private lands are involved, how can polarization be avoided and consensus attained? What is policy on non-native species? How might plan written in 1997 differ from one on same subject (for example, management and restoration of a watershed) prepared in 1967? – beneficial (use)

Essentially, your plan should illustrate the problems and frustrations in moving from a stated goal to implementation to achieve the goal.

mega scale
– global emissions (Newsweek).

– Next 2 wks ask each to tell how they are what they're

– dam removal;

– E.M., exploitation - sustainability, - environm. protection - Quincy Lib. Group. – Jack Ward Thomas – Univ. Mont. Mike Dombeck

Quincy | Id. grizzly article reality

sources – background -
Text – case history - Applegate - - "stakeholders" – ; 612-615 chapt 18 Applegate partnership OR - USFS, BLM, Private CA

Text Part IV
Practical Application. Human Consideration

Final Take Home Exam
FW 555

Definition of the lowest (in a phylogenetic sense) unit which qualifies for protection under the Endangered Species Act will be a major topic to be resolved for re-authorization of the act.

If you are asked for your opinion on the matter, what would you advise on such aspects as:

How the selected unit of diversity is defined and identified - pros and cons of using a taxonomic based approach - should only "legal" species be accepted?

What about subspecies and intraspecific parts of species which have no formal classification?

How would you respond to the argument that intraspecific diversity is nonadaptive (therefore no need to preserve) and thus all significant genetic variation would be preserved as long as any population of a species (or a genus) still exists?

The writings of S. J. Gould can be used to argue against preservation of subspecies and intraspecific units of a species. Would you challenge such an authority?

TAKEHOME EXAM
FW 555

Discuss the reasons why typical goals of conservation biology such as restoration of endangered species, maintenance, enhancement of biodiversity, maintain integrity, etc., are more difficult to achieve than typical natural resource "commodity" goals, such as increase in AUM's, board feet of timber, recreational use, etc. You can use a real or hypothetical case to illustrate your points. Some terms that can be useful are: limitations, constraints, biological-scientific aspects, political-institutional aspects, theories, principles and paradigms, actions and implementation (by government agencies), public policy determination (politics and pressure groups), internal contradictions, uncertainties, unknowns, unpredictables, methods and models, H-D method, test, control, inferences, and consensus.

What are your recommendations for improving the success rate for achieving conservation goals?

Do 1 (2:) - Sept. 21 . **FW 555 TAKE-HOME EXAM** — on Oct. 2nd week

Give a brief, in-depth, definition of following, with implications for Conservation Biology. -- by reading pertinent chapters of text. - genes/pop

1. Biodiversity. Chapt. 1 → species (how many?) Variety of living organ. Table 4.1 p. 70

(see 9 & 10) Evol. Sig. Unit intra. = pop. salmon

prioritize importance - characteristic - birds megafauna mam | vert. — — ants biomass bacteria decomposition

2. Ecocentric/biocentric view of nature. — p. 40 Table 2.2 Chapt. 2.2

nature | individuals animal rights PETA Defenders W? hunting wildlife vs. Anthropocentric

Sierra Club Wilderness Soc.

Moral standing - human - Rolston - degrees

3. Utilitarian/commodity/instrumental values of natural resources.

agencies - purpose

Direct human value - commodities, vs. intrinsic -- Holmes Rolston

valuation: good, beneficial, bad, worthless + how we got where we are

Don Young : AK Cong. (wise use, People of West, Mtn. St. Legal Found. - James Watt)

4. Aldo Leopold. - hunter - wildlife Mgt.

Pinchot Yale - forester

Land ethic - bridge gap. USFS N.M.

holistic - intelligent tinkerer — pred. hunter wolf Think like a mountain

- 2 Types A land or commodity B something more

5. Endangered Species Act. 1973.

- laws: effect change - nature protection

1988 NEPA - Conservation coalitions / legal expertise / biol. experts

6. Nonequilibrium or dynamic equilibrium theory of ecology (re: determinants of community structure and the uncertainty principle).

stochastic deterministic

disturbance: fires/floods models - predictions / patterns of regularity

catastrophes. tides

resiliency vs. stability pop. cycles / - chaos theory Monte Carlo - model

chapt. 11

7. Ecosystem management.

USFS -- interaction all sp.

Timber, road builders spotted owl, salmon - but word/deed lag time USFS 1992 - sued

grazing - - maintain ecol. integrity structure / functioning - Why? - sustainability

9-10

8. Landscape ecology.

* Whole book - Barry Noon - scale spatial - temporal

Text ? index, glossary: fragmentation, connectedness,

9. Keystone species.

- regulates, influence, community more than biomass / energetic -

Top down control brown tree snake Guam - birds

- predator - Robert Payne - ants / bacteria - Music [illegible] - nonnative - non coevolved

- starfish - algae - mollusks - starfish disruptive roles in disturbance

10. Flagship or umbrella species. - not keystone, not important function

spotted owl - whole ecosystem

- old growth forests - many other sp.

amphibians - 17 species

p. 4 fig. 1.1
hanson pap.

Example 1996

FINAL TAKE-HOME

FW555

Conservation biology is eclectic, drawing from many disciplines, and is an imprecise science. This makes for a problem of moving from often vague generalities (a goal, such as to maintain biodiversity and healthy ecosystems) to specifics -- what actions can be implemented to achieve a goal. Discuss how you envision the theories, principles, methods, and models associated with conservation biology can be applied to resolve a problem -- a case history approach to a real or hypothetical situation or issue such as endangered species restoration, improved multiple use management of federal lands where traditional dominant uses conflict with other uses and with goals of conservation biology, including sustainability.

FW 555 Final Take Home Exam

Why do we want to conserve biodiversity anyway? This is the topic addressed in the November 1994 newsletter of the Society for Conservation Biology. The article states that it comes as a rude surprise to find out how many people in the world are ignorant of, indifferent toward, or outright hostile to the conservation of biodiversity. We must communicate more effectively at several levels of society. We must sell biodiversity to many constituencies before we can succeed in conserving it.

Four arguments or sales pitches are suggested:

1. Legal -- several federal laws, such as ESA, mandate conservation of biodiversity (but intent of laws are continually circumvented).
2. Intrinsic values of nature -- ecocentric-biocentric philosophy. Warmly embraced by the true believers but few anthropocentric utilitarians ("what good is it?") are swayed. Works best for charismatic megafauna.
3. Economics -- more rational anthropocentric point of view, "for our own good," sustainability, rational use of resources, etc. Currently pushed by federal agencies as ecosystem management, but results of recent elections are not encouraging.
4. Keep government off your back -- avoid "environmental train wrecks" by good conservation programs -- avoid endangered species listings. Opponents response is to revise Endangered Species Act.

What philosophy, position/arguments (can be multiple) do you recommend to effectively communicate why we should want to conserve biodiversity? What counter-arguments might be anticipated and how would you counter the counter-arguments?

For example, the precepts of Aldo Leopold's "land ethic" might be recommended because it appears to nicely bridge the gap between anthropocentric and ecocentric points of view; it is widely known and held in high esteem (Leopold's views are used as the "authority"). Counter-arguments could point out that Leopold's views on ecology are outdated (non-equilibrium theory, strengths of linkages -- it's okay to lose some of the parts, etc.). A counter to the counter could emphasize the basic and very valid truism stressed by Leopold about the complexities and uncertainties inherent in natural systems -- we cannot expect good predictions on the outcome of an action.

Obviously, there is no "most correct answer." This is an exercise in critical thinking and an understanding that achieving conservation goals can be difficult and frustrating.

SPECIAL GRADUATE SEMINAR

FW 561AV: ADVANCED TOPICS IN FISHERIES BIOLOGY
EY 592 V: INTERDISCIPLINARY SEMINAR IN ECOLOGY

FALL SEMESTER 1998

CONTEMPORARY ISSUES IN FISHERIES AND AQUATIC ECOLOGY

This year's seminar will address aspects and feasibility of watershed and fisheries restoration (rehabilitation, enhancement). For example: "We've spent billions of dollars to bolster dwindling Northwest salmon runs, yet the numbers of fish continue to decline" (Seattle Post-Intelligencer headline re failed attempt to "restore"). What went wrong? Examination of underlying causes of successes and failures can provide some insights.

Instructors: Robert Behnke, Department of Fishery and Wildlife Biology
LeRoy Poff, Department of Biology

Time: 3:10-4:00 p.m., Tuesday

Place: 130 Wagar Building

Reference Number: FW 561 AV: 225283
EY 592 V: 232195

Credits: 1

Grading Options: Letter grade or S/U basis is decided between students and instructors.

Fish

Horsetooth Res. (Brett Johnson)
artificial environment, non native, non coevolved spp. transfer

trophic levels interactions
- pelagic
- benthic
- prey-?

mysis
smelt
walleye
sm bass
wipers

ecol. integrity
biol. function
processes
- energy

ecosystem
terrestrial
< vegetation

classic
- alpine
- tundra
- riparian
- ?

aquatic
- lacustrine
- fluvial
- marsh

CE Bu Rec BLM 75 ?
AZ
Tu? NPS

agencies -
purpose - single, dominant
- water | Bur Rec.
| C.E. navigation
| Flood control channelize
power - BPA
TVA
| SCS - 1964
ESA - FERC
1994 - ? value
dam removal
? trees
→ banks, channel, erosion, birds, wild

native?
- moose -
- ?
- extreme ecology
- deep ecology
- sound science?
- Coparg - Poudre
? polluted R. - Colo
- River Fest
- polarization -
spectrum
wilderness soc.

'trout
cold water
trout
warm
carp
sucker

Barry Noon

Wed. Sept. 9

1[10] - 2[00]

L. Ecol. NR 315

7905

NRA
D.U. - TU Sierra Club

- Kevin

Wed. Sept. 2 ?

~~Hewitson~~ (?)

Mullan

Sedan

- John ?
Wiltzius - Ground Moss

Matt Holford

- Pyramid L.
? "strains"
- clippings

~~Nisbet~~
Oxygen
Holford
- Trowbridge

Trout -

Heritage / Henke

SW Nat.

Seattle Fri 8:05 AM
UA 1280 Denver
10th noon

Kip Travis
1-800 251-2594

Rhino
horns - 1.

- condor - few generations
- wild - Tame firm.
- Zoo pop.
- Fish - domestication
- Devil's Hole

NR115

Schedule Conservation Biology Seminer

March	10	Theresa Race Zoo pop.
	17	Break
	24	Hilary Petit: Min. viable pop.
	31	No class
April	7	Carol Ann Moorhead: Rare plants
	14	Greg Block: open
	21	John Presuhn: urbaniz. - Hawaii?
	28	No class
May	5	Nick Smith-Sebasto - Bear ecol. and Cat Brown - Hab. fragment.

attendance

- Rn 7W 566

Conserv. Biol
- re Wild 4 - Fish Mgr.
- Ecosystem sem -
-
- Two Fiddlers -
- Soils Hawaii field ship

NRA meeting
D.U.

Seminar in Forest Sciences, F 793D

Fall 1992 Schedule
Thursdays 12:10 - 1:00
Forestry Room 127

September 3:	**Organizational Meeting - Graduate Students Only.**
September 10:	Dr. Dave Anderson, Dept. of Fish and Wildlife Biology *"Brief Sketch of the Old Growth Forest / Northern Spotted Owl Issue in the Pacific Northwest"*
September 17:	Dr. Dan Binkley, Dept. of Forest Sciences *"Ecosystem Studies in the Noatak National Preserve, Northern Alaska"*
September 24:	Dr. Tom Stohlgren, Nat'l Park Service & Dept. of Forest Sci. *"Climate Change in Rocky Mountain National Park: A Research Program on Management and Ecology"*
October 1:	Dr. Pat Pellicane, Dept. of Forest Sciences
October 8:	Dr. Jordi Cortina, Visiting Scientist, Dept. of Forest Sciences
October 15:	Dr. Rick Laven, Dept. of Forest Sciences
October 22:	Dr. Linda Joyce, U.S. Forest Service *"Forest Sector Sensitivity to Climate"*
October 29:	Dr. Dean Urban, Dept. of Forest Sciences
November 5:	Dr. Pat Kennedy, Dept. of Fish and Wildlife Biology *"Forest Management Planning at the Landscape Scale: Implications for Habitat Management"*
November 12:	Dr. Dave Betters, Dept. of Forest Sciences *"Plantation Forests in Brazil"*
November 19:	Dr. Phil Omi, Dept. of Forest Sciences
December 3:	Dr. Doug Rideout, Dept. of Forest Sciences
December 10:	Dr. Indy Burke, Dept. of Forest Sciences

HSI; Internal contradictions; Constituency - conflicts; Chem. corp. - Entomol.; Forest Products; Livestock; Hunting, fishing; jobs; deterministic - stochastic; predict weather; capacity; uncertainty; Community; Environment; pollution; conflicts?; Entomol; Pesticide; ★ Rachel Carson; Range; Watershed; Recreation

FW 561 AV Advanced Topics in Fisheries Biology
EY592 V Interdisciplinary Seminar in Ecology

CONTEMPORARY ISSUES IN FISHERIES AND AQUATIC ECOLOGY

Fall 1997

This site will be updated periodically.

Tentative Schedule

SEP 11
Dr. LeRoy Poff, Assistant Professor, CSU Biology Dept.
The natural flow regime: a paradigm for river conservation and restoration

SEP 18, TBD:
John Barthelow- IFIM Definitions, Agreeing on Terminology OR
Lee Lamb- Legal and Institutional Trends in Instream Flow

SEP 25, TBD:
John Barthelow- IFIM Definitions, Agreeing on Terminology OR
Lee Lamb- Legal and Institutional Trends in Instream Flow

OCT 2
Jason Kent, USGS and CSU Civil Engineering graduate student
IFIM Case History and Analysis

OCT 9
Claudio Meier, CSU Civil Engineering and GDPE graduate student
1. How should minimum flows for regulated rivers be established? 2. How "natural" does the flow regime below a dam have to be to maintain ecological integrity of a regulated river?

OCT 16
Daren Carlisle, CSU Fishery and Wildlife Biology graduate student
10. Is there a scientific basis for arguing that some species (including endangered ones) are more "worthy" of management than others?

OCT 23
Fred Wurster, CSU Watershed Science graduate student
11. Are large dams permanent features of the landscape? How socio-economically tied to them are we? Is dam removal practical?

OCT 30
TBD

NOV 6
Deb Finn, CSU Biology graduate student
7. If ecological integrity is an endpoint for aquatic ecosystem management or restoration, how is it defined and at what scales must it be measured?

NOV 13
Lisa Courtney, CSU Fishery and Wildlife Biology graduate student
13. What have we learned about the effectiveness of new dam operations for river restoration from "experimental floods" (e.g., Glen Canyon)?

NOV 20
John Ptacek, CSU Fishery Biology major
5. Can we predict ecological effects of water management in river ecosystems?

DEC 4
Drs. Kevin Bestgen and Dan Beyers, CSU Larval Fish Laboratory
Native Fish Restoration in the Upper Colorado River Basin

DEC 11
Wrap-up

Last Modified 9/4/97
Brett Johnson

IFIM
Definitions, Issues, and Potential Future

by
John Bartholow

for
Contemporary Issues
in Fisheries and Aquatic Ecology

September 18, 1997

<u>Topics</u>

1. IFIM
    - Who, what, when , where, why, how?
    - Context
    - Definitions
    - Assumptions & limitations

2. Issues
    - *Fisheries essays*
    - Mistakes made
    - Questions unanswered

3. Future Potential
    - Evolving and converging technologies
    - Continued questions

4. Questions?

5. If time, suitability criteria - preference vs use

IFIM Context

What is IFIM?

Incremental methodology is a *process* of developing and negotiating instream flow recommendations by evaluating alternative flow *regimes* through time based on aquatic ecosystem (micro- and macro-habitat) *needs*.

IFIM developed for:
- Constructing flow recommendations for stated management *objectives*
- *Quantifying* impacts of altered flows
- Developing mitigation plans or habitat improvement projects
- Negotiating operations rules

IFIM may be contrasted with *standard setting* which uses a single, fixed rule to establish a (minimum) flow requirement despite dynamic ecosystem needs.

IFIM may also be contrasted with *PHABSIM* (the Physical Habitat Simulation System), a specific bio-hydraulic model useful for developing a habitat versus flow index.

Though IFIM implies using some measure of ecological function with discharge, it does not equate to PHABSIM. Other techniques have been employed, such as wetted perimeter, visual aesthetics, etc..

Historical Context

Developed by US Fish & Wildlife Service as a tool (stick?) for evaluating small hydropower projects. Hydrologic methods (Tenant, 7Q10, wetted perimeter, usable width, habitat mapping) were seen either as (1) non-negotiable, either inflexible or non quantitative, (2) not-biologically relevant, (3) or too labor intensive.

Must answer the *incremental* question: If flows were different by X amount, *how much* would the aquatic system be impacted?

Must fit *incrementalism* as a “method” of decision making, recognizing that major changes to the status quo are not likely.

Important Definitions

Instream Flow Incremental Methodology (IFIM) -

An interdisciplinary problem solving process composed of linked models that describe the spatial and temporal features of aquatic habitat resulting from a given river regulation alternative. IFIM includes a scoping process, and studies of hydrology, microhabitat, macrohabitat, habitat suitability criteria, water temperature, and institutional decision-making; linkages to other investigations are possible.

Instream Flow Study -

An investigation that establishes the relationship between of one or more physical, chemical, or biological variables and stream discharge through space and/or time, empirically or with the use of a computer model(s) such as PHABSIM.

Macrohabitat -

A longitudinal segment of river within which physical and/or chemical conditions influence the suitability of the segment for an aquatic organism.

Microhabitat -

Small localized areas within a larger scale habitat type (mesohabitat) used by an aquatic organism for specific purposes or events, typically described by a combination of depth, velocity, substrate, and cover.

Macro Variables	Micro Variables
Water Quality	**Depth**
Water Temperature	**Velocity**
Gradient	**Surface Area**
Bed Particle Size	**Substrate**
Channel Structure	**Cover**
Channel Dimensions	**Pool/riffle Ratio**
Channel Pattern	**Species**
Discharge	**Activity**
Food Source	**Size or Life Stage**

Reference (Baseline) Condition -

The conditions occurring during the reference time frame, usually referring to water supply, habitat values, or population status. The reference condition is often an actual recent historical condition, but may also represent: (1) the same climatological-meteorological conditions but with present-level water development and operations; (2) the same climatological-meteorological conditions but with both current and proposed future development on line; and/or (3) virgin or pre-development conditions.

Time Series Analysis -

Analysis of the pattern (frequency, duration, magnitude, and timing) of time-varying events, such as habitat area, temperature, power, etc..

Total Habitat -

Total available wetted area conditioned by microhabitat and macrohabitat suitability and summed for all relevant river segments, i.e., the area of a stream with suitable macro and microhabitat.

Important Assumptions & Limitations

Habitat, not fisheries, based.
Species exhibits describably preference or avoidance to one or more micro and/or macro habitat variables.
Fish populations respond to reducing habitat bottlenecks (though not instantly nor linearly).
Most hydraulic models assume a steady, well mixed condition.
Suitability curves do not reflect rate of change of the environment.
IFIM requires professional judgement.
IFIM does not provide one best answer.
Species interactions not well understood
Data requirements are large.

Issues

Mistakes made in applications of IFIM:

- Focus on single lifestage
- Focus on single time
- Not cognizant of water supply
- Not testing transferability of criteria
- Leaving “common sense” behind
- Focus on single species
- Focus on single place
- No agreement on assumptions
- Not looking through time

Questions raised by Castelberry et al.

Scientific defensibility
- Hydraulic & substrate sampling and measurement problems
- Biological sampling and measurement problems
- Meaning and uncertainty of weighted usable area (WUA)
- Adaptive management is IT!

Response by Van Winkle et al.

Playing it by ear is not sufficient
Need dramatic experiments with testable hypotheses, lest learning not occur
Institutional framework is not generally capable of long-term monitoring
Management objectives must be acceptable to and understandable by the public, ecologically meaningful, and *measurable*.
Adaptive management must include quantitative (absolute or relative) prediction tool[s].
Models are the means, incorporating (1) theory, (2) hypotheses, (3) variables, and (4) measures.
Individual based modeling can be such a tool, replacing suitability indices
- Uncertainty is not going away

Future Potential

Evolving and converging technologies

Biological
- Community dynamics
- Habitat diversity indices
- Population modeling

Physical
- Channel morphology
- Sedimentation (budget)

Hydrological
- 2-D and 3-D hydraulics

Multi-disciplinary melding

Continued Research Needs

Biological understanding!
- Instream prediction
  - transferability from system to system
  - variability requirements
  - community dynamics
  - network analysis
  - water quality as stressors
- Out of stream prediction
  - riparian responses
  - wetland responses
  - floodplain responses

Hydrological understanding!
- Variability - management under (or with) inter- and intra-annual hydrologic uncertainty
- Compliance

Physical understanding!
- Bedrock channels - prediction?
- Alluvial channels - prediction
- Floodplain channels - prediction

Institutional understanding!
- Implementing water budgets
- Integrating economics
- Defining society's objectives
- Defining and achieving "balance" between use and abuse in a dynamic and uncertain environment
- Continued development of statutory authority
- Continued public education

Validation/Evidence!
- Monitoring - positive and negative
- Adaptive management
- Communication

If IFIM is to continue, we need to close the gap between the promise and the practice!

Alonso Aguirre
Department of Fishery and Wildife Biology
Colorado State University
Fort Collins, Colorado 80523

DISEASE AND CONSERVATION

-Introduction

-Historical background: african ungulates and rinderpest

-Myxomatosis in rabbits

-Tsetse control and african ungulates

-Lungworm and Rocky Mountain bighorn sheep

-Diseases of waterfowl: botulism and duck plague

-Disease and endangered species

-Lead poisoning and the bald eagle

-Lead posioning in other endangered species

-Mauritius pink pigeons and an herpesvirus

-Eastern Equine Encephalitis and whooping cranes

-Inclusion body disease in captive cranes

-Pere David´s deer and malignant catarrh fever

-Canine distemper and the black-footed ferret

-Malaria and the hawaiian birds

-Conclusions

RECOMMENDED READINGS

Anderson, R. C. 1971a. Lungworms. Pages 81-126 in J. W. Davis and R. C. Anderson eds. Parasitic diseases of wild mammals. Iowa State University Press, Ames.

_______ . 1972. The ecological relationships of meningeal worm and native cervids in North America. J. Wildl. Dis. 8:304-310.

Anderson, R. M. and R. M. May. 1979. Population biology of infectious diseases I. Nature 280:361-367.

_______ . 1982. Coevolution of hosts and parasites. Parasitology 85:411-426.

Dobson, A. P. and R. M. May. 1983. Disease and Conservation. Pages 345-365 in M. E. Soule ed. Conservation biology. Sinauer Assoc. Inc. Sunderland, Mass.

Edwards, M. A. and U. McDonnell eds. 1982. Animal disease in relation to animal conservation. Symposia Zool. Soc. London, No.50. Academic Press, London.

Fenner, F. and Ratcliff, F. N. 1965. Myxomatosis. Cambridge University Press, England.

Forrester, D. J. 1971. Bighorn sheep lungworm-pneumonia complex. Pages 158-173 in J. W. Davis and R. C. Anderson eds. Parasitic diseases of wild mammals. Iowa State University Press, Ames.

Gillespie, J. H. 1975. Natural selection for resistance to epidemics. Ecology 56:493-495.

Hibler, C. P. 1981. Elaeophorosis. Pages 53-60 in W. J. Adrian ed. Manual of common wildlife diseases in Colorado. Colorado Division of Wildlife, Fort Collins.

Kaplan, C. 1985. Rabies: a worlwide disease. Pages 1-20 in P. J. Bacon ed. Population dynamics of rabies in wildlife. Academic Press, New York.

King, W. B. 1985. Islands birds: will the future repeat the past?. ICBP Tech. Publ. No. 3. 15 pp.

Levin, B. R. et al. 1982. Evolution of parasites and hosts: group report. Pages 213-243 in R. M. Anderson and R. M. May eds. Population biology of infectious diseases. Dahlem Konferenzen, Berlin, Heidelberg, New York: Springer-Verlag.

May, R. M. and R. M. Anderson. 1979. Population biology of infectious diseases: Part II. Nature 280:455-461.

Parsons, P. A. 1983. The evolutionary biology of colonizing species. Cambridge University Press, New York 262 pp.

Senior, M., C. R. E. Halnan, and E. H. Tong. 1962. An outbreak of malignant catarrh among the Pere David deer. The Veterinary Record. 74:932-936.

Course: FW 300 Ichthyology
Natural history and evolution of fishes; their zoogeography, classification, anatomy, basic physiology and ecological adaptations.

Prerequisites: BY 112

Instructor: Robert J. Behnke - 427 - Zool.

Time: Lect. 1 MWF - Room 212 Z
Lab. 2-4 MW - Room 212 Z

Text: Lagler, Bardoch and Miller, 1962
Ichthyology, John Wiley & Sons Inc. 545 p.

Supplementary texts and reprints are provided for the laboratory and loan to interested students. Laboratory manual (Behnke) supplied to all students.

Course Outline:

A. Introduction -

Morphology, anatomy and basic physiology. Lectures and labs integrated with dissection of carp specimen by each student. Anatomical features, organs, sensory systems, physiology and basic terminology covered with comparative material demonstrating homologous structures adapted to different ways of life. Evolutionary trends in structure and function. Emphasis on how a fish is put together inside and out--what makes it run--and how structures can evolve to allow derivative groups to exploit new environments and new life styles.

B. Phylogeny of fishes

Lectures and lab integrated to discuss and demonstrate the major classes and orders of fishes. Evolutionary trends which diagnose the various taxa. Natural history, ecology and zoogeography of the groups.

C. Zoogeography

Principles of zoogeography; factors determining fish distribution; convergent evolution to fill similar ecological niches in different geographical areas; evaluation of information for introduction of new species on a rational basis.

D. Evolution, systematics and Taxonomy

Natural selection and origin of species from the level of the DNA to the population. Methods of study of evolution (speciation, variability and divergence = systematics) and the arrangement of the diversity produced by evolution into a system of classification (taxonomy). Potential information available from morphological studies (orthodox) and new techniques (biochemical, cytogenetic and computer analysis of data).

E. Term paper

Each student writes a major term paper with emphasis on some aspect of ichthyology to be examined in-depth.

OUTLINE FOR COURSE IN SYSTEMATIC ICHTHYOLOGY

I. Historical Review

A. History of systematic biology and ichthyology.

B. Concepts of animal classification.

C. Development of evolutionary thought and phylogenetic studies; their effect on a system of natural classification.

II. Comparative Fish Anatomy and Physiology

A. Skeletal system.

B. Integument

C. Muscles

D. Circulation and respiration

E. Sensory organs

F. Digestion

G. Excretion and Osmo-regulation

H. Nervous and endocrine systems

I. Reproduction

These lectures will be associated with laboratory work in the dissection and skeletonizing of specimens to observe the structures discussed.

III. Evolution and Phylogeny of Fishes

A. Classes, subclasses, superorders

B. Geologic time periods and the appearance of major structural advances in diverging phyletic lines.

C. Evolutionary pathways; successful and extinct groups; homology and analogy.

D. The teleost fishes.

1. Attainment of the combination of characters leading to dominance.

2. Radiation and relationships

IV. Functional Morphology

A. Adaptive significance of characters used in classification.

B. Specializations and adaptive radiation; evolution for specific niches.

C. Convergence, parallelism

V. Principles of Classification

A. Goals of a natural system of classification

B. Establishing facts denoting true affinities

C. Concepts of classification

1. Phyletic and phenetic schools

D. International rules of zoological nomenclature

E. The binomial system

F. Genus, species, subspecies, populations; definitions and concepts.

G. Process of speciation

1. Genetic divergence; levels of taxonomic recognition.

Two papers will be required. A laboratory report, at approximately mid-term, based on a literature survey of a topic; and a final term paper based on independent research. (For example: a study of intra-specific variability or comparative osteology.)

Febuary 16, 1967

ABSTRACT
Genetics Seminar H226

The Origin, Evolution and Distribution of the Salmoninae

Richard Wilmot

The salmoninae are an important group of fishes making up a sizeable portion of the commercial fisheries industry. They are also one of the favorites with the sports fisherman.

Salmoninae is a subfamily consisting of five genera; Oncorhynchus(Pacific Salmon), Salmo(Trouts), Salvelinus(Chars), and Hucho and Brachymystax(Asian Trouts). Two other genera possibly belong; Cristivomer and Salmothymus.

The salmoninae are found naturally only in the Northern Hemisphere from as far north as the Arctic Ocean to as far south as the Atlas Mountains of Algeria and Morrocco.

They are believed to have arisen in freshwater in Asia and crossed over to North America by the land bridge over the Bering Straits. From here then they differentiated into the Pacific Salmon and entered saltwater.

Fossil records are very poor for the salmonid type fishes and only deposits from the Pleistocene and Pliocene yield reliable specimens.

The species specific muscle myogens of certain salmonids has been compared by starch gel electrophoresis. This method is very useful in species identification, and equally significant, a valuble tool in establishing phylogenetic relationships of closely related groups.

Svardson(1945) proposed a polyploid type of evolution for the salmonids from an ancestor with 10 chromosomes. This theory has largely been discredited today. The feeling now is that speciation arose from the fusion and fragmentation of chromosome arms to give varying combinations of metacentric and acrocentric chromosomes. Random union and dissociation offers unlimited opportunities for future karyological evolution.

Literature Cited

Behnke, R.J. 1965. A systematic study of the family salmonidae with special reference to the genus Salmo. Ph.D. Thesis. Univ. California, Berkley.

Boothroyd, E.R. 1959. Chromosome studies of three Canadian populations of Atlantic Salmon, Salmo salar L. Can. J. Genet. Cytol. Vol. 1:161-172.

Hikita, T. 1962. Ecological and morphological studies of the genus Oncorhynchus (Salmonidae) with particular consideration on phylogeny. Sci. Rpts. Hokkaido Salmon Hatchery, No.17:1-97.

Neave, F. 1958. The origin and speciation of Oncorhynchus. Trans. Roy. Soc. Canada. Vol.52:25-39.

Ohno, S., C. Stenius, E. Faisst and M.T. Zenzes. 1965. Post-zygotic chromosomal rearrangements in Rainbow Trout(Salmo irideus Gibbons). Cytogenetics. Vol.4:117-129.

> Rees, H. 1964. The question of polyploidy in the salmonidae. Chromosoma. Vol.15: 275-279.

Romer, A.S. 1961. Fish origins - fresh or saltwater? In Papers in Marine Biology and Oceanography. Deep Sea Res. Vol.3:261-280.

Rounsefell, G.A. 1962. Relationships amoung North American salmonidae. U.S. Fish. and Wildlife Ser., Fish. Bull., No. 209. Vol.62:235-270.

Simon, R.C. 1963. Chromosome morphology and species evolution in the five North American species of Pacific Salmon(Oncorhynchus). J. Morp. Vol.112:77-97.

Simon, R.C. and A.M. Dollar. 1963. Cytological aspects of speciation in two North American teleosts, Salmo gairdneri and Salmo clarki Lewisi. Can. J. Genet. Cytol. Vol.5:43-49.

Svardson, G. 1945. Chromosome studies on salmonidae. Medd. St. undersokn. forsoksanst. sotvattensfisket. No.23:1-151.

Tsuyuki, H. and E. Roberts. 1963. Species differences of some members of salmonidae based on their muscle myogen patterns. J. Fish. Res. Bd. Canada. Vol.20:101-104.

Vladykov, V.D. 1963. A review of salmonid genera and their broad geographic distribution. Trans. Roy. Soc. Canada. Vol.1:459-504.

FW 561 AV -- Advanced Topics in Fisheries Biology
EY 592 V -- Interdisciplinary Seminar in Ecology

FALL 1997

CONTEMPORARY ISSUES IN FISHERIES AND AQUATIC ECOLOGY

This year's seminar will be devoted to current issues facing aquatic ecologists and fisheries managers, such as instream flow determination. How should regulated rivers be managed- for endangered species, recreation, ecosystem integrity, hydropower, irrigation, flood control..? How can we optimize "multiple use" both upstream (reservoirs) and downstream? Discussions will address assumptions, methods and methodologies used to resolve conflicts and confront uncertainty.

INSTRUCTORS:

Robert Behnke and Brett Johnson, Department of Fishery and Wildlife Biology
LeRoy Poff, Department of Biology

TIME and PLACE: 3:10-4:50 pm Thursdays, Wagar 132

REFERENCE NUMBERS:

FW 561AV:	206347	section 001	(FWB students)
EY 592V:	217468	section 002	(GDPE students)

CREDITS: 1-3 credit

GRADING OPTIONS: Letter grade or S/U basis decided between students and instructors

Resent-Message-Id: <9704162046.AA08750@picea>
Comments: Authenticated sender is <judyt@picea.cnr.colostate.edu>
Resent-From: judyt@picea.CNR.ColoState.EDU
Resent-To: brett
Resent-Date: Wed, 16 Apr 1997 14:43:01 +0000
Return-Path: <lpoff@tu.org>
X-Sender: lpoff@mail.tu.org
Date: Tue, 15 Apr 1997 18:06:43 +0400
To: fwb@picea.CNR.ColoState.EDU
From: "N. LeRoy Poff" <lpoff@tu.org>
Subject: Message for Dr. Bob Behnke

ATTN: FOR DR. BOB BEHNKE

Brett,

I re-structured the information Bob sent me about the Fall seminar, as you'll see below. After talking with Bob this afternoon, we agreed that this would be useful as an "add-on" to the previously posted flyer. Also, I'd like to suggest that this information be posted to grad students directly via e-mail. I can do that for Biology and I'll enquire with Dan Binckley about posting it to a GDPE grad student list.

The questions that I've listed are certainly not exhaustive, but ones that I'd like to see students answer for me! Feel free to add any others you might want to see pursued. I'll wait to hear back from you before I move on sending this to Biology and to GDPE.

Cheers,
LeRoy

--cut here----------------------

FW 592 V -- Advanced Topics in Fisheries Biology
EY 592 V -- Interdisciplinary Seminar in Ecology

Fall 1997

CONTEMPORARY ISSUES IN FISHERIES
AND AQUATIC ECOLOGY

As human demands on aquatic resources continue to grow, conflicts among different "user-groups" will continue as well. Scientific information will increasingly be needed to help society manage its resources in a sustainable manner; however, scientific certainty is often not sufficient to completely resolve important conflicts about how resource management should be practiced. Therefore, arguments about the long-term biological and ecological consequences of modifying habitats (for flood control, irrigation withdrawals, hydropower generation, clear-cutting, etc.) and of altering species relations (through stocking exotics, harvest practices, etc.) continue to generate hot debate. In this seminar, we will focus on important fisheries and ecological issues that are at the heart of many contemporary conflicts in aquatic resource management. These may include, but are not limited to:

1) How should minimum flows for regulated rivers be established?
2) Can streams and rivers be successfully restored based solely on engineering and hydrological principles?
3) If ecological integrity is an endpoint for aquatic ecosystem restoration, how is it defined and at what scales must it be measured?
4) How can biodiversity be practically defined, and is it necessary for ecosystem "health"?
5) What role should genetics play in fishery management?
6) Is there a scientific basis for arguing that some species (including endangered ones) are more "worthy" of protection than are others?

All students interested in the application of scientific knowledge (and uncertainty) to real-world managment of aquatic resources are encouraged to enroll.

INSTRUCTORS:

Robert Behnke and Brett Johnson, Department of Fishery and Wildlife Biology;

LeRoy Poff, Department of Biology

TIME and PLACE: 3:10-4:50 pm Thursdays, Wagar 132

REFERENCE NUMBERS:

FW 561 AV: 206347 section 001 (FWB students)
EY 592 V: 217468 section 002 (GDPE students)

Credits: 1-3 credit hours

Grading Options: Letter grade or S/U with instructors permission

Trout Unlimited
1500 Wilson Blvd., Suite 310
Arlington, VA 22209-2310
703/284-9403 (V)
703/284-9400 (FAX)

Date sent: **Tue, 15 Apr 1997 18:06:43 +0400**
To: **fwb@picea.CNR.ColoState.EDU**
From: **"N. LeRoy Poff" <lpoff@tu.org>**
Subject: **Message for Dr. Bob Behnke**

ATTN: FOR DR. BOB BEHNKE

<fontfamily><param>Times</param><bigger><bigger>Brett,

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LeRoy

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EY 592 V -- Interdisciplinary Seminar in Ecology

<bold>Fall 1997

</bold>

<bold>CONTEMPORARY ISSUES IN FISHERIES

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AFS PROGRAM CHANGES

Program Summary, Thursday, September 17 - Session 2E will be held in the Wurlitzer Room.

Thursday, September 17, Session 2B.

Paper No. 2. Change author to David McDaniel, U. S. Fish and Wildlife Service, Leetown, West Virginia.

Paper No. 8. Change author to Wilmer Rogers, Auburn University, Auburn, Alabama.

Thursday, September 17, Session 2C.

Paper No. 1. Change to No. 4.

Paper No. 2. Replace with: The effect of environmental variability on California dungeness crab and salmon catch.
Louis W. Botsford, University of California, Davis, California and Richard D. Methot, Bodega Marine Laboratory, Bodega Bay, California.

Paper No. 3. Change to No. 5.

Paper No. 4. Change to No. 1.

Paper No. 5. Delete.

Paper No. 6. Change to No. 3.

Thursday, September 17, Session 2D.

Paper No. 1. Delete.

Paper No. 2. Change to No. 1. Add D. W. Schindler as second author.

Paper No. 3. Change to No. 2.

Paper No. 4. Change to No. 3.

Add new No. 4. Electrolytic balance and energy mobilization in acid stressed rainbow trout (Salmo gairdneri) and their relation to reproductive success.
Raymond M. Lee, Shelby D. Gerking, Arizona State University, Tempe, Arizona and Barbara Jezierska, Poland.

Thursday, September 17, Session 2F.

Replace last paper in session (at 1445) with:
Upstream movements of subadult striped bass at fish passage facilities in the Connecticut River watershed.
Christine M. Moffitt, University of Idaho, Moscow, Idaho.

runoff during the late Pleistocene epoch. Malheur Lake is fed by Silvies River in the north and Donner und Blitzen River in the south, while Harney Lake receives water from Silver Creek. In addition, some isolated creeks occur in the north and southeastern portions of the basin which come down from the mountains and dissipate onto the broad valley floor.

The purpose of the study is to determine on the basis of species composition and individual characteristics the patterns of distribution of fishes within the basin, and to relate these patterns to the natural history of the area. At one time (probably in the Pleistocene) the streams and rivers were connected through Malheur Gap with Malheur River, a tributary of the Snake River system. Thus one would expect a priori that fishes in Harney Basin would coincide with those in the Snake. And this has proven to be the case, with one major exception. Silvies River, the largest in the basin, has been found to contain a fauna which is unmistakably allied with that of the lower Columbia drainage. This anomaly can possibly be explained if stream capture or some related phenomena has resulted in a transfer of fish from the John Day River which is just north of Silvies and is part of the lower Columbia system. An actual comparison of the fish populations within the basin with those of adjacent drainages is presently being carried out. This involves making a series of counts and measurments from representatives of each species present in each river or creek. A multi-variate statistical analysis will be preformed on the data by the campus computer center so that a graphical comparison both within and between species will be possible. The project will hopefully be completed by the end of this summer.

# # #

Grad Projects cont'd.

The most probable cause of the low percentage of immatures in the Oregon harvest is a differential in migration whereby immatures produced early in the summer migrate south prior to the opening of the season, thus being unavaliable to the hunter. If all the immatures produced were still present when the season opened this low percentage of immatures would indicate that adults are more vunerable to hunting pressure. Our hunter bag checks also indicate that an unknown percentage of immatures are still in the nest during the early part of the season which makes them unavaliable to the hunter. Unfortunately too few immatures have been banded and recovered to presently verify a differential in migration or vulnerability from analysis of banding data. To answer some of the above and related questions raised by our research a new research program will be initiated this summer by the Dept. of Fisheries and Wildlife, OSU.

The author wishes to acknowledge the cooperation of the Oregon State Game Commission, California Department of Fish and Game, William L. Finley Wildlife Refuge and their personnel during the course of this study.

# # #

THE ORIGIN AND DISTRIBUTION OF THE FISH FAUNA OF THE HARNEY BASIN, OREGON
By Peter Bisson

The Harney or Malheur Basin is one of the largest of the internally draining, semi-desert basins which occur in the extensive high lava plains of southeastern Oregon. The center of the basin is occupied by Harney and the larger Malheur Lake, both of which represent the playa remnants of a once vast pluvial lake which received a great deal of precipitation and glacial

(cont'd.)

Rm. 232 8 AM
Wed. Dec. 3

- Spec. Reg. -

- First: What meant - Spec. Reg. - - -
- Dif. fm. "normal" a state-wide - - more restrictive no., size, - . → Reduce angling mortality - spread catch - - Goal to increase CPMH & $\bar{x}$ size (2yr) by recycling - C & R. ^ fish caught more than once -
- C & R - No kill. - C & R below, above, in between. (min. max. "slot" limits)

widely used - Trout & bass fisheries. - . Pred./prey ratios (why ahead)
Enormous controversies - - TU FFF - push - savoir - trend.
St. agencies resist - - "wasteful" of fish - antagonize - - doesn't work
enforcement prob., - "elitism" - why didn't work 20-40 yrs ago but now on same waters?
why more impt. now →

Strat. Plan ★

Historical Perspective.

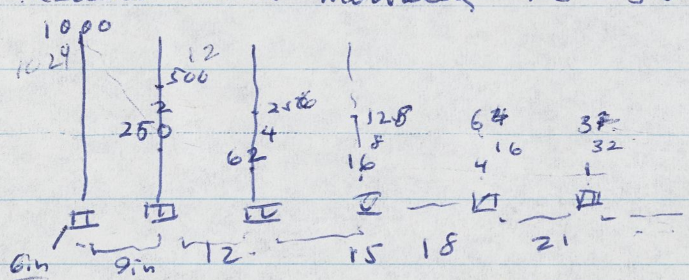
- Overexploitation
(A) how quant. angl. pressure hrs./ac./ha
(B) how many hrs. catch 50%? → sp. dif? - 769 - 30% - 12 - 50%
(C) - compensatory mort. total: nat. + ang. 75% = 60 + 15 - 15 -

45 yrs - Hazz. Plan - Pa. - 1934 -
Why not better consensus? - Pa. -!
I - Overprotection -
protect fm. poachers & fish hogs -
size bag limits - bluegill, perch, crappie, bullheads - - No science, law enforcement
propagation (fry) close trib.
II - Enlightenment, liberaliz.
- Sci. Fish Biol. 1930s Mich. - Carl Hubbs -
N.H. - Earl Hoover - TVA Eschmeyer.
- 1950 - K.R. Allen Horokiwi stream - what found?
- fry stocking useless - great surplus - - Nat. mortal. other angl. mort. inconsequential - - True - but -
TVA lakes - - ang. pressure - 1930s - 40s -
- Thus - Max. Sust. yield. - - - harvest all surplus

II

- Since anglers taking so few - so little of surplus.
liberalize - do away w/ season, length limits, bag limit
(bag psychology. - if more than 3-4 - might as well be no limit).
ex. 10/day .. 90-95% 1-2-3 5-10 4 ...

- Present 3-4 fold increase - Define overexploitation (if angler
Demand, wild trout streams - kill reduced more survive to next yr. - - at
some pt. overexploit. occurs - what pressure?
- What sp. . .
>500 - Brown - R.B. - Brk. - Cutt. 10-50
— ✱ - Not apply randomly (dart ~~board~~) -
- what attributes? - Angl. Pressure for that sp. to overexpl.
- Age - growth of pop. - brook 3 yr. 10 in.
(Wont work - causes bad feelings lack confidence -
* Then - pick ~~places~~ sites! - - Why can we no
1 mi. sections - - alternate - not whole R. ???
(Lawrence Crk. Wis. closed 1 mi. 5 yr.) -
- max age 7 yr — 21 in. Reduce total mortality 75 = 50%



(St. Joe R.
10 x > 10 ...
30 x > 13 in

---

when use ~~min~~ - ~~Trophy fish~~ large no. >(14 in).
max - Trophy - release all >13 in Yellowstone L.
slot > over prod. stunting - Thin? -

Coexist. 2/more sp. - Br./Rb So. Platte
Br./cutt N. Mex.
favor - spec. C.R. ... - Penn. E.B. ...

III

- * - Survival after release ?
- London Times - - -
  Bouck - Ball 12 of 14 died 8 days - (bled!)
- bait vs. artific. lures -
  ——— - need single barbless ? -
  No! - avoid elitism, antag.
  - large treble -
- Wydeski [illegible] (25%) - why 3% in hatch-bait - ?
- Madison R - high summer mortality
  - high temp. - expertise anglers - catch again - [illegible]
  post spawners -
  - [illegible] 13X tagged RB
  `caught RB 3X -

Barry Nehring - So. Platte :

--- 2000 hrs / acre / yr.

- N. Res, Days, Public Relations

Standard 30 - 70. — C. & R 70 - 30
5% R.B., 9% brw, > 12 in — 64% R.B, 49% brn > 12 in.

Hot Crk. CA 3800 hrs/acre/yr.
brown trout - 2 fish bag

1 mi. section - begin
1976 2307 catchable
- catch 7,047 (CPMH .6)
harvest 794 (release 6253)
end season 1,453 (only 60 unacc.)
- each fish C & R 3X - 5.

- Challenge biol. to learn dynamics of fish pop. - -
future: no longer - merely adj. hatch. sched. to anticipate demands

S. P. Platania
November 1984

FW 540

Regulations to Control Harvest of Stream Fishes

Alexander, G.R. 1974. The consumption of trout by bird and mammal predators on the North Branch Au Sable River. Michigan Department of Natural Resources, Dingell-Johnson Study Final Report F-30-R-8, Michigan. pp. 133-172.

Alexander, G.R. 1977. Food of vertebrate predators on trout waters in north central lower Michigan. Michigan Academy 10(2):181-195.

Alexander, G.R. 1977. Consumption of small trout by large predatory brown trout in the North Branch of the Au Sable River, Michigan. Michigan Department of Natural Resources Fisheries Research Report 1855:26 pp.

Alexander, G.R., and J.R. Ryckman. 1976. Trout production and catch under normal and special angling regulations in the North Branch of the Au Sable River, Michigan. Michigan Department of Natural Resources Fisheries Research Report 1840:14 pp.

Barnhart, R.A., and T.D. Roelofs. editors. 1980. Catch-and-release fishing as a management tool. California Cooperative Fishery Research Unit, Humbolt State University, Arcata, California.

Behnke, R.J. 1978. Use of native trout in special regulation fisheries. Pages 45-47 in K. Hashagen, ed., Wild Trout Management Symposium Proceedings. California Trout, Inc.

Behnke, R.J. 1980. Special Regulations:Historical Perspective. Pages 58-63 in R. Whaley, ed., Proceedings of the 15th Annual Meeting of the Colorado-Wyoming Chapter, American Fisheries Society. Wyoming Game and Fish, Casper Wyoming.

Borgeson, D.P. 1979. Controlling predator-prey relationships in streams. Pages 425-430 in H. Clepper, ed., Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, D.C.

Carpenter, M.R., and J.M. Deinstadt. 1980. Attitudes of trout stream anglers and their relation to trout stream management. Pages 19-25 in R.A. Barnhart and T.D. Roelofs, eds., Catch-and-release fishing as a management tool. California Cooperative Fishery Research Unit, Humbolt State University, Arcata, California.

Cooper, E.L. 1970. Management of trout streams. Pages 153-162 in N.G. Benson, ed., A century of fisheries in North America. American Fisheries Society Special Publication Number 7.

Dienstadt, J.M. 1980. Catch-and-release angling in California wild trout streams. Pages 119-124 in R.A. Barnhart and T.D. Roelofs, eds., Catch-and-release as a management tool. California Cooperative Fishery Research Unit, Humbolt State University, Arcata, California.

Fatora, J.R. 1970. Noontootla-A sixteen-year creel and use history of a southern Appalachian trout stream under changing management regulations. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissions 24:622-637.

Fleener, G.G. 1971. Harvest of fish from Courtois Creek. Missouri Department of Conservation, Dingell-Johnson Project F-I-R-20, Study 5-11, Job Number 3.

Fleener, G.G. 1974. Harvest of fish from the Big Piney River. Missouri Department of Conservation, Dingell-Johnson Project F-I-R-22, Study 5-2, Job Number 1.

Fox, A.C. 1975. Effects of traditional harvest regulations on bass populations and fishing. Pages 392-398 in R.H. Stroud and H. Clepper, eds., Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Hunt, R.L. 1970. A compendium of research on angling regulations for brook trout conducted at Lawrence Creek, Wisconsin. Wisconsin Department of Natural Resources Research Report 54:37 pp.

Johnson, T.H., and T.C. Bjornn. 1978. Evaluation of angling regulations in management of cutthroat trout. Idaho Game and Fish Department, Federal Aid Project F-59-R-7, F-58-R-8. 153 pp.

Klein, W.D. 1974. Special regulations and elimination of stocking:influence on fishermen and the trout population at Cache la Poudre River, Colorado. Colorado Technical Publication Number 30:57 pp.

Latta, W.C. 1973. The effect of a flies-only fishing regulation upon trout in the Pigeon River, Otsego County, Michigan. Michigan Department of Natural Resources Fisheries Research Report 1807:28 pp.

May, R.H. 1980. The semantics of modern trout management: an angler's view. Pages 77-83 in R. Whaley, ed., Proceedings of the 15th Annual Meeting of the Colorado-Wyoming Chapter, American Fisheries Society, Wyoming Game and Fish, Casper, Wyoming.

Nehring, R.B. 1980. Special regulations evaluations in Colorado. Pages 84-94 in R. Whaley, ed., Proceedings of the 15th Annual Meeting of the Colorado-Wyoming Chapter, American Fisheries Society. Wyoming Game and Fish, Casper, Wyoming.

Pettit, S.W. 1977. Comparative reproductive success of caught-and-released and unplayed hatchery female steelhead trout (*Salmo gairdneri*) from the Clearwater River, Idaho. Transactions of the American Fisheries Society 106(5):431-435.

Pettit, S.W. 1980. Steelhead catch-and-release research and regulations on the Clearwater River, Idaho. Pages 169-175 in RA.A Barnhart and T.D. Roelofs, eds., Catch-and-release fishing as a management tool. California Cooperative Fishery Research Unit, Humbolt State University, Arcata, California.

Reingold, M. 1975. Effects of displacing, hooking, and releasing migrating adult steelhead trout. Transactions of the American Fisheries Society 104(3):458-460.

Sanderson, A.E., Jr. 1958. Smallmouth bass management in the Potomac River Basin. Transactions of the North American Wildlife Conference 23:248-262.

Shetter, D.S. 1969. The effects of certain angling regulations on stream trout populations. Pages 333-353 in T.G. Northcote, ed., Symposium on salmon and trout in streams. H.R. MacMillian Lecture in Fisheries, University of British Columbia, Vancouver.

Shetter, D.S., and G.R. Alexander. 1962. Effects of flies only restriction on angling and fall trout populations in Hunt Creek, Montmorency County, Michigan. Transactions of the American Fisheries Society 91(3):295-302.

Shetter, D.S., and G.R. Alexander. 1966. Angling and trout populations on the North Branch of the Au Sable River, Crawford and Otsego counties, Michigan, under special and normal regulations, 1958-63. Transactions of the American Fisheries Society 95(1):85-91.

Shetter, D.S., and L.N. Allison. 1955. Comparison of mortality between fly-hooked and worm-hooked trout in Michigan streams. Michigan Department of Conservation, Institute of Fisheries Research Miscellaneous Publication 9:44 pp.

Shetter, D.S., and L.N. Allison. 1958. Mortality of trout caused by hooking with artifical lures in Michigan waters 1956-1957. Michigan Department of Conservation, Institute of Fisheries Research Miscellaneous Publication 12:15 pp.

Surber, E.W. 1968. Effects of a 12-inch size limit on smallmouth bass populations and fishing pressure in the Shenandoah River, Virginia. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 22:300-311.

Vincent, E.R. 1980. Effects of special angling regulations on wild trout populations. Page 95 in R. Whaley, ed., Proceedings of the 15th Annual Meeting of the Colorado-Wyoming Chapter, American Fisheries Society, Wyoming Game and Fish, Casper, Wyoming.

Wydoski, R.S. 1980. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 in R.A. Barnhart and T.D. Roelofs, eds., Catch-and-release fishing as a management tool. California Cooperative Fishery Research Unit, Humbolt State Univeristy, Arcata, California.

Additional References

Anderson, R. M. and R. B. Nehring. 1984. Effects of a catch-and-release regulation on a wild trout population in Colorado and its acceptance by anglers. N. Am. J. Fish. Mgmt. 4:257-265.

Hunt, R. L. 1981. A successful application of catch and release regulations on a Wisconsin trout stream. Wisconsin Dept. Nat. Res. Tech. Bull. 119.

Feb. 8 -- Lecture 7. Additive vs. compensatory mortality and MSY.

Reading:

Nichols, J. D., M. J. Conroy, D. R. Anderson, and K. P. Burnham. 1984. Compensatory Mortality in waterfowl populations: a review of the evidence and implications for research and management. Trans. N. American Wildl. Nat. Res. Conf. 49:535-554.

Optional:

Nichols, J. D. 1991. Responses of North American duck populations to exploitation. Pages 498-525 In C. M. Perrins, J-D. Lebreton, and G. J. M. Hirons, eds. Bird Population Studies, Oxford, New York, N.Y.

Smith, G. and R. Reynolds. 1992. Hunting and mallard survival. J. Wildl. Manage. 56:306-316.

Sedinger, J. S., and E. A. Rexstad. 1994. Do restrictive harvest regulations result in higher survival rates in mallards? A comment. J. Wildl. Manage. 58:571-577.

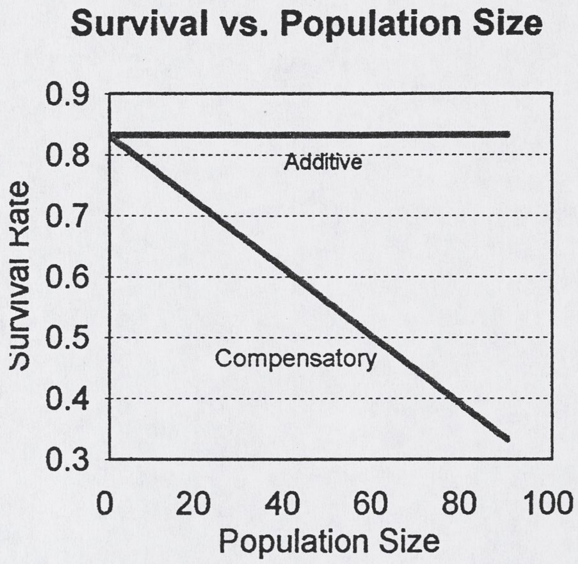
Smith, G. and R. Reynolds. 1994. Hunting and mallard survival: a reply. J. Wildl. Manage. 58:578-581.

Clark, W. R. 1987. Effect of harvest on annual survival of muskrats. J. Wildl. Manage. 51:265-272.

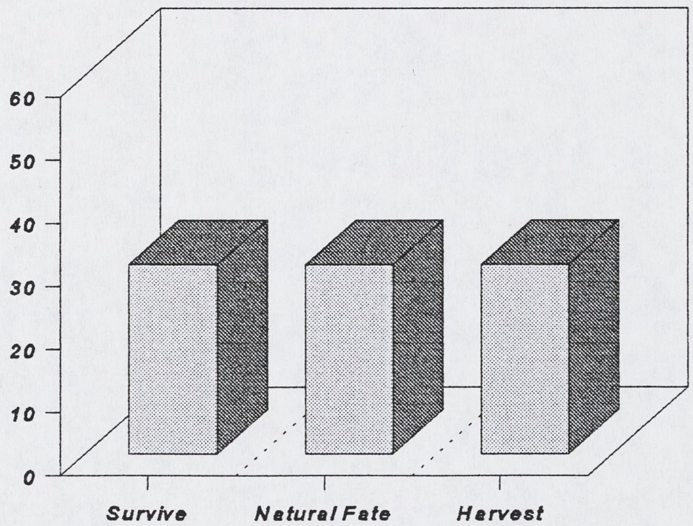
I will illustrate the concept of compensatory mortality with a simple example. Assume that 90 animals start the biological year. All harvest takes place before any natural mortality occurs. Further assume that the natural mortality occurs in density-dependent fashion, i.e., survival from the end of the harvest period to the start of the next year is defined as

$$S = S_0 - S_1 N$$

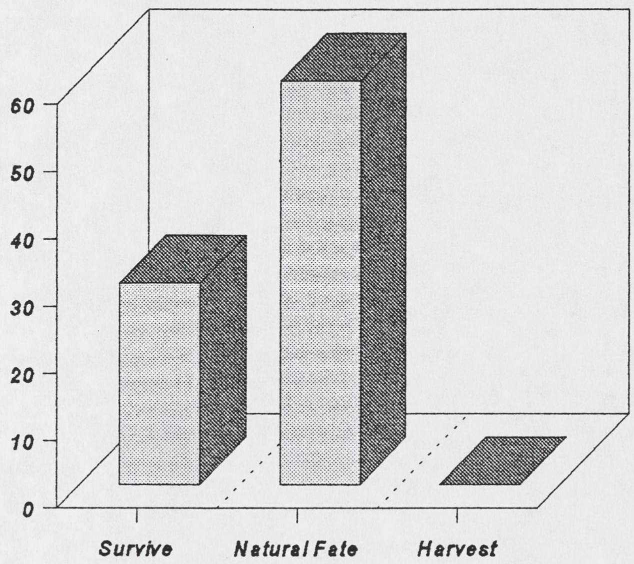
and let $S_0 = 0.8333$ and $S_1 = 0.0055556$. This function is plotted on the following graph, along with the density-independent situation where no response in survival is allowed as a function of population size. These lines are labels compensatory for density dependence and additive for density independence because these are the underlying assumptions that result in compensatory and additive mortality.



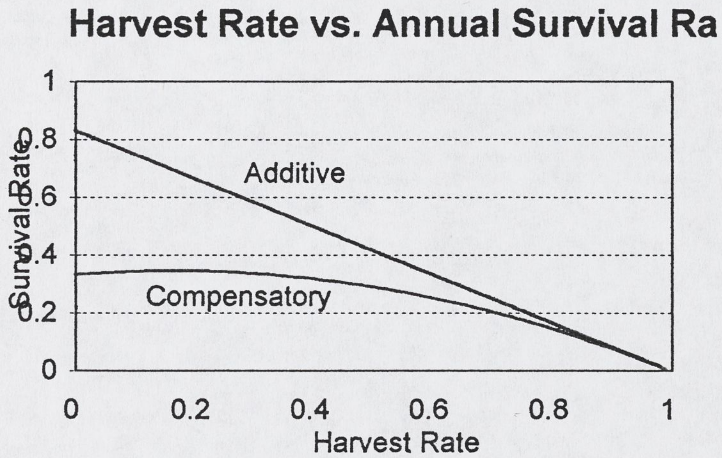
Assume now, that for the base situation, 1/3 of the 90 animals be removed by hunting, so that for the 60 left, S = 0.8333 - 0.0055556(60) = 0.5 under the assumption of density dependence. Thus, 30 of these animals survive the year.



Now, we want to manipulate the system by removing the hunting mortality, i.e., let the harvest rate equal zero. Under the assumption of a density-dependent response to the removal of hunting, 90 animals undergo natural mortality, and the survival rate is S = 0.8333 - 0.0055556(90) = 0.3333. Thus, only 30 animals survive the year, just as in the case of hunting mortality of 33%.

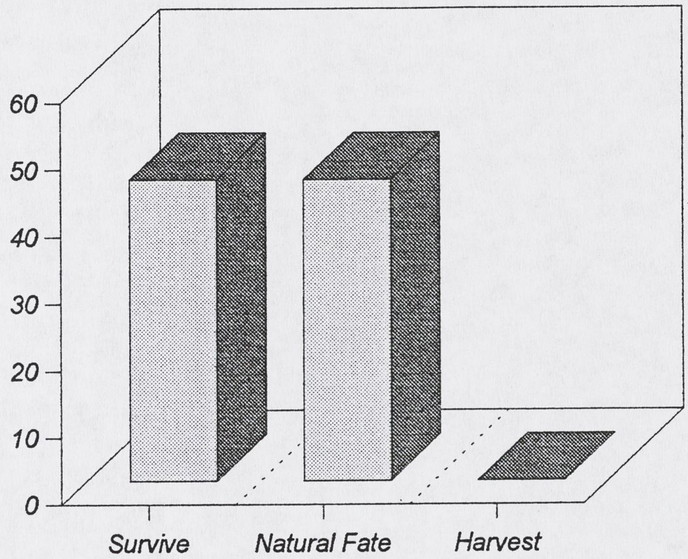


The hunting mortality is compensated for by an increase in survival of the animals remaining after the hunting season by the density-dependent decrease in mortality because of fewer animals present in the population. If we graph the overall survival rate, i.e., the probability of surviving the hunting season times the probability of surviving the rest of the year, we get the relationship:

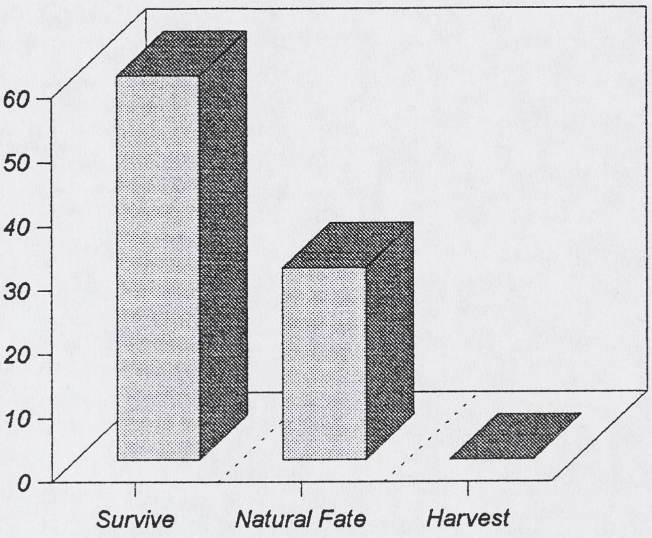


This curve of compensation is relatively flat for quite a range of harvest rates, because the natural survival rate compensates for the increase in harvest rate by increasing because of the decreasing number of animals in the population.

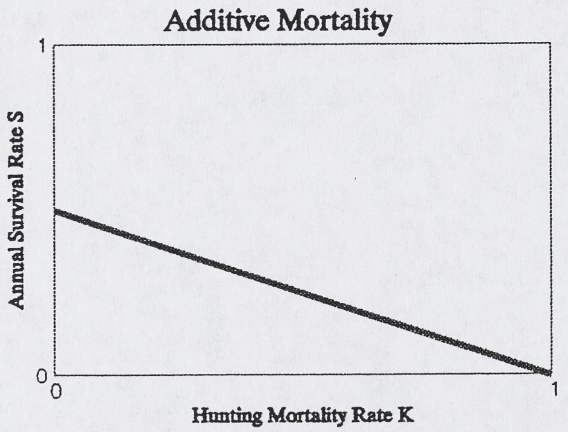
If the hunting mortality had been additive, then the survival rate observed for the 60 animals in the base situation would continue to apply to 90 animals, so that 45 would survive the year. This situation is demonstrated in the following histogram, and is illustrated in the above plot by the line labeled additive. No response in the natural mortality rate is available to compensate for increased harvest, so the additive line decreases linearly in response to an increase in the harvest rate.



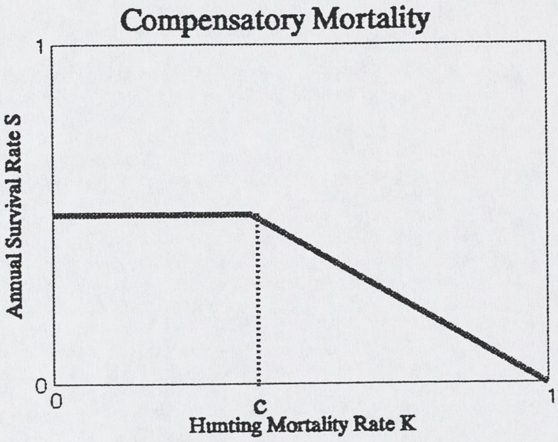
Another common misconception about our example is that if the harvest is removed, all the harvested animals will live, giving the following result. This result I label super additivity. To achieve this response in a population, you would have to have reverse density-dependence, i.e., the natural mortality rate would have to decrease as the population increased.



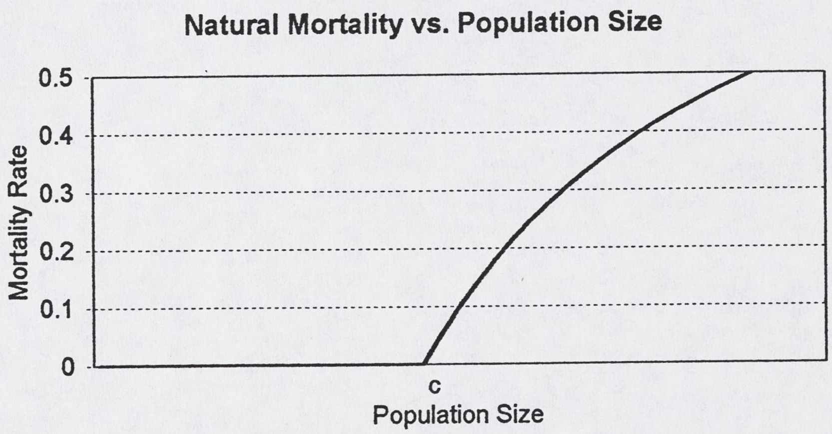
Anderson and Burnham (1976) presented a mathematical argument for compensatory mortality. They derived their results based on instantaneous rates of harvest and natural mortality. The example above is based on finite rates, with the assumption of no natural mortality during the harvest period. For finite rates and no natural mortality during the hunting season, their additive mortality results are the same straight line graph as shown above. However, if some natural mortality occurs during the hunting season, the line deviates below the straight line shown above.



Under the compensatory mortality hypothesis with density dependence operating on survival rate after the hunting season, Anderson and Burnham (1976) present the following graph. The shape and general conclusions reached from this graph are the same as illustrated above. Over some range of harvest (0 to *c*), the annual survival rate remains unchanged in response to harvest. However, beyond the threshold value of harvest (*c*), the density-dependent response of the population cannot compensate for the harvest, so the annual survival rate declines.



The natural mortality function to generate such a survival function in response to hunting mortality is the following. The population identified with *c* corresponds to the population size at the threshold in the above graph.



Testing between the 2 hypotheses

- Regression of $\hat{S}_i$ vs. $\hat{K}_I$, where *K* is kill rate, not carrying capacity. Sampling covariance of the 2 estimates $\hat{S}_i$ and $\hat{K}_I$ induces a negative relationship (Burnham and Anderson 1979). This covariance must be removed to compute a proper test of these 2 quantities.
- Splitting raw data in half (Nichols and Hines 1983) is one approach to removing the covariance. Half the data are used to estimate $\hat{S}_i$ and the other half to estimate $\hat{K}_I$.
- Both hypotheses in a single equation (Burnham et al. 1984)
  - $S_i = S_0 \ (1 - \underline{b}K_i)$
  - H_0: b = 0 means compensation
  - H_a: b < 0 means partial compensation

H_a: b = 1 means additive

Continuity of compensatory and additive hypotheses

Relation of survival to population size (or harvest)

Instantaneous vs. finite representations

$N_t = N_0 \exp\{[b - (m_0 + n_0 - m_0 n_0)]t\}$ where m_0 is fishing mortality in the absence of natural mortality, and n_0 is natural mortality in the absence of fishing mortality. This equation assumes additive mortality. The term $m_0 n_0$ just specifies that a fish cannot die from both natural and fishing mortality. In reality, m_0 can never be measured (see Anderson and Burnham 1981). The parameters m and n are actually measured, so that overall mortality is m + n which conceptually is not equal to $m_0 + n_0 - m_0 n_0$.

For compensatory mortality, n must be made a function of m.

Examples.

Waterfowl (Burnham and Anderson 1984, Burnham et al. 1984, Nichols et al. 1984, Smith and Reynolds 1992, Sedinger and Rexstad 1994, Smith and Reynolds 1994)

Muskrats (Clark 1987)

Mule deer (Bartmann 1992)

Discussion.

Why have so many studies examined reproduction in response to population size, but not survival rates?

Laboratory exercise: 1) Quattro Pro model of additive and compensatory mortality based on a finite survival rate model, and 2) Quattro Pro model with and without compensation -- Piceance mule deer population (Bartmann et al. 1992).

Literature Cited

Anderson, D. R. And K. P. Burnham. 1976. Population ecology of the mallard: VI. The effect of exploitation on survival. Resour. Publ. 128. U. S. Fish Wildl. Serv. 66pp.

Anderson, D. R. and K. P. Burnham. 1981. Bobwhite population responses to exploitation: two problems. J. Wildl. Manage. 45:1052-1054.

Bartmann, R. M., G. C. White, and L. H. Carpenter. 1992. Compensatory mortality in a Colorado mule deer population. Wildlife Monograph 121:1-39.

Burnham, K. P., and D. R. Anderson. 1984. Tests of compensatory vs. additive hypotheses of mortality in Mallards. Ecology 65:105-112.

Burnham, K. P., G. C. White, and D. R. Anderson. 1984. Estimating the effect of hunting on annual survival rates of adult mallards. J. Wildl. Manage. 48:350-361.

Clark, W. R. 1987. Effect of harvest on annual survival of muskrats. J. Wildl. Manage. 51:265-272.

Nichols, J. D., and J. E. Hines. 1983. The relationship between harvest and survival rates of mallards: a straightforward approach with partitioned data sets. J. Wildl. Manage. 47:334-348.

Nichols, J. D., M. J. Conroy, D. R. Anderson, and K. P. Burnham. 1984. Compensatory Mortality in waterfowl populations: a review of the evidence and implications for research and management. Trans. N. American Wildl. Nat. Res. Conf. 49:535-554.

Sedinger, J. S., and E. A. Rexstad. 1994. Do restrictive harvest regulations result in higher survival rates in mallards? A comment. J. Wildl. Manage. 58:571-577.

Smith, G. and R. Reynolds. 1992. Hunting and mallard survival. J. Wildl. Manage. 56:306-316.

Smith, G. and R. Reynolds. 1994. Hunting and mallard survival: a reply. J. Wildl. Manage. 58:578-581.

Giardia and *Cryptosporidium* in Surface Water: An Etiological Perspective

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Prepared for Z692 JV- Ecology and Evolution in Extreme Habitats,
Limnology Graduate Seminar

26 October 1993

Abstract: *Giardia* and *Cryptosporidium* do not complete their life cycle in water; however, their waterborne occurrence has emerged as an important vehicle for the spread of infection because of their ecological adaptation to form environmentally resistant stages, i.e., the cyst and oocyst. *Giardia*, which may have a very early position in the evolution of eukaryotes, continues to be the predominant cause of identifiable waterborne disease. *Cryptosporidium,* which is possibly phylogenetically unique among the other coccidian taxon, joined the list of diseases transmitted via water in 1984 with the number of waterborne outbreaks gaining momentum steadily. While human sewage is the main source of contamination; beaver, muskrat and cattle have been implicated as important animal reservoirs for *Giardia* and *Cryptosporidium*, respectively. Cross-transmission between man and these animals has been documented at least circumstantially. More research is needed to identify aquatic or water inhabiting animals that perpetuate the life cycles of these protozoan parasites. Watershed characteristics and management have been shown to affect cyst and oocyst concentrations significantly.

Pertinent Reading: Hibler, C.P. and C.M. Hancock. 1990. Waterborne Giardiasis in: Drinking Water Micobiology. Springer-Verlag, New York
Sections 13.1, 13.2 & 13.5

Models that Predict Stream Fish Populations from Habitat

Allen, K.R. 1951. The Horokiwi stream: a study of a trout population. Bulletin 10, New Zealand Department of Fisheries. 231p.

Annear, T.C., and A.L. Conder. 1983. Evaluation of instream flow methods for use in Wyoming. Wyoming Game and Fish Department Completion Report to the Bureau of Land Management, Contract No. YA-512-CT9-226, 248p.

Barber, W.E., M.E. Oswood, and S. Deschermeier. 1981. Validation of two habitat fish stream survey techniques: the area and transect methods. U.S. Forest Service. Final Dept. Contract No. 53-0109-0-00054.

Barber, W.E., M.E. Oswood, and S.J. Deschermeier. 1982. Validation of two fish habitat survey methods in southeast Alaska. Pages 225-231 in N.B. Armantrout, ed., Acquisition and Utilization of Aquatic Habitat Inventory Information Symposium. Western Division of The American Fisheries Society Publication.

Binns, N.A. 1979. A habitat quality index for Wyoming trout streams. Wyoming Game and Fish Department, Fishery Research Report, Monograph Series Number 2, 75p.

Binns, N.A., and F.M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S.D.I. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-82/26. 248p.

Bovee, K.D., and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. Instream Flow Information Paper 3. U.S.D.I. Fish and

Wildlife Service, Office of Biological Services. FWS/OBS-77/63. 39p.

Burton, R.A., and T.A. Wesche. 1974. Relationship of duration of flows and selected watershed parameters to the standing crop estimates of trout populations. Wyoming Water Resources Research Institute, Water Resources Series No. 52. 86p.

Chow, V.T. (ed.) 1964. Handbook of applied hydrology. McGraw-Hill, New York. 1418p.

Cline, R., G. Cole, W. Megahan, R. Patten, and J. Potyondy. 1981. Guide for predicting sediment yields from forested watersheds. U.S. Forest Service, Northern and Intermountain Regions Publication. 48p. + app.

Duff, D.A., and J.L. Cooper. 1978. Techniques for conducting stream habitat surveys on National Resource Land. U.S.D.I. Bureau of Land Management. Technical Note 83, 73p.

Eifert, W.H., and T.A. Wesche. 1982. Evaluation of the stream reach inventory and channel stability index for instream habitat analysis. Wyoming Water Resources Institute, Water Resources Series No. 82. 106p.

Enk, M.D. 1977. Instream overhead bank cover and trout abundance in two Michigan streams. M.S. Thesis, Michigan State University, East Lansing, 127p.

Fraley, J.J., and P.J. Graham. 1981. Physical habitat, geologic bedrock types and trout densities in tributaries of the Flathead River drainage, Montana. Pages 178-185 in N.B. Armantrout, ed., Proceedings of a symposium for the acquisition and utilization of aquatic habitat inventory information. Western Division American Fisheries Society, 376p.

Hall, J.D., and N.J. Knight. 1981. Natural variation in abundance of salmonid populations in streams and its implications for design of impact studies. U.S. Environmental Protection Agency. EPA-600/S3-81-021, 85p.

Harshbarger, T.J., and H. Bhattacharyya. 1981. An application of factor analysis in an aquatic habitat study. Pages 180-184 in D.E. Capen, ed., The Use of Multivariate Statistics in Studies of Wildlife Habitat. USDA Forest Service Gen. Tech. Rept. RM-87. 249p.

Havey, K.A., and R.M. Davis. 1970. Factors influencing standing crops and survival of juvenile salmon at Barrows Stream, Maine. Transactions of the American Fisheries Society 99:297-311.

Heller, D.A., J.R. Maxwell, and M. Parsons. 1983. Modeling the effects of forest management on salmonid habitat. U.S.D.A. Forest Service, Pacific Northwest region, 63p.

Hendrickson, G.E., and C.J. Doonan. 1972. Hydrology and recreation of the cold-water rivers of Michigan's southern peninsula. U.S. Geological Survey Water Information Series Report 3, 83p.

Hendrickson, G.E., R.L. Knutilla, and C.J. Doonan. 1973a. Hydrology and recreation on the cold-water rivers of Michigan's upper peninsula. U.S. Geological Survey Water Information Series Report 4, 39p.

Hendrickson, G.E., R.L. Knutilla, and C.J. Doonan. 1973b. Hydrology and recreation of selected cold-water rivers of the St. Lawrence River basin in Michigan, New York, and Wisconsin. U.S. Geological Survey Water Resources Investigations 8-73, 73p.

Hunt, R.L. 1971. Responses of a brook trout population to habitat development in Lawrence Creek. Wisconsin Department of Natural Resources, Technical Bulletin No. 48, 35p.

Johnson, D.H. 1981. The use and misuse of statistics in wildlife habitat studies. Pages 11-19 in D.E. Capen, ed., The Use of Multivariate Statistics in Studies of Wildlife Habitat. U.S.D.A. Forest Service General Technical Report RM-87.

Klamt, R.R. 1976. The effects of course granitic sediment on the distribution and abundance of salmonids in the central Idaho batholith. M.S. Thesis, University of Idaho, Moscow. 85p.

Latta, W.C. 1965. Relationship of young-of-the-year trout to mature trout and groundwater. Transactions of the American Fisheries Society 94:32-69.

Leathe, S.A., and P.J. Graham. 1983. Cumulative effects of micro-hydro development on the fisheries of the Swan River drainage, Montana. Draft of First Annual Progress Report to Bonneville Power Administration Project 82-19.

Lewis, S.L. 1969. Physical factors influencing fish populations in pools of a trout stream. Transactions of the American Fisheries Society 98:14-19.

Lotspeich, F.B. 1980. Watersheds as the basic ecosystem: this conceptual framework provides a basis for a natural classification system. Water Resources Bulletin 16:581-586.

Lotspeich, F.B., and W.S. Platts. 1982. an integrated land-aquatic classification system. North American Journal of Fisheries Management 2:138-149.

McKernan, D.L., D.R. Johnson, and J.I. Hodges. 1950. Some factors influencing the trends of salmon populations in Oregon. Transactions of the 15th North American Wildlife Conference: 427-449.

Murphy, M.L., C.P. Hawkins, and N.H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities.

Transactions of the American Fisheries Society 110:469-478.

Nehring, R.B. 1979. Evaluation of instream flow methods and determination of water quantity needs for streams in the state of Colorado. Colorado Division of Wildlife Report to the U.S. Fish and Wildlife Service Cooperative Instream Flow Service Group, Contract Number 14-16-0006-78-909.

Neter, J., and W. Wasserman. 1974. Applied Linear Statistical Models. R.D. Irwin, Inc., Homewood, Illinois, USA. 842p.

Nickelson, T. 1976. Development of methodologies for evaluating instream flow needs for salmonid rearing. Pages 588-596 in J.F. Osborn and C.H. Allmin, eds., Instream Flow Needs, Volume II. American Fisheries Society, Bethesda, Md. 657p.

Nickelson, T.E., W.M. Beidler, and M.J. Willis. 1979. Streamflow requirements of salmonids. Oregon Department of Fish and Wildlife Report. Federal Aid Project. AFS-62. Annual Report, 30p.

Orth, D.J., and O.E. Maughan. 1982. Evaluation of the incremental methodology for recommending instream flows for fishes. Transactions of the American Fisheries Society 111:413-445.

Orth, D.J., R.N. Jones, and O.E. Maughan. 1982. Considerations in the development of curves for habitat suitability criteria. Pages 124-133 in N.B. Armantrout, ed., Acquisition and utilization of aquatic habitat inventory information. Western Division, American Fisheries Society.

Oswood, M.E., and W.E. Barber. 1982. Assessment of fish habitat in streams: goals, constraints, and a new technique. Fisheries 7(3): 8-11.

Paragamian, V.L. 1981. Some habitat characteristics that affect abundance and winter survival of smallmouth bass in the Maquoketa River, Iowa.

Pages 45-53 in L.A. Krumholz, ed., The Warmwater Streams Symposium. American Fisheries Society, Bethesda, Maryland.

Pfankuch, D.J. 1975. Stream reach inventory and channel stability index. U.S.D.A. Forest Service, Northern Region. 26p.

Platts, W.S. 1974. Geomorphic and aquatic conditions influencing salmonids and stream classification. U.S.D.A. Surface Environment and Mining Program. 199p.

Platts, W.S. 1976. Validity of methodologies to document stream environments for evaluating fishery conditions. Pages 267-284 in, J.F. Osborn and C.H. Allman, eds., Instream Flow Needs, Volume II, American Fisheries Society, Bethesda, Maryland.

Platts, W.S. 1982. Stream inventory garbage in--reliable analysis out: only in fairy tales. Pages 75-84 in N.B. Armantrout, ed., Acquisition and Utilization of Aquatic Habitat Inventory Information Symposium. Western Division of The American Fisheries Society Publication.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service, Intermountain Forest and Range Experiment Station General Technical Report INT-138, 70p., Ogden, Utah.

Scarnecchia, D.L. 1981. Effects of stream flow and upwelling on abundance of wild coho salmon (Oncorhynchus kisutch) in Oregon. Canadian Journal of Fisheries and Aquatic Sciences 38:471-475.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. 2nd edition. W.H. Freeman and Company, San Francisco, California, USA, 859p.

Sonntag, N.C., P. McNamee, J. Webb, and R. Hilborn. 1982. Development of a timber/anadromous fisheries/wildlife tradeoff simulation model for southeast Alaska. Final Report to the U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station. 160p.

Stalnaker, C.B. 1979. The use of habitat structure preferenda for establishing flow regimes necessary for maintenance of fish habitat. Pages 321-337 in J.V. Ward and J.A. Stanford, eds., The Ecology of Regulated Streams. Plenum Press, New York.

Stewart, P.A. 1970. Physical factors influencing trout density in a small stream. Master's Thesis, Colorado State University, Ft. Collins, CO. 78p.

Stowell, R., A. Espinosa, T.C. Bjornn, W.S. Platts, D.C. Burns, and J.S. Irving. 1983. A guide for predicting salmonid response to sediment yields in Idaho batholith watersheds. Draft of March 1983.

Swanston, D.N., W.R. Meehan, and J.A. McNutt. 1977. A quantitative geomorphic approach to predicting productivity of pink and chum salmon streams in southeast Alaska. U.S.D.A. Forest Service Research Paper PNW-227, 16p.

U.S. Army Corps of Engineers. 1980. A habitat evaluation system for water resource planning. Environmental Analysis Branch, Lower Mississippi Valley Division, Vicksburg, Mississippi, USA. 89p. + app.

U.S. Fish and Wildlife Service. 1980. Ecological Services Manual - Habitat Evaluation Procedures (HEP). ESM 102. U.S. Department of the Interior, Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

U.S. Fish and Wildlife Service. 1981. Ecological Services Manual - Standards for the Development of Habitat Suitability Index Models. ESM 103. U.S. Department of the Interior, Fish and Wildlife Service, Division of Ecological Services, Washington, D.C.

Wesche, T.A. 1974. Relationship of discharge reductions to available trout habitat for recommending suitable streamflow. Wyoming Water Resources Research Institute, Water Resources Series 53, 73p.

Wesche, T.A. 1976. Development and application of a trout cover rating system for IFN determinations. Pages 224-234 in J.F. Osborn and C.H. Allman, eds., Instream Flow Needs, Volume II, American Fisheries Society, Bethesda, Maryland.

Wesche, T.A. 1980. The WRRI trout cover rating method: Development and application. Wyoming Water Resources Research Institute, Water Resources Series No. 78, 46p.

Wesche, T.A. 1983. Overview of instream habitat evaluation methods currently applied in the western region. Paper presented at the Western Division Meetings of the American Fisheries Society, 14p.

Wesche, T.A., D.W. Reiser, W.F. Wichers, and D.L. Wichers. 1977. Fishery resources and instream flow recommendations for streams to be impacted by Cheyenne's proposed Phase II development. Report submitted to Wyoming Game and Fish Department by the Water Resources Research Institute, University of Wyoming, Laramie, Wyoming. 14p.

White, R.J. 1975. Trout population responses to streamflow fluctuation and habitat management in Big Roche-a-Cri Creek, Wisconsin. Verh. Internat. Verein. Limnol. 19:2469-2477.

White, R.J., E.A. Hansen, and G.R. Alexander. 1976. Relationship of trout abundance to stream flow in midwestern streams. Pages 597-615 in J.F. Osborn and C.H. Allman, eds., Instream Flow Needs, Volume II, American Fisheries Society, Bethesda, Maryland. 657p.

Ziemer, G.L. 1973. Quantitative geomorphology of drainage basin related to fish production. Alaska Department of Fish and Game Informational Leaflet No. 162. 26p.

PROBLEMS OF SYMPATRIC SPECIATION IN ICHTHYOLOGY

R. J. Behnke

Mayr, Linsey and Usinger define sympatric speciation as: "Speciation in the absence of geographic isolation." Formerly, many believed sympatric speciation to be an observed fact. Mayr has spoken forcefully against sympatric speciation and his influence on contemporary thought has resulted in the theory falling into disrepute.

The species flocks of cichlid fishes in Lake Nyassa, East Africa, of cottoid fishes in Lake Baikal, Siberia, and of cyprinoid fishes in Lake Lanao, Phillipines, are often advanced as arguments in favor of sympatric speciation. Brooks (1950) rejects Mayr's explanation of species flocks resulting from multiple colonization, but he also rejects sympatric speciation as the answer. Brook's intra-lacustrine isolation via geographic barriers would be acceptable to Mayr's point of view.

Many of the difficulties involved are semantic. In its simplest terms the question can be stated: Can a population of fish, or any sexually reproducing organism, enter a new environment and fraction off into distinct populations to utilize all niches of the environment, without benefit of geographic isolation? The problem is, how might isolating mechanisms be evolved as long as the population is in contact in a continuous environment?

Habitat preference and homing instinct might be the mechanisms of isolation for sympatric speciation in fishes, but they involve many unproved assumptions.

BIBLIOGRAPHY

Brooks, J. L. 1950.
Speciation in ancient lakes. Quart. Rev. Biol. 25: 30-60; 131-176.

Cope, O.L. 1957.
Races of cutthroat trout in Yellowstone Lake. in: Contributions to the study of subpopulations of fishes. U. S. Fish and Wildlife Ser. Spec. Sci. Rept. No. 208: pp. 74-84.

Dobzhansky, T. 1951.
Genetics and the Origin of the Species. Columbia Univ. Press. N. Y. 364 pp.

Frost, W. 1955.
An historical account of the char in Windemere. Salmon and Trout mag. No. 143: 15-24.

Herre, A. W. C. T. 1933.
The fishes of Lake Lanao, a problem in evolution. Amer. Nat. 67: 154-162.

Mayr, E. 1942.
Systematics and the Origin of the Species. Columbia Univ. Press, N. Y. 334 pp.

Mayr, E. 1947.
Ecological factors in speciation. Evolution, 1: 265-288.

Thorpe, W. H. 1945.
The evolutionary significance of habitat selaction. Jour. of Animal Ecol. 14:67-70

Vernon, E. H. 1957.
Morphometric comparison of three races of kokanee (Oncorhynchus nerka) withen a large British Columbia lake. Jour. Fish. Res. Bd. Can., 14(4): 573-598.

Worthington, E. B. 1940.
Geographical differentiation in freshwater with special reference to fish. in: The New Systematics, ed. Julian Huxley. pp. 287-302.

SYMPATRIC SIBLING SPECIES OF SALMONID FISHES WITH INFERENCES FOR FISHERIES MANAGEMENT

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The currently accepted criteria for defining species emphasizing reproductive isolation has some serious limitations for the taxonomy of the family Salmonidae, where strong, innate, reproductive homing behavior may allow genetic segregation between two or more morphologically similar populations with only slight genetic differentiation.

Although the coexistence of closely related populations of salmonid fishes is a prime cause for taxonomic confusion and disagreement, this phenomenon suggests some innovative applications for fisheries management. In order for two or more populations to coexist in the same environment in nature, there must be some degree of ecological segregation to avoid direct competition. It then can be assumed that two or more coexisting populations will exploit the resources more effectively and produce more total biomass than either or any one could alone.

Examples in the literature exploring the nature of ecological segregation between coexisting salmonid fishes are limited to natural situations where the populations have been coexisting for thousands of years and the behavioral mechanisms for coexistence are probably incorporated into the genotypes.

The pertinent question for fisheries management application is: Can two closely related groups (for example, races or subspecies of a species) without genetic programming for coexistence in their evolutionary history, be introduced together and initiate ecological segregation?

Results from a study of two populations of cutthroat trout introduced in a small Colorado lake is enlightening. Their behavior is interpreted as an example of interactive segregation, whereby behavior patterns expressed in allopatry are modified in sympatry to avoid direct competition and allow coexistence. This, in turn, resulted in a striking difference in angling vulnerability between the two populations.