Conceptual Framework for the Use of Fish Parasites as Bioindicators of Acute and Chronic Environmental Perturbation After the 2010 *Deepwater Horizon* Oil Spill in the Gulf of Mexico

Stephen A. Bullard[1] & George W. Benz[2]

ash.bullard@auburn.edu

[1]Auburn University, Aquatic Parasitology Laboratory
[2]Middle Tennessee State University, Department of Biology

Outline:

1. DHOS Backdrop: what we expected, what is now
2. Taxonomic diversity of fish parasites
3. Parasites as indicators ecosystem functioning

Outline:

1. DHOS Backdrop: what we expected, what is now

2. Taxonomic diversity of fish parasites

3. Parasites as indicators ecosystem functioning

A few big oil spills:

(taken from http://www.nytimes.com/interactive/2010/05/10/us/20100510_OIL_TIMELINE.html)

- (4.2, 2%) January 30th, 1969: Santa Barbara, CA- offshore oil well leak lasting 12 days, 35 miles of shore affected
- (1.26, 0.6%) December 17th, 1976: Los Angeles, CA- oil tanker *Sansinena* explodes, LA Harbor heavily impacted
- (68.7, 34%) March 17th, 1978: Brittany, France- oil tanker *Amaco Cadiz* runs aground, 125 miles of shore affected
- (140, 70%) June 3rd, 1979: Yucatan, Gulf of Mexico- exploratory oil well *Ixtoc* explodes, sinks
- (10.8, 5%) March 24th, 1989: Prince William Sound, AK- oil tanker *Valdez* runs aground, ~1,300 miles of coast affected
- (4.2, 2%) June 8th, 1990: Gulf of Mexico- oil tanker *Megaborg* fire
- (378, 189%) January 21st, 1991: Kuwait- Gulf War I, Iraqi troops ignite wells in retreat
- (20, 10%) November 19th, 2002: Galecia, Spain- tanker *Prestige* sinks
- (3.8, 2%) August 31st, 2005: Gulf Coast States, US- Hurricane Katrina damages or sinks 50 offshore wells; onshore oil-holding facilities spill refined oil (estimate excludes gas stations)
- (24% of total) April 20th, 2010: Gulf Coast States, US- DHOS sinks, leaks oil for 86 days, spills >200M gallons of oil


DHOS on 24 May 2010 imaged by NASA Terra satellite


OIL SPILL IN THE GULF
DAY 55
SUNDAY
PRESS-REGISTER
SERVING SOUTH ALABAMA SINCE 1813
A MESSAGE FROM OBAMA
Letter to Gulf Coast residents
PAGE 16A
MOBILE/BALDWIN
$2
WORST DAY YET
THICK SHEETS OF OIL BLANKET BALDWIN BEACHES
INSIDE TODAY
OIL SPILL COVERAGE
EDITORIAL
BP should accelerate oil claims process
FULL EDITORIAL/15A
ORANGE BEACH SPILL PROTEST
COVERAGE/PAGE 1C
BUSINESS DOOMED?
TOURISM IMPACT
COAST GUARD PRESSES BP TO MOVE FASTER ON OIL/9A
WHO WOULD BP BOYCOTT HURT?/1F
Pipe boom plan at Perdido Pass
Engineers to build $4.6 million steel barrier to keep oil out of wetlands, waterways to north
Pile support boom plans

GREEN
IMPROVE YOUR LIFE. IMPROVE THE WORLD.
A NEWS BLOG
THE NEWSROOM
Scientist: Oil spill off Louisiana coast 'could prove to be just as devastating as the Exxon Valdez catastrophe'
Buzz up! 1 vote
Share 31
retweet 15
Email
Print
This is the Exxon Valdez oil spill
11 million gallons total
This is the Deepwater Horizon oil spill
6 million gallons per week

Home | SAI | Wire | Clusterstock | Money Game | War Room | Travel | Latest | Video | Hive

Oil | Solar | Wind | Nukes | Cars | Garbage | Climate Change | Most Commented | Hive | Tape

Hot » Big Tech | China | Gadgets | Hedge Funds | Online | iPhone ... more topics

Gigantic Plumes Of Oil Are Forming Under The Gulf -- Spill Vastly Worse Than It Seems On Surface

Henry Blodget | May 15, 2010, 10:22 PM | 4,903 | 58

Like

AAA

More good news about the Gulf oil leak from Justin Gillis at the New York Times: huge plumes of oil are forming in the water and taking their time about rising to the surface. So the leak is much worse than it appears from the air (and it looks bad enough already from there).

The low end of the leak-rate estimate is now 25,000 barrels a day. The high end is 80,000. The latter is one Exxon Valdez every few days.

juvenile spotted seatrout, *Cynoscion nebulosus*

red drum, *Sciaenops ocellatus*

juvenile inshore lizardfish, *Synodus foetens*

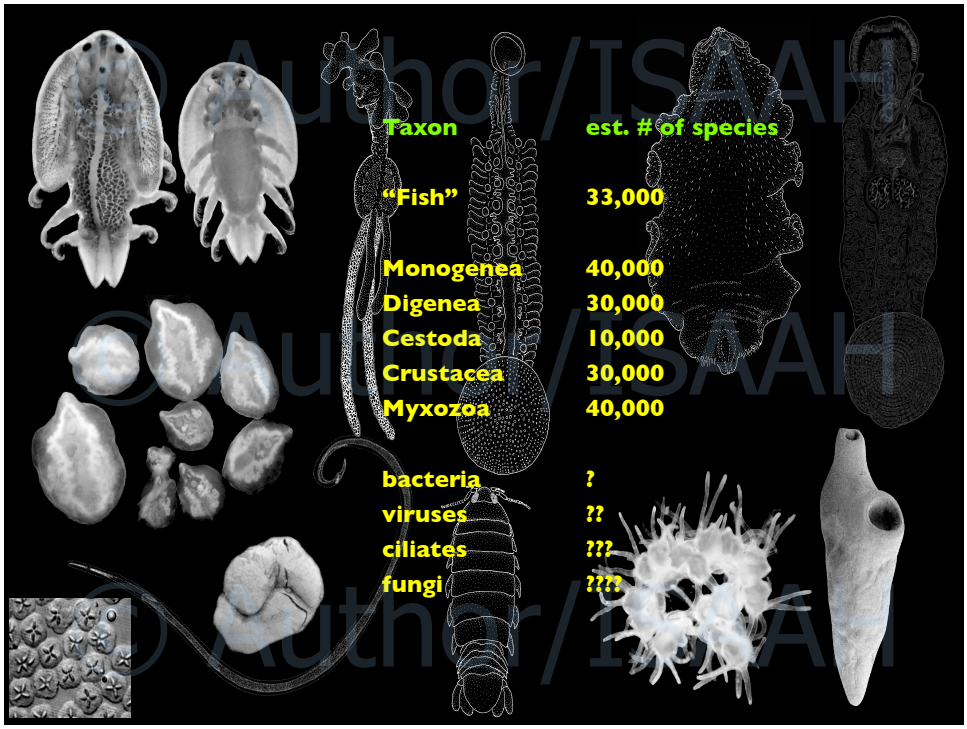
juvenile halfbeak, *Hyporhamphus unifasciatus*

Outline:

1.DHOS Backdrop: what we expected, what is now

2.Taxonomic diversity of fish parasites

3.Parasites as indicators ecosystem functioning



Kingdom Animalia— animals
Phylum Myxozoa (Cnidaria)— myxozoans, myxosporidians
Phylum Platyhelminthes— flatworms
- Superclass Turbellaria— turbellarians
  - Order Tricladida— triclads, turbellarians
- Superclass Cercomeria*
  - Class Aspidogastrea*— aspidogastreans, soleworms, aspidobothreans, aspidogastrids
  - Class Digenea*— digeneans, flukes, digenes, digenetic trematodes
  - Class Monogenea*— monogeneans, monogenoideans, monogenes, monogenetic trematodes
  - Class Cestoda*— cestodes, cestoideans: gyrocotylideans and eucestodes, tapeworms

Phylum Nematoda— nematodes, roundworms, threadworms
Phylum Acanthocephala*— acanthocephalans, spiny-headed worms
Phylum Annelida— annelids, segmented worms
- Order Hirudinida— true leeches

Phylum Arthropoda— arthropods
- Subphylum Uniramia— uniramians
  - Subclass Acari— mites
- Subphylum Crustacea— crustaceans
  - Class Maxillopoda— maxillopodans
    - Subclass Ostracoda— ostracods, seed shrimp
    - Subclass Copepoda— copepods
    - Subclass Branchiura*— branchiurans, fish lice
    - Subclass Cirripedia— barnacles
  - Class Malacostraca— malacostracans
    - Order Isopoda— isopods
    - Order Amphipoda— amphipods

Phylum Mollusca— molluscs
- Class Gastropoda— gastropods, snails

Phylum Chordata— chordates
- Subphylum Craniata— craniates
  - Superclass Agnatha— jawless fishes
    - Class Myxini— hagfishes, slime eels
    - Class Cephalaspidomorphi— lampreys
  - Superclass Gnathostomata— jawed vertebrates
    - Class Chondrichthyes— chondrichthyans
    - Class Actinopterygii— ray-finned fishes

A universally-accepted classification scheme for taxa within Animalia does not exist.

Outline:

1. DHOS Backdrop: what we expected, what is now
2. Taxonomic diversity of fish parasites
3. Parasites as indicators ecosystem functioning

Compare parasite community richness in a fish species from oiled and non-oiled marsh localities.

Ectoparasites inform short-term (acute) changes

Endoparasites inform long-term (chronic) changes

Determinates of parasite distribution in nature

- Temporal (seasonal) and spatial (geographic) distribution of hosts
- Host feeding ecology (food web interactions among hosts)
- Phylogenetic position of host ('innate' specificity)
- Abiotic factors (water temperature, salinity, pH, depth, light, pollution)

Possibility #1: A high level of parasite species richness (biodiversity) in a given host in a given locality indicates an unhealthy, contaminated, perturbed environment wherein hosts are being killed or stressed

Possibility #2: High parasite biodiversity indicates an intact, pristine environment with all required intermediate hosts present (endoparasites) and all required water quality parameters optimized (endo- and ectoparasites)

Fish parasites as indicators of environmental health

Rueckert, S., W. Hagen, A.T. Yuniar, & H.W. Palm. 2009. Metazoan fish parasites of Segara Anakan Lagoon, Indonesia, and their potential use as **biological indicators**. Reg. Environ. Change 9:315–328.

Pérez-del Olmo A., J.A. Raga, A. Kostadinova, & M. Fernández. 2007. Parasite communities in *Boops boops* (L.) (Sparidae) after the **Prestige oil-spill:** detectable alterations. Marine Pollution Bull. 54:266–276.

Dzikovski, R., I. Paperna, & A. Diamant. 2003. Use of fish parasite species richness indices in analyzing **anthropogenically impacted coastal marine ecosystems**. Helgoland Marine Res. 57:220–227.

Broeg, K., S. Zander, A. Diamant, W. Körting, G. Krüner, I. Paperna, & H.v. Westernhagen. 1999. The use of fish metabolic, pathological and parasitological indices in **pollution monitoring**. I. North Sea. Helgoland Marine Res. 53:171–194.

Diamant, A., A. Banet, I. Paperna, H.v. Westernhagen, K. Broeg, G. Krüner, W. Körting, & S. Zander. 1999. The use of fish metabolic, pathological and parasitological indices in **pollution monitoring**. II. The Red Sea and Mediterranean. Helgoland Marine Res. 53:195–208.

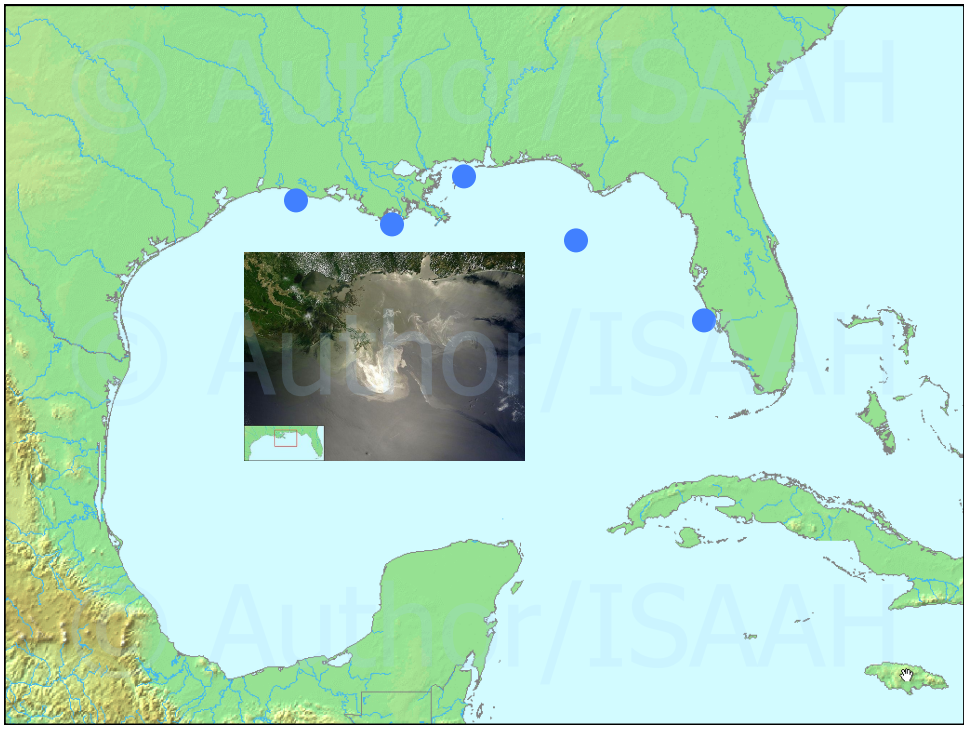
MacKenzie, K. 1999. Parasites as pollution indicators in marine ecosystems: a **proposed early warning system**. Marine Pollution Bull. 38:955–959.

MacKenzie, K., H.H. Williams, A.H. McVicar, & R. Siddal. 1995. Parasites as indicators of **water quality** and the potential use of helminth transmission in **marine pollution studies**. Adv. Parasitol. 35:86–144.

Khan, R.A. & J. Thulin. 1991. Influence of **pollution** on parasites of aquatic animals. Adv. Parasitol. 30:201–238.

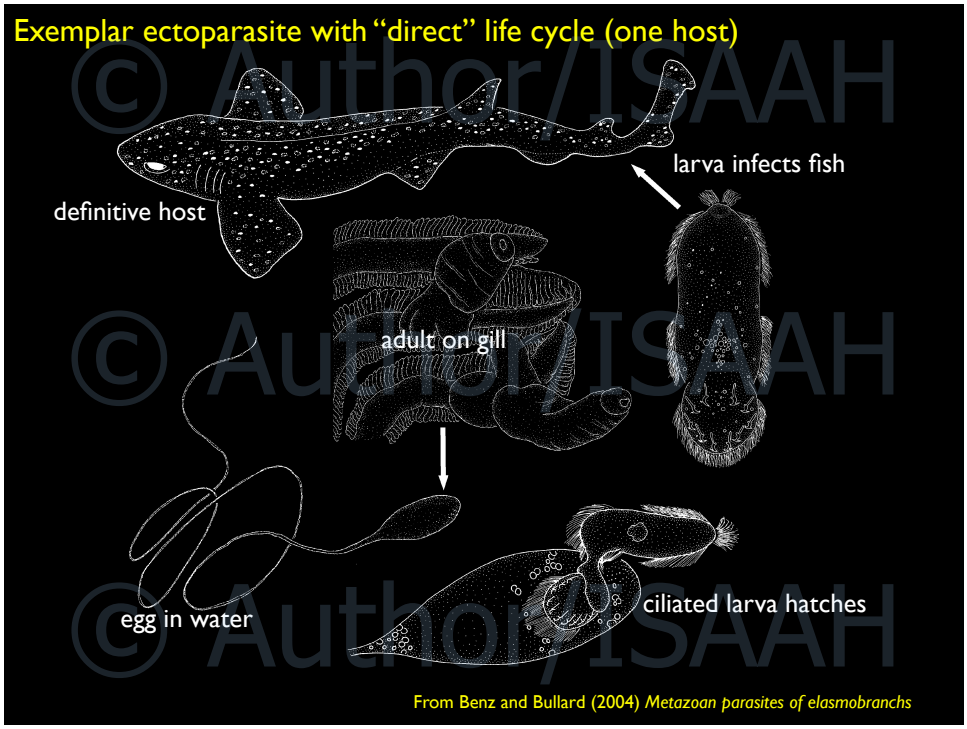
Khan, R.A. 1990. Parasitism in marine fish after chronic exposure to petroleum hydrocarbons in the laboratory and to the **Exxon Valdez oil spill**. Bull. Environ. Contamination and Toxicology 44:759–763.

Overstreet, R. M. 1977. Some parasites and diseases of estuarine fishes in **polluted habitats** of Mississippi. Annals of the New York Academy of Sciences 298:427-462.




Fish hosts that 'stay put' (less vagile)
killifishes, *Fundulus* spp.
sailfin molly, *Poecilia latipinna*
diamond killifish, *Adinia xenica*
sheepshead minnow, *Cyprinodon variegatus*
© Author/ISAAH

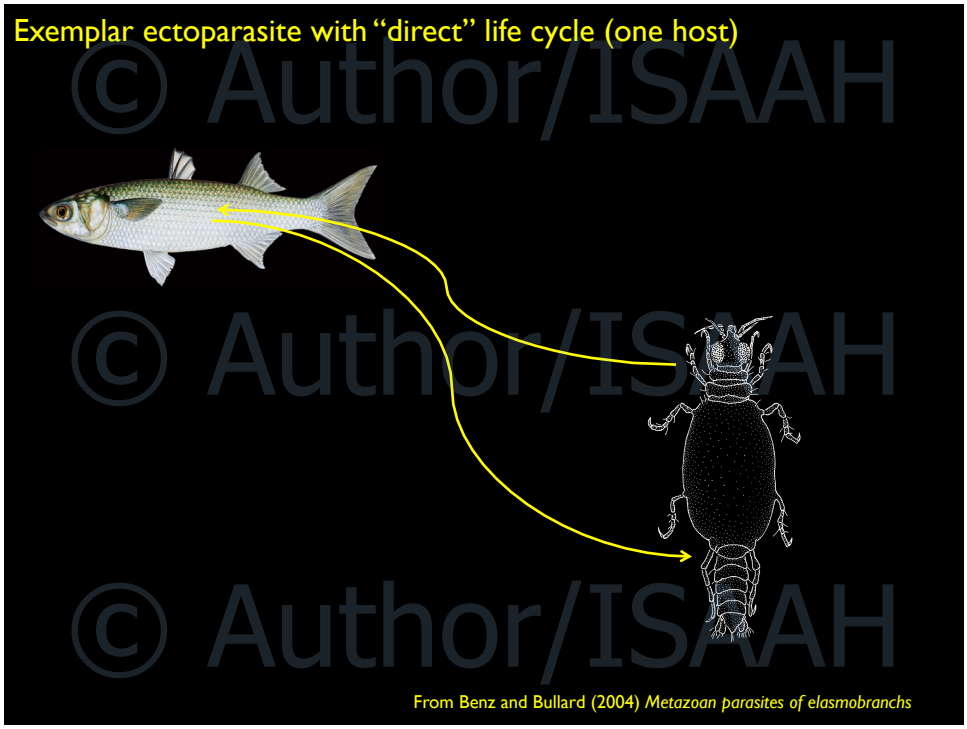

Fish hosts with wide ranges (more vagile)
Gulf menhaden, *Brevoortia partonus*
striped mullet, *Mugil cephalus*
© Author/ISAAH


Exemplar ectoparasite with "direct" life cycle (one host)
larva infects fish
definitive host
adult on gill
egg in water
ciliated larva hatches
From Benz and Bullard (2004) *Metazoan parasites of elasmobranchs*

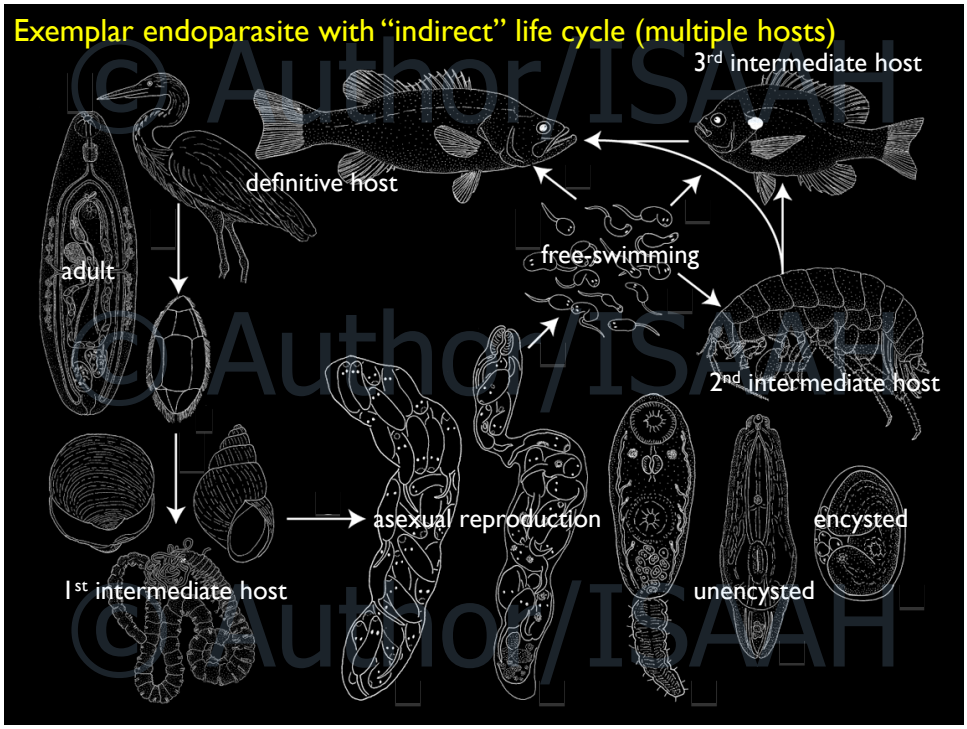

skin of blacktip shark, *Carcharhinus limbatus* infected with *Dermophthirius penneri*

inner opercle of red drum, *Sciaenops ocellatus*, infected with *Branchiella* sp. (left) and *Echetus* sp. (right)

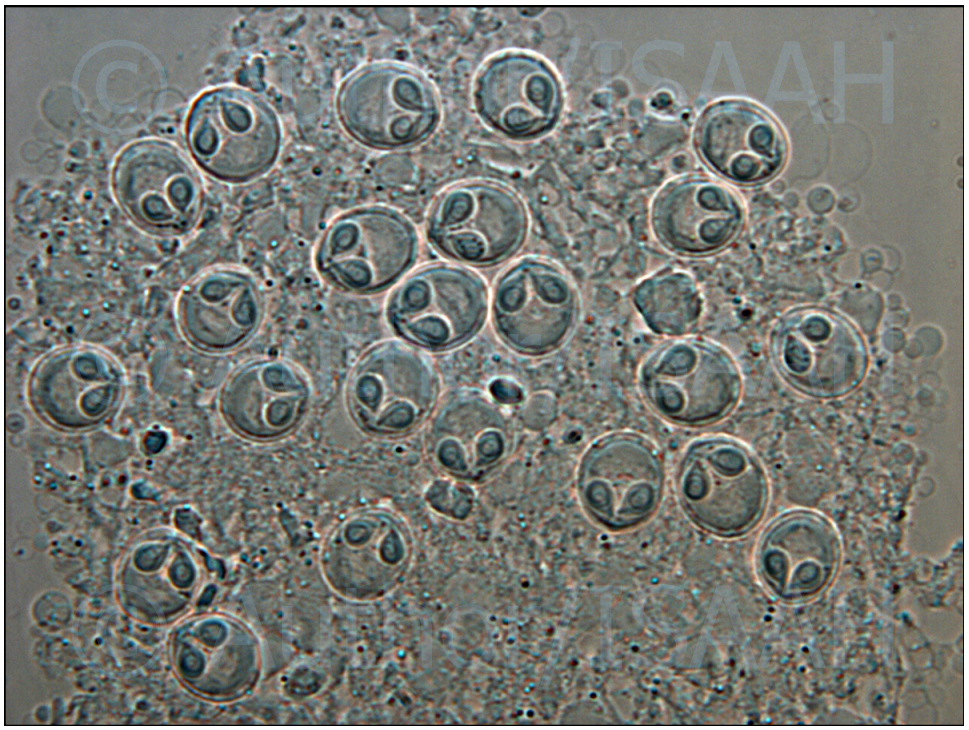
Exemplar ectoparasite with "direct" life cycle (one host)

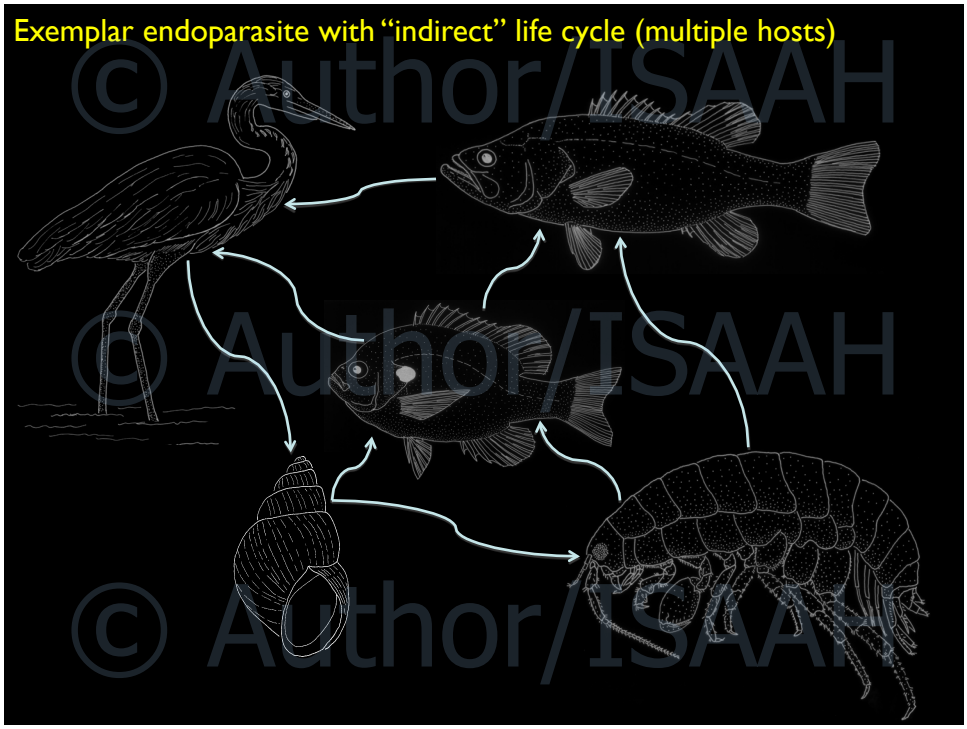


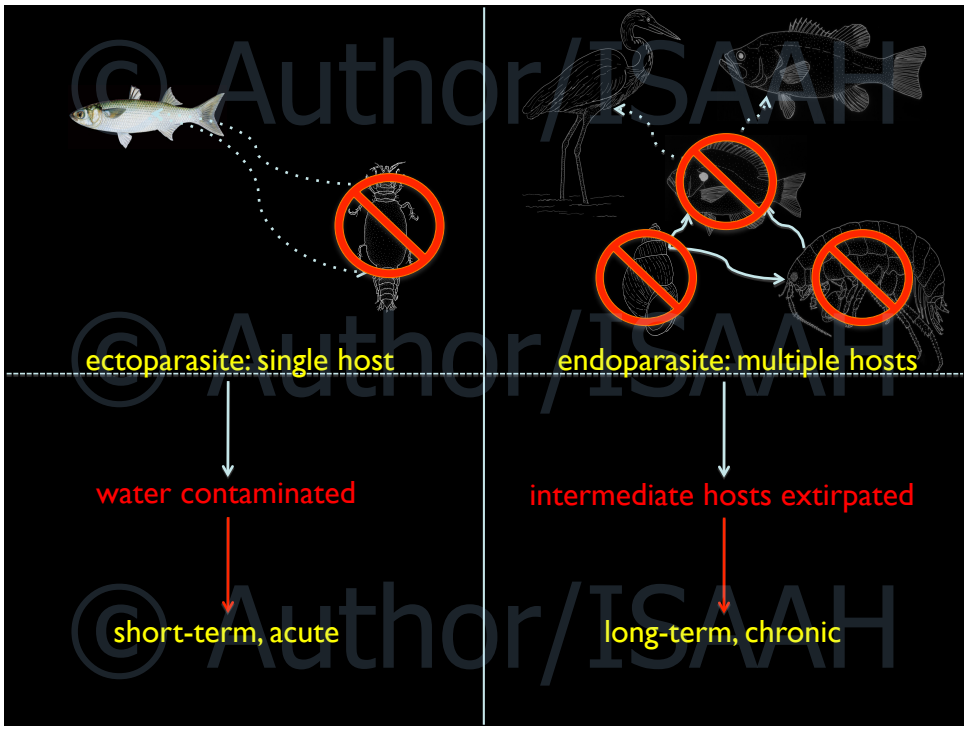
From Benz and Bullard (2004) *Metazoan parasites of elasmobranchs*


Exemplar endoparasite with "indirect" life cycle (multiple hosts)
3rd intermediate host
definitive host
adult
free-swimming
2nd intermediate host
asexual reproduction
encysted
1st intermediate host
unencysted
© Author/ISAAH


© Author/ISAAH
forcibly excysted metacercaria of *Clinostomum* sp. ("yellow grub") in bass *Morone* sp.




Exemplar endoparasite with “indirect” life cycle (multiple hosts)
© Author/ISAAH
© Author/ISAAH
© Author/ISAAH


© Author/ISAAH
ectoparasite: single host
endoparasite: multiple hosts
water contaminated
intermediate hosts extirpated
short-term, acute
long-term, chronic
© Author/ISAAH
© Author/ISAAH

Acknowledgements

Funding from National Science Foundation RAPID response, Systematic Biology and Biodiversity Inventories

In partnership with:

Mark Grace and personnel of the National Marine Fisheries Service (NMFS, NOAA), Southeast Fisheries Science Center, Pascagoula, MS

Micah Bakenhaster and colleagues, Florida Marine Research Institute, Florida Wildlife Conservation, Tampa, FL

William Hawkins and colleagues, Gulf Coast Research Laboratory, University of Southern Mississippi, Ocean Springs, MS

Myron Fischer and colleagues, Louisiana Department of Wildlife and Fisheries, Research & Assessment Division, Grand Isle, LA