RE-THINKING HATCHERIES

A REVIEW OF THE COSTS AND BENEFITS

Presenters:

- Julie Claussen, Director of Operations
- David Philipp, Chair Board of Directors

Fisheries Conservation Foundation

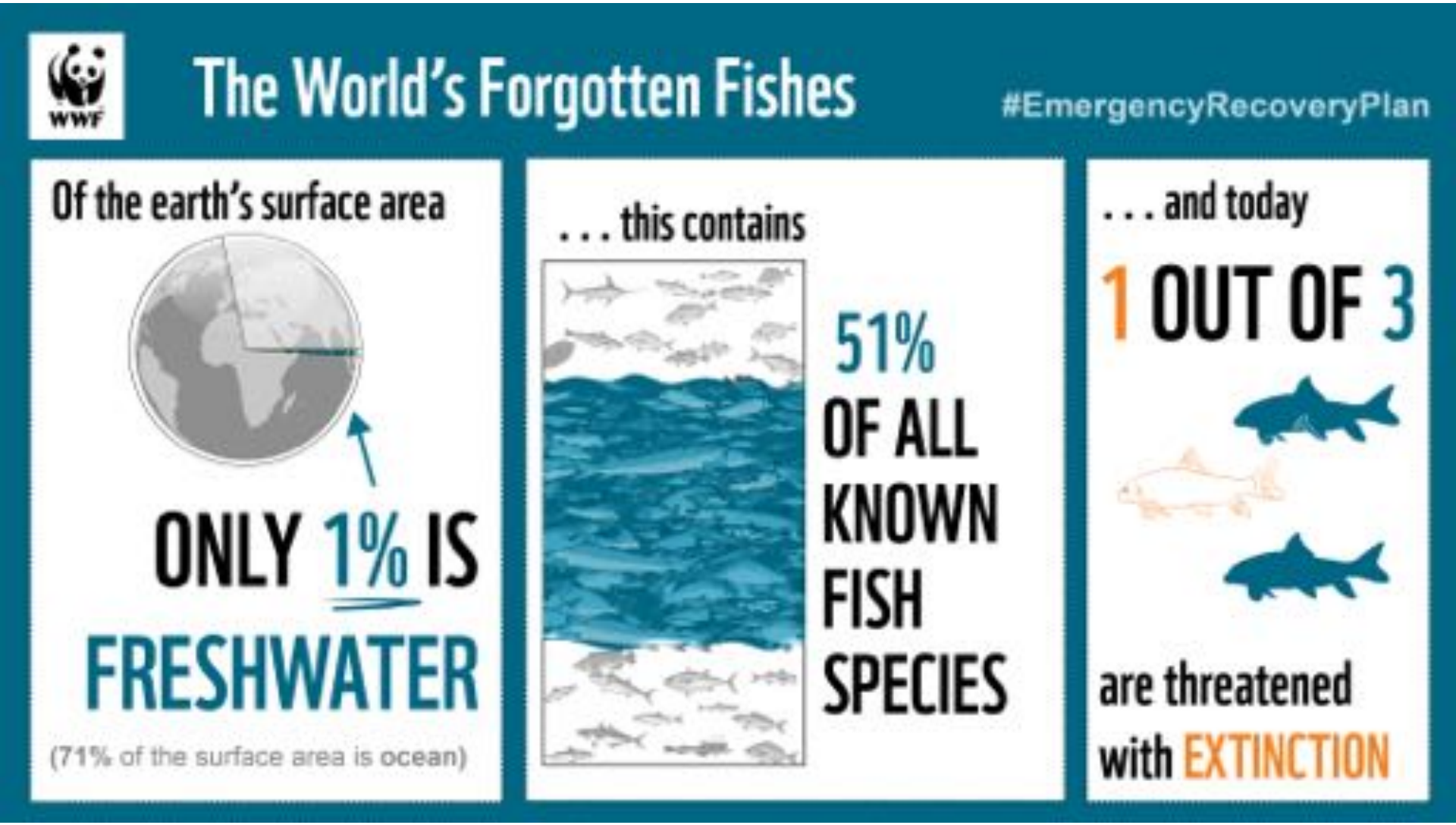
IFC International Finance Corporation WORLD BANK GROUP

Creating Markets, Creating Opportunities

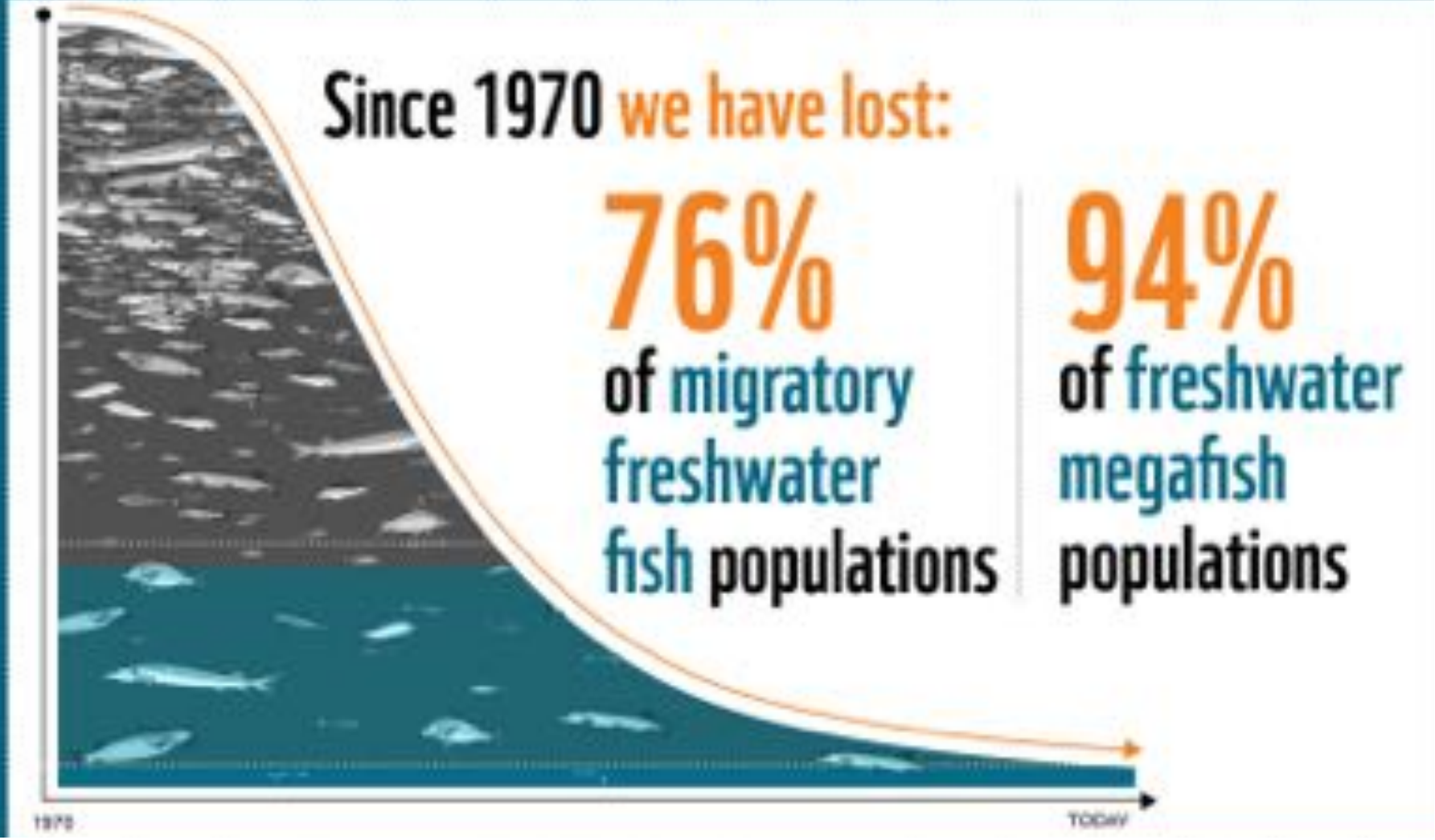
WILD FISH ARE VITAL FOR:

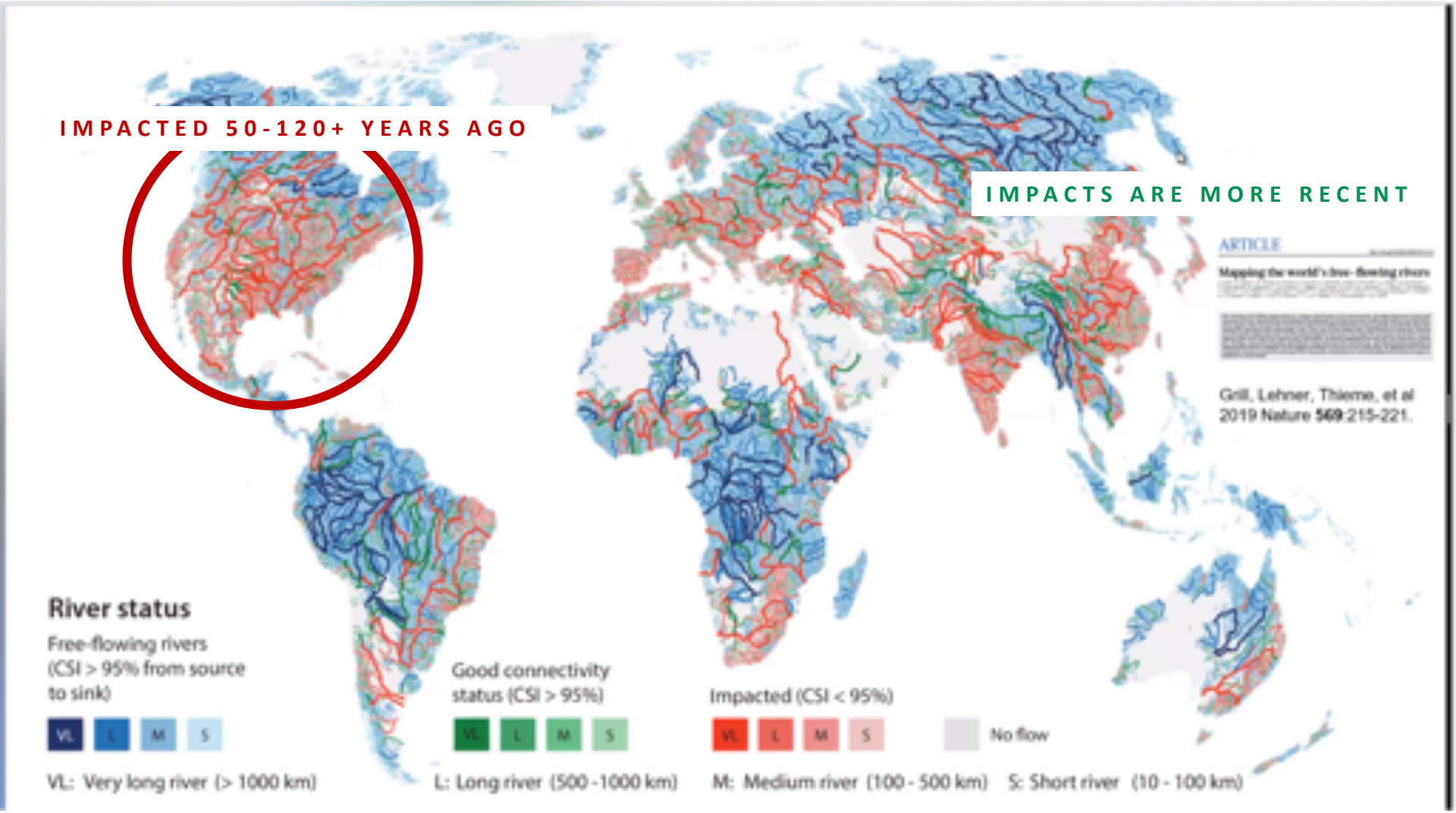
- Ecosystem Health
- Food and Nutrition
- Economy

WILD FISH ARE VITAL

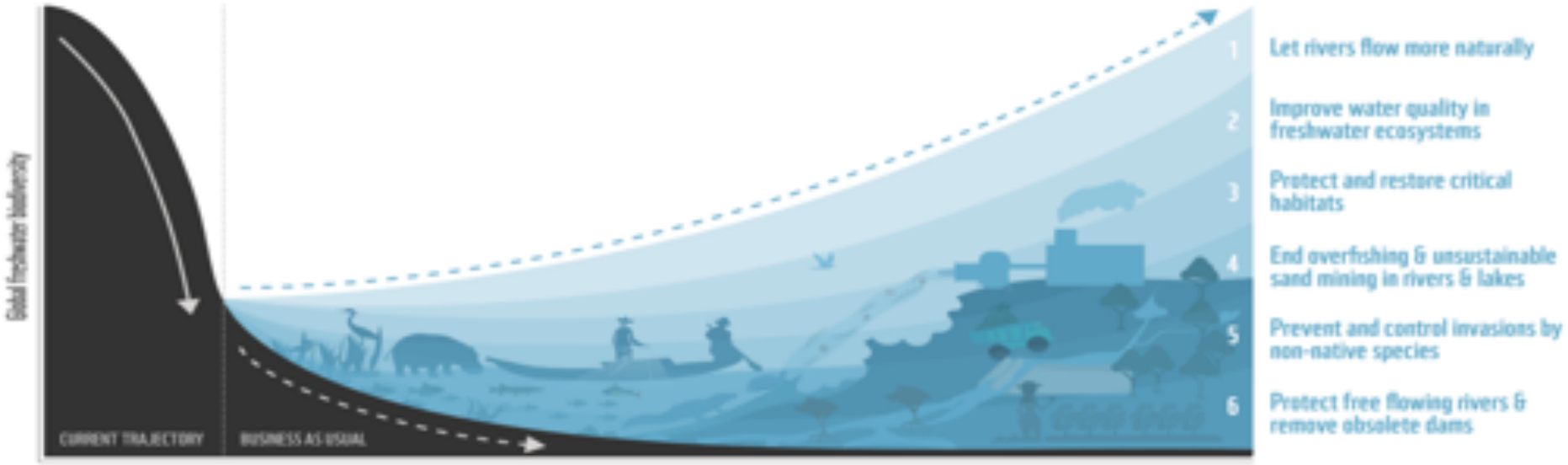


The World's Forgotten Fishes





A brighter future for freshwater fishes:
Emergency Recovery Plan for freshwater biodiversity



RECOVERY PLAN

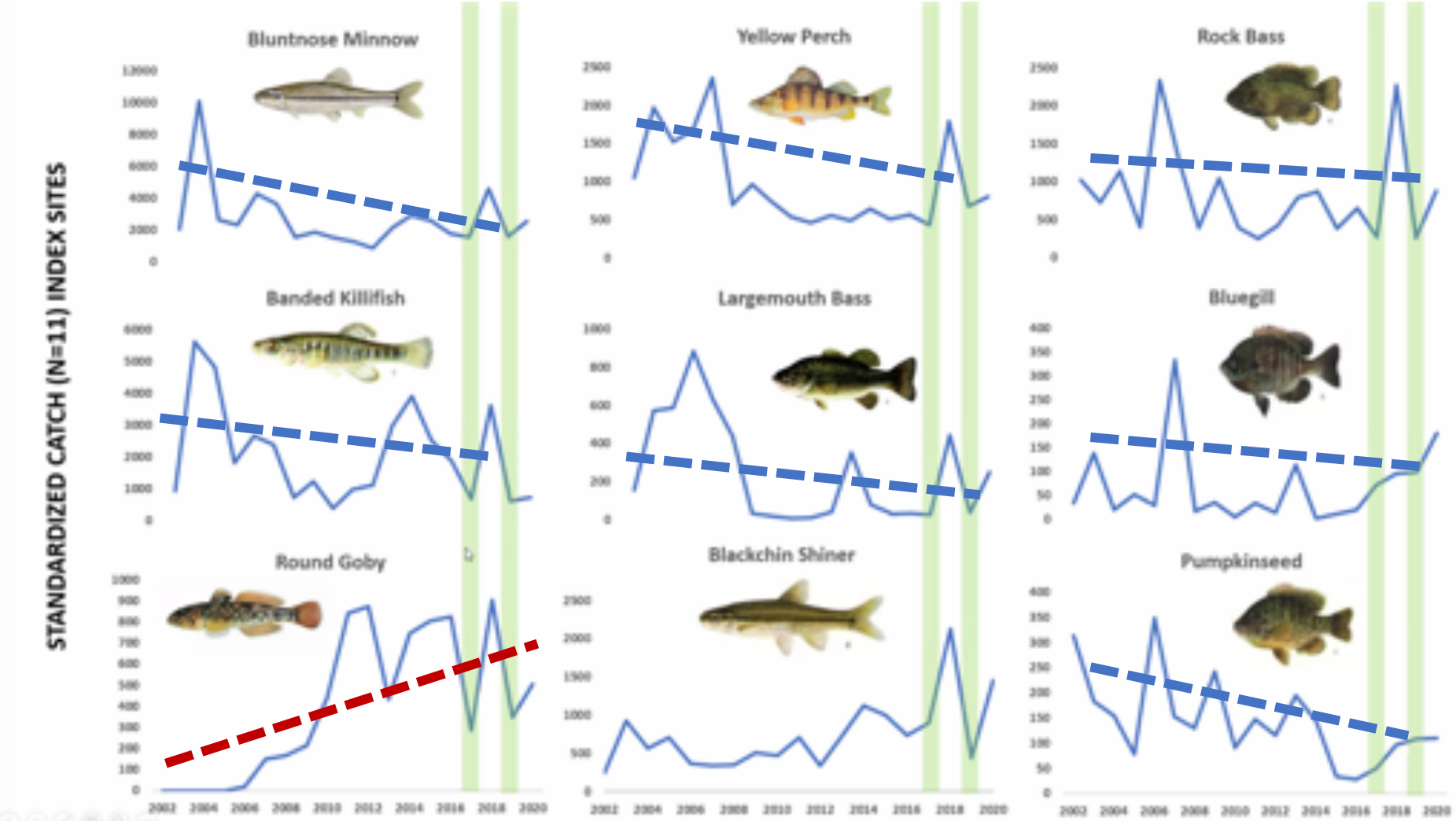
HATCHERIES: COMMON MITIGATION OPTION

HATCHERIES: COMMON MITIGATION OPTION

HOW DO WE KNOW IF THIS IS THE BEST OPTION?

ONTARIO CANADA – ST LAWRENCE RIVER

ALL NATIVE SPECIES POPULATION TRENDS ARE DECLINING…



IFC International Finance Corporation WORLD BANK GROUP
Creating Markets, Creating Opportunities

HISTORY OF FISH CULTURE

DAM CONSTRUCTION IN EARLY 1940'S-60'S CAUSED GROWTH IN HATCHERIES

The **National Fish Hatchery System** was established in the U.S. in 1871.

The request for 2019 budget for the National Fish Hatchery System operation and maintenance was **$82.2 million**.

RESEARCH ON THE CONSEQUENCES

Evolutionary Applications ISSN 1752-4571

SYNTHESIS

Fitness of hatchery-reared salmonids in the wild

Hitoshi Araki,[1,2] Barry A. Berejikian,[3] Michael J. Ford[4] and Michael S. Blouin[1]

1 Department of Zoology, Oregon State University, Corvallis, OR, USA
2 Eawag, The Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum, Switzerland
3 NOAA, Northwest Fisheries Science Center, Manchester, WA, USA
4 NOAA, Northwest Fisheries Science Center, Seattle, WA, USA

Potential for domesticated–wild interbreeding to induce maladaptive phenology across multiple populations of wild Atlantic salmon (*Salmo salar*)

Dylan J. Fraser, Cóilín Minto, Anna M. Calvert, James D. Eddington, and Jeffrey A. Hutchings

Abstract: We report how aquaculture may negatively alter a critical phenological trait (developmental rate) linked to survival in wild populations. At the southern limit of the species range in eastern North America, the persistence of small populations may be constrained by interbreeding with farmed salmon that escape regularly. A common garden experimental protocol implemented over an 8-year period, including wild hybrids (F_1, F_2, wild backcrosses) had slower

ARTICLE

Received 29 Jun 2015 | Accepted 7 Jan 2016 | Published 17 Feb 2016 DOI: 10.1038/ncomms10676 OPEN

A single generation of domestication heritably alters the expression of hundreds of genes

Mark R. Christie[1,2,3], Melanie L. Marine[3], Samuel E. Fox[3,4], Rod A. French[5] & Michael S. Blouin[3]

ARTICLE

Assessing the Long-Term Reproductive Contribution of Stocked Fish to Largemouth Bass Populations

Michael A. Nannini, Matthew J. Diana, Julie E. Claussen, David P. Philipp & David H. Wahl

Pages 606-612 | Received 16 Aug 2013, Accepted 11 Dec 2013, Published online: 14 Apr 2014

Download citation https://doi.org/10.1080/00028487.2014.880738 Check for updates

etic underpinnings associated with the earliest stages of plant and animal cation h... elusive. Because a genome-wide response to selection can take neratio... ciated with domestication may first as h... to test this sis, w... eratio... nent. grou... could not be of gene ex... adaptation f... and metab... adaptation...

Article

Condition and performance of juvenile Atlantic salmon (*Salmo salar*): effects of rearing practices on hatchery fish and comparison with wild fish

D G McDonald, , C L Milligan, , W J McFarlane, , S Croke, , S Currie, , B Hooke, , R B Angus, , B L Tufts, and , K Davidson

Published on the web 12...

Loss of genetic variation in hatchery-reared Indian major carp, *Catla catla*

M. M. Hansen, V. Simonsen, K.-L. D. Mensberg, Md. R. I. Sarder, Md. S. Alam

First published: 27 November 2006 | https://doi.org/10.1111/j.1095-8649.2006.01285.x | Citations: 10

Open Access

How well can captive breeding programs conserve biodiversity? A review of salmonids

Dylan J. Fraser

First published: 29 October 2008 | https://doi.org/10.1111/j.1752-4571.2008.00036.x | Citations: 111

Dylan J. Fraser, Department of Biology, Dalhousie University, Halifax, NS B3H 4J1, Canada. Tel.: (902) 494 6279; fax: (902) 494 3736; e-mail: dylan.fraser@dal.ca

Environment

Hatchery life changes fish genetics, Oregon study finds

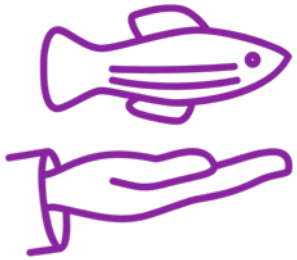
Updated Jan 09, 2019; Posted Feb 17, 2016

By Kelly House | The Oregonian/OregonLive

Hatchery steelhead

Steelhead writhe in a hatchery. A new study used steelhead from the Hood River to determine that hatchery life changes fish at the genetic level.

HOW HAS FISHERIES MANAGEMENT EVOLVED?



PAST

FISH CULTURE = FISHERIES MANAGEMENT

NOW

FISHERIES MANAGEMENT = RANGE OF TOOLS

- Habitat Conservation
- Monitoring of Populations
- Ecosystem Approaches

WHY ARE FISH CULTURED?

AQUACULTURE

SUPPLEMENTAL STOCKING

WHY STOCK FISH BACK INTO NATURE?

POSSIBLE OBJECTIVES:

1. Supplement a Depressed Population
2. Re-introduce an Extirpated Population
3. Establish a New Population

GOAL:

Stock juveniles that grow up to be adults and enhance population numbers

…it all seems so easy!

ASSUMPTION

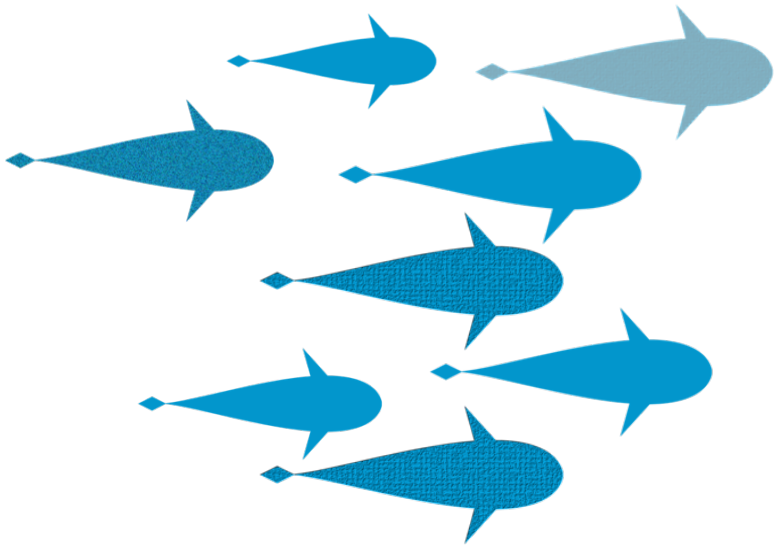
NATURAL PRODUCTION OF OFFSPRING
VERSUS
HATCHERY PRODUCTION OF OFFSPRING

In a hatchery, reproduction is artificially controlled by humans.

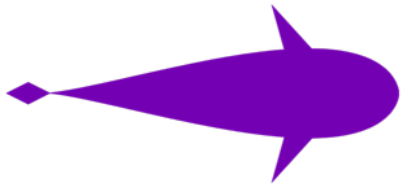
In the wild, reproduction is complex, involving mate choice and competition.

IN THE WILD

MANY ARE REJECTED AND FAIL

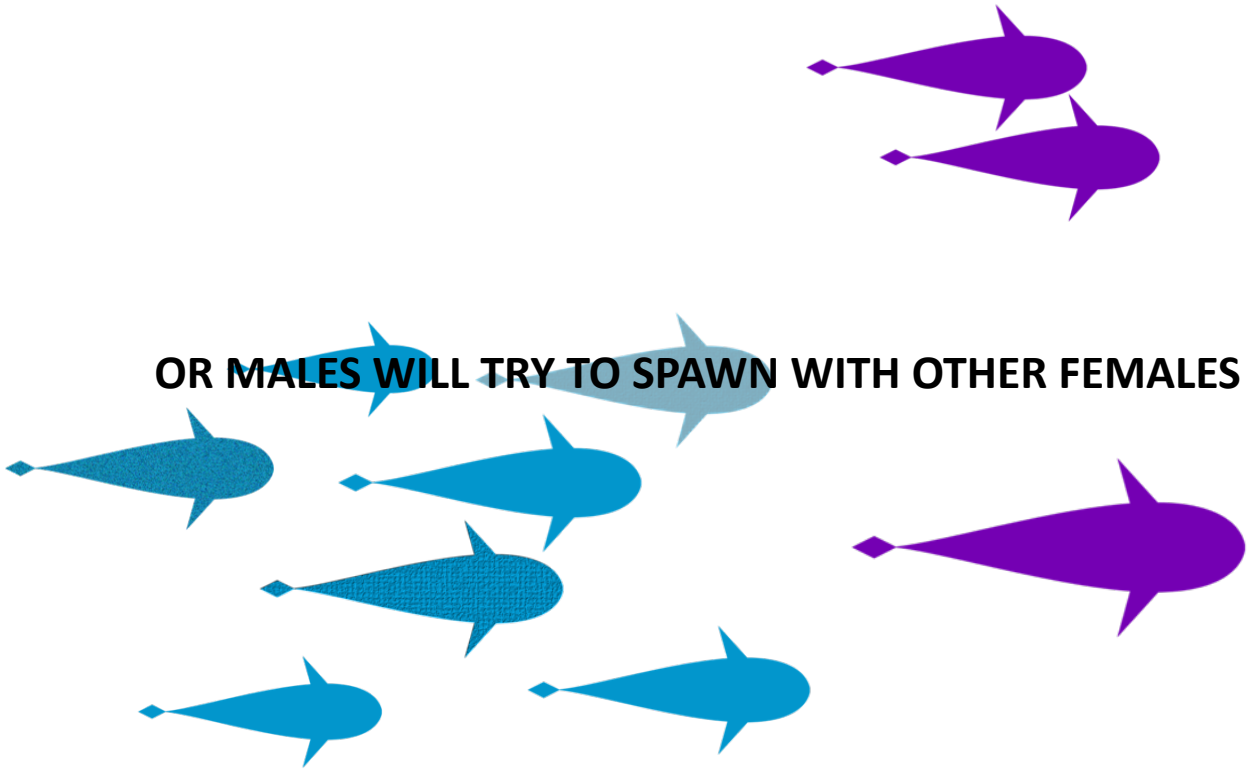


FEMALES CAN BE VERY SELECTIVE



MALES COMPETE TO GAIN ACCESS TO FEMALES TO SPAWN

IN THE WILD

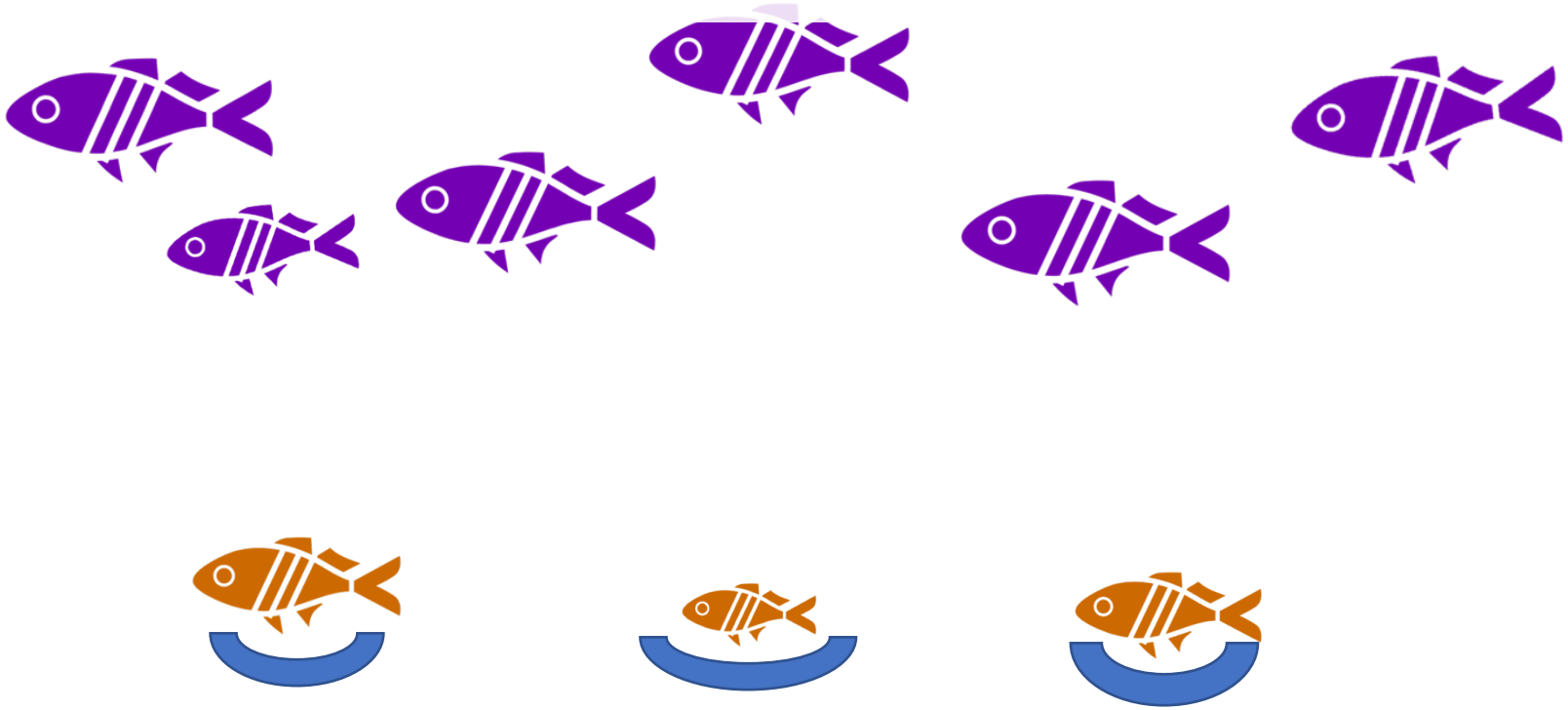


OR MALES WILL TRY TO SPAWN WITH OTHER FEMALES

DUE TO AGE OR BODY CONDITION, SOME MALES CANNOT COMPETE AND MAY SKIP A YEAR OF SPAWNING

MANY FACTORS INFLUENCE MATE CHOICE:

- AGGRESSION IN DEFENDING A TERRITORY
- NEST QUALITY
- COLOR CAN CORRELATE TO BODY CONDITION



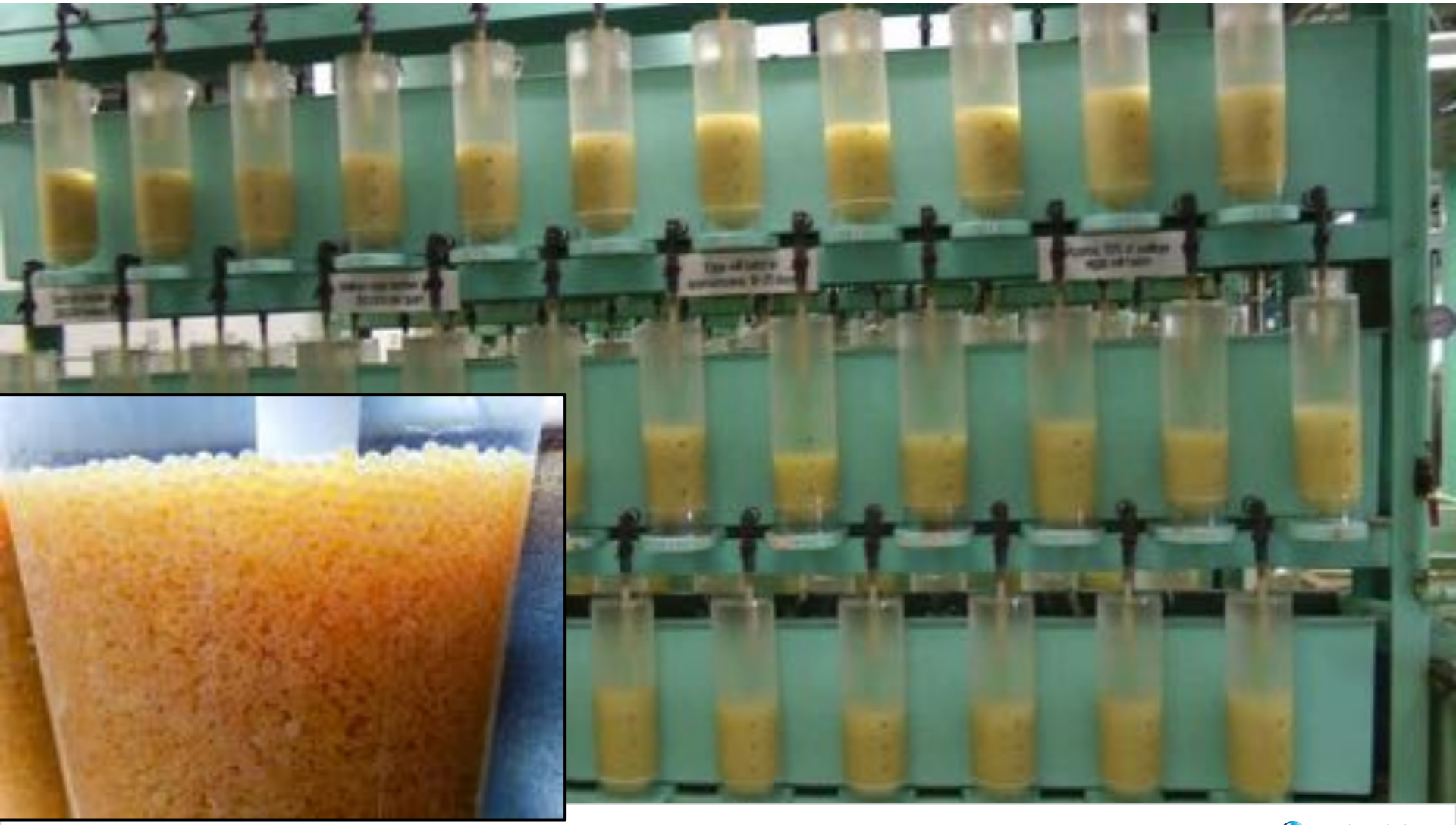
IN THE WILD → HIGH COMPETITION

IN A HATCHERY → NO COMPETITION

In the wild, egg and fry development and survival depend on water temperature, fungus, and predation.

IN THE WILD → **LESS THAN 0.001% OF FRY SURVIVE TO ADULTS**

IN A HATCHERY → OPTIMIZE SURVIVAL



IN A HATCHERY → OPTIMIZE SURVIVAL

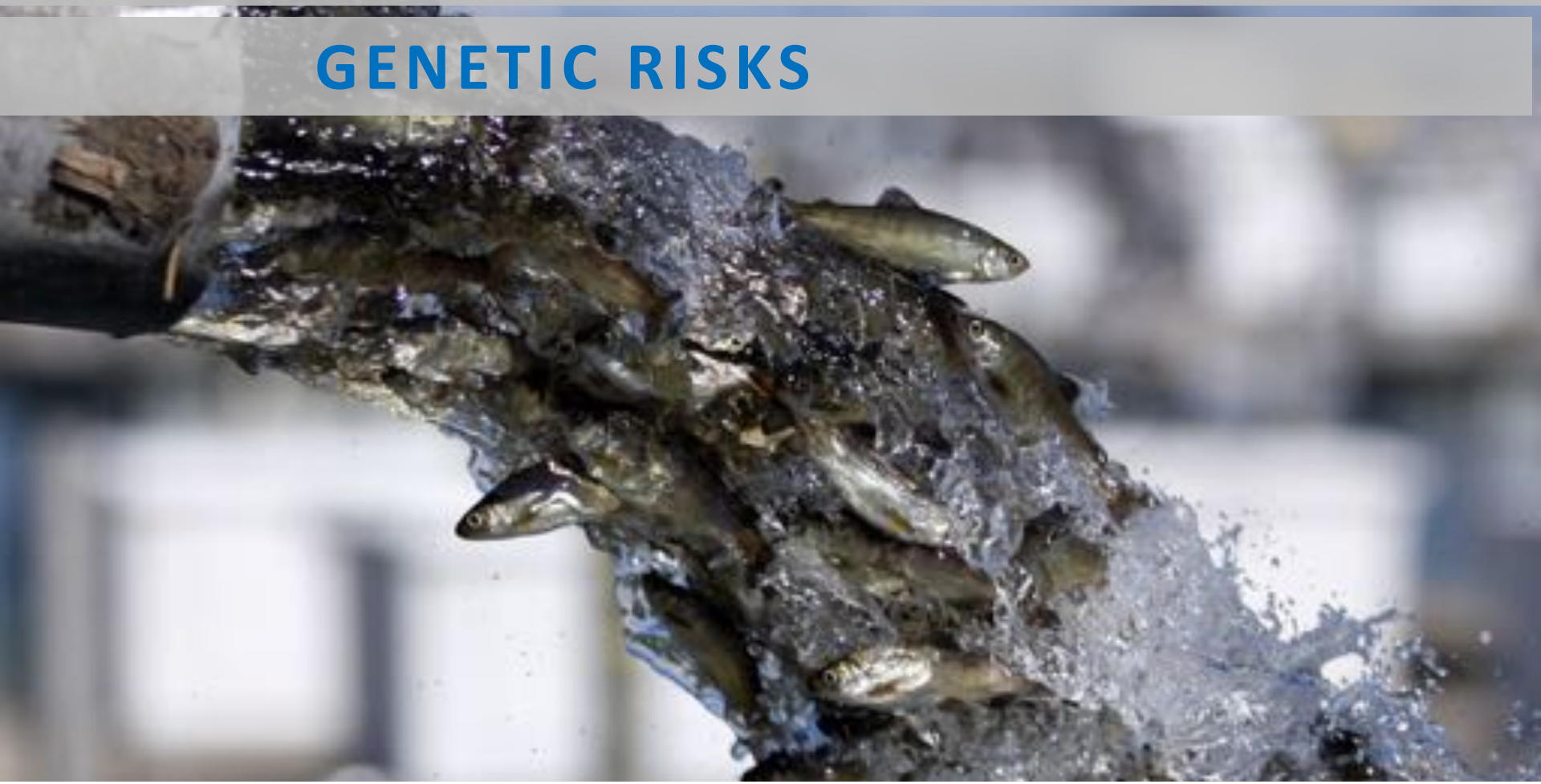
FISH REPRODUCTION

WHY IS THIS IMPORTANT?

RISKS ASSOCIATED WITH STOCKING

ECOLOGICAL RISKS

GENETIC RISKS



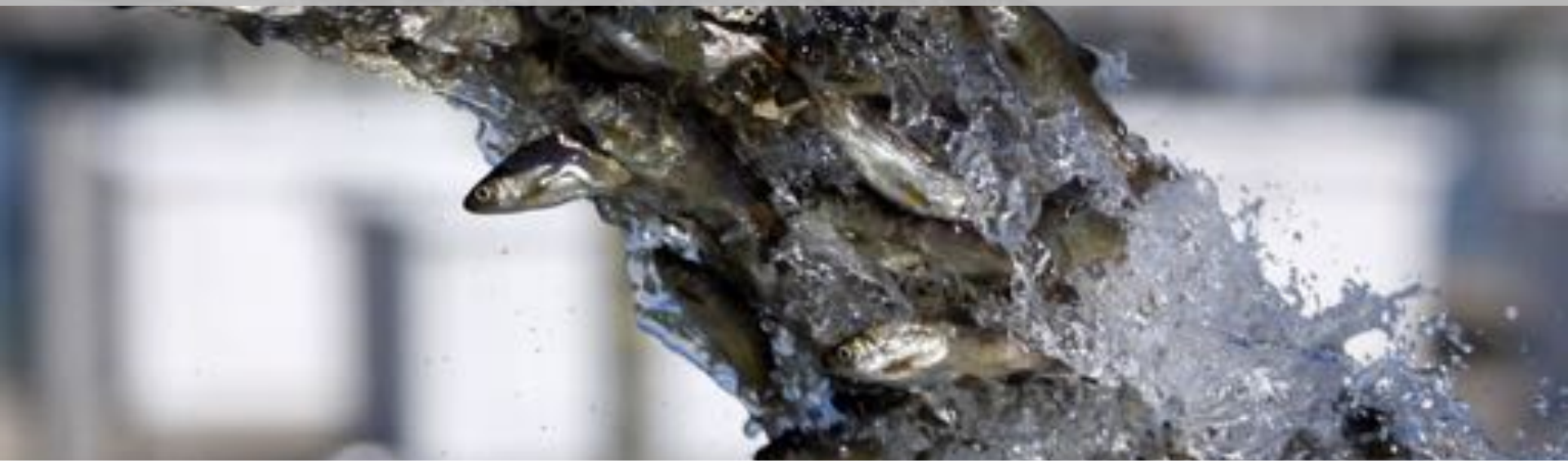
RISKS ASSOCIATED WITH STOCKING

ECOLOGICAL RISKS:

DISEASE

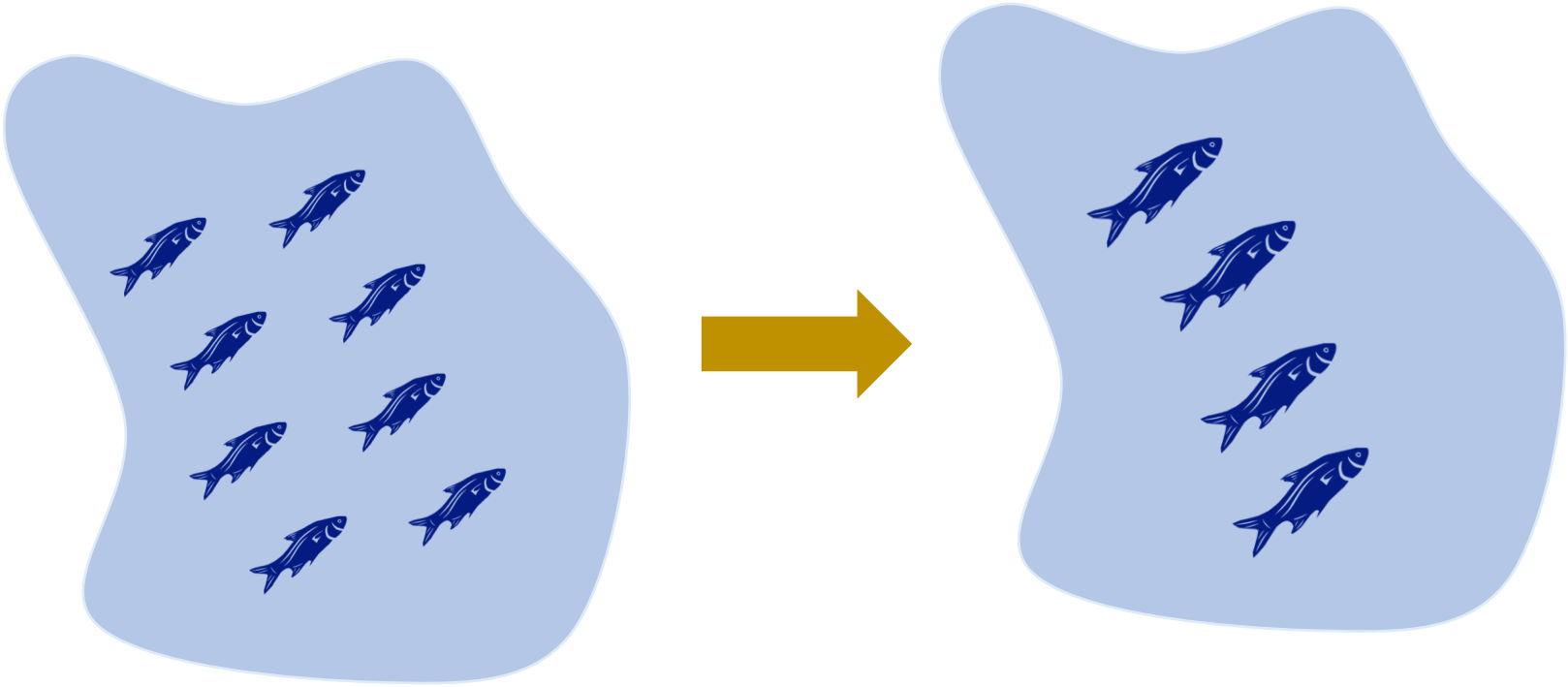
COMPETITION

PREDATION



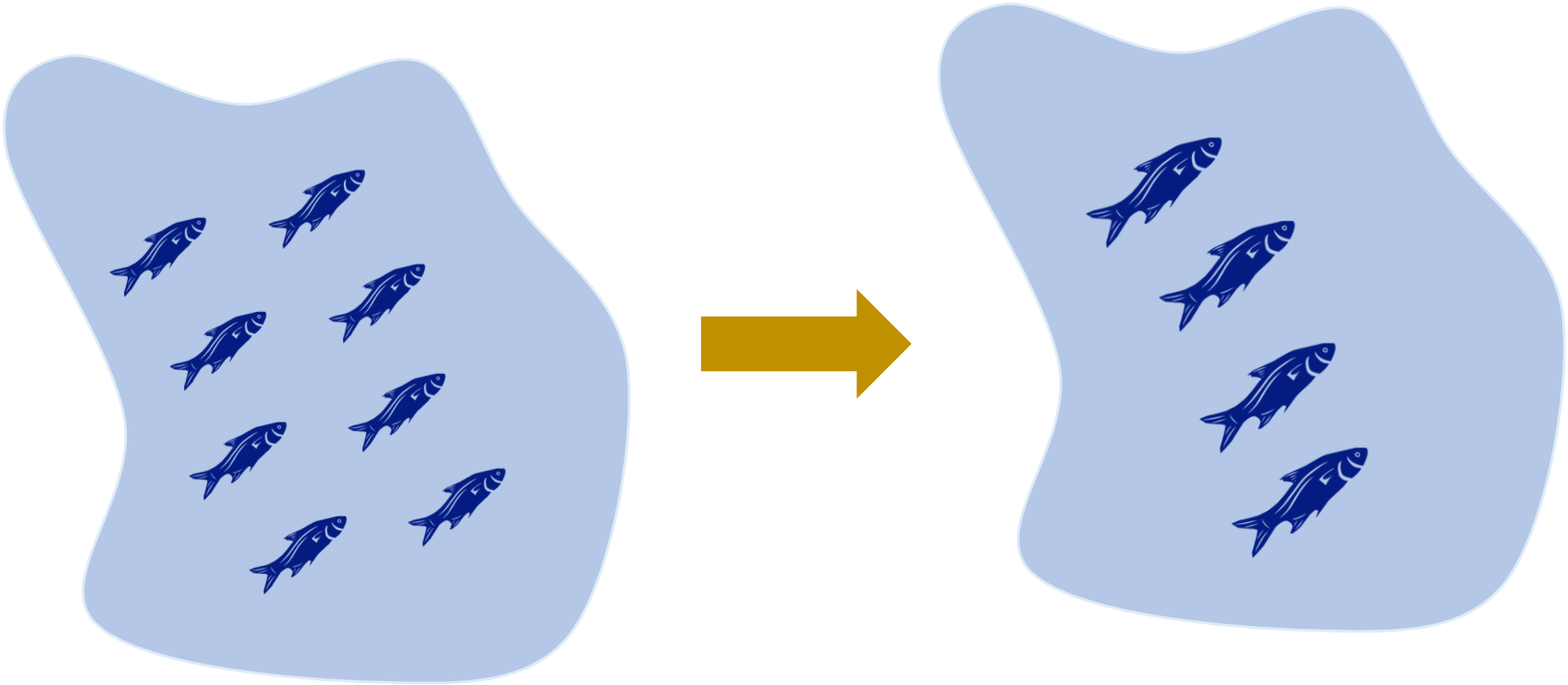
DISEASE

COMPETITION AND NATURAL MORTALITY



COMPETITION AND NATURAL MORTALITY

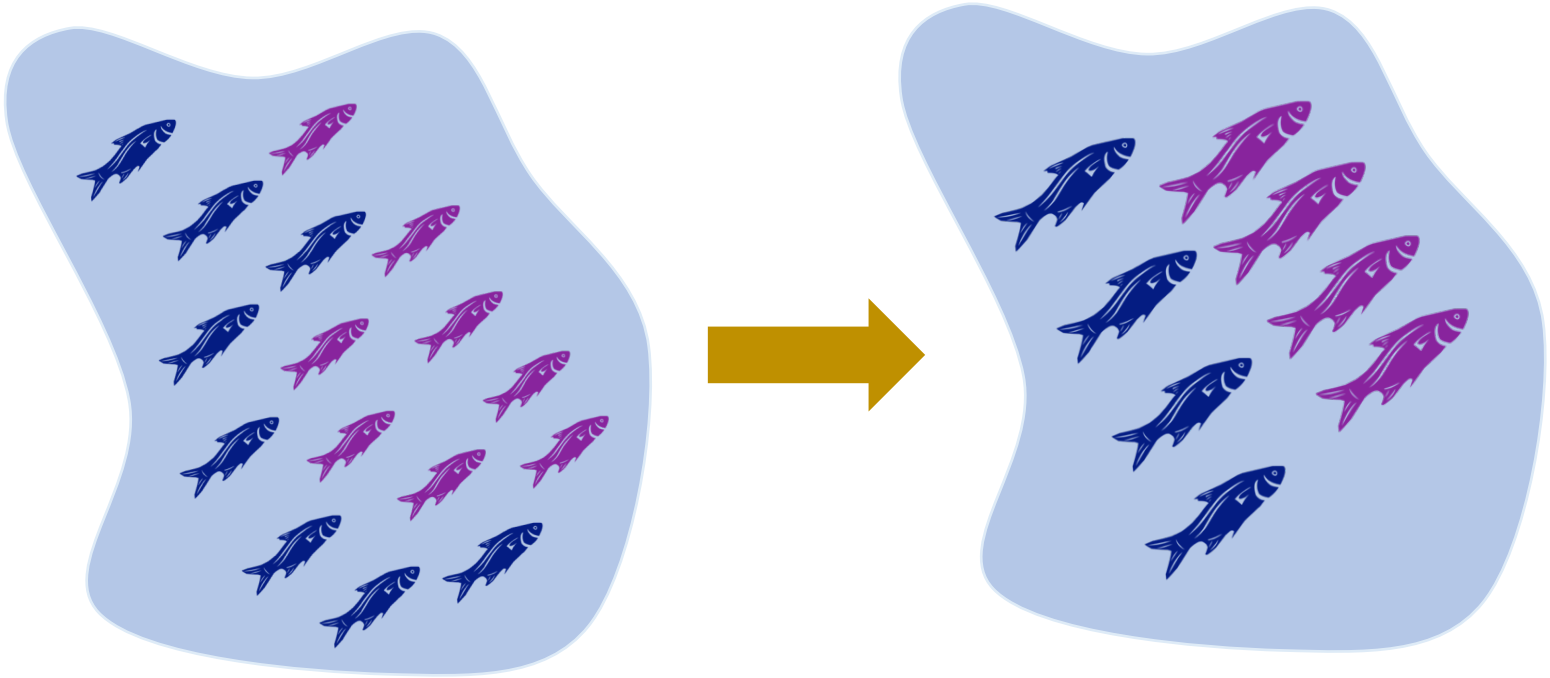
In the wild -- from egg to adulthood, mortality is 99.99%.



COMPETITION

Strategy of Stocking:

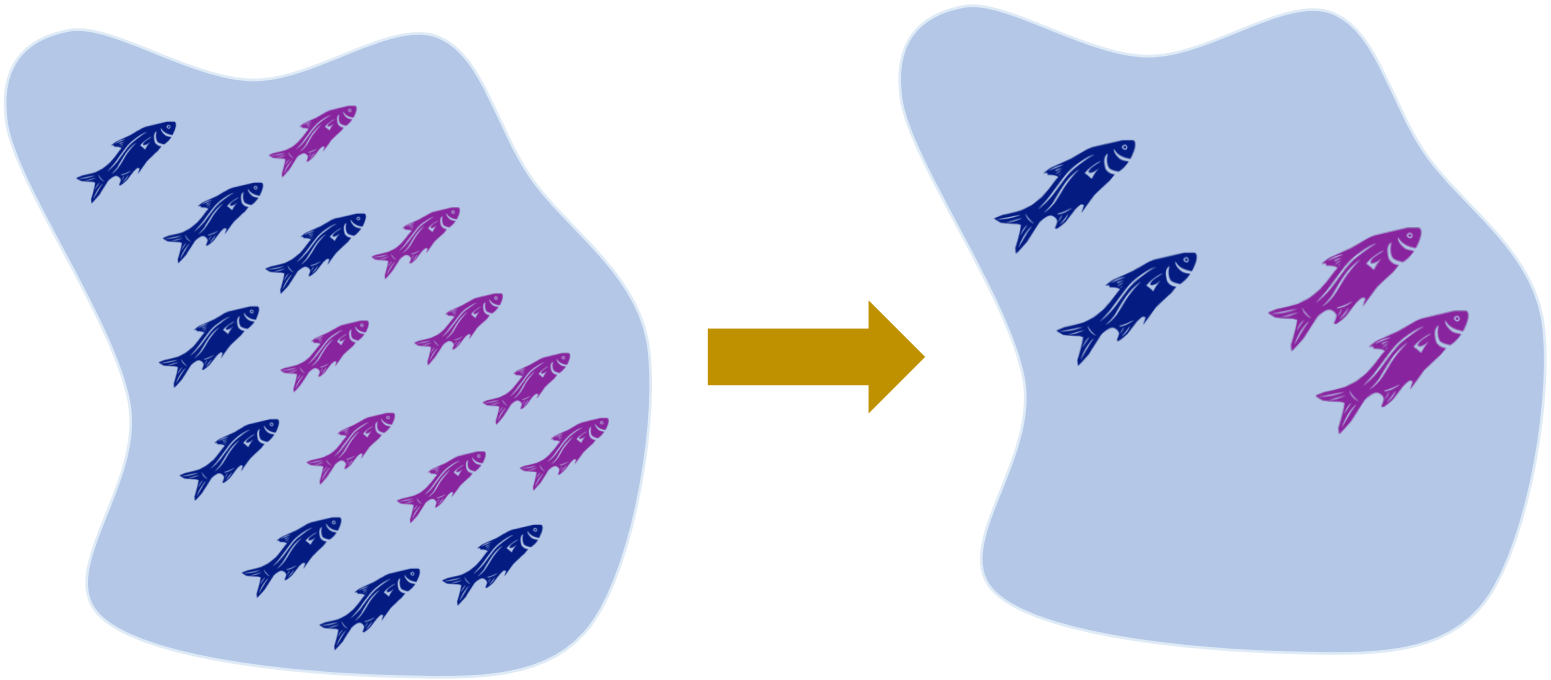
Increasing juveniles will providre more adults in the river.



COMPETITION

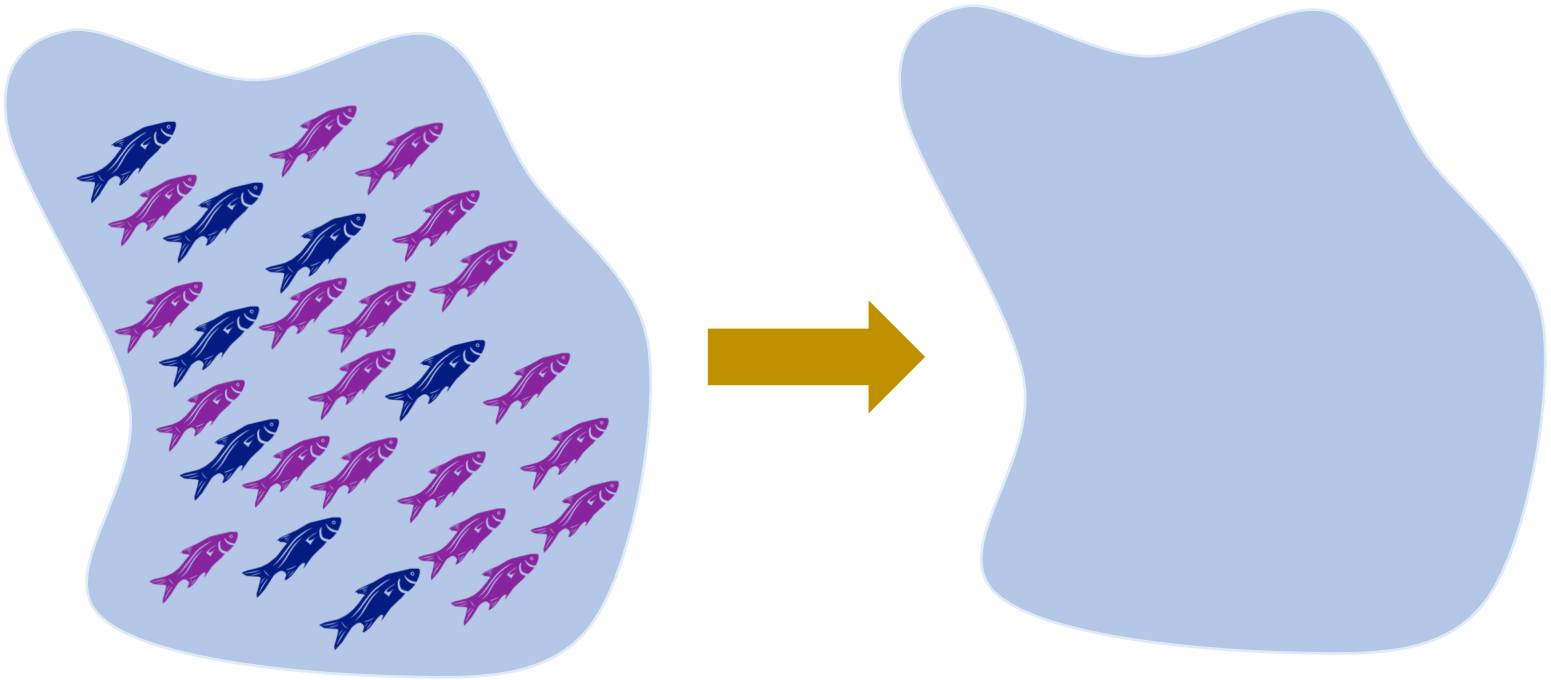
Unfortunately:

Stocked fish do not add to native juveniles; they displace them.



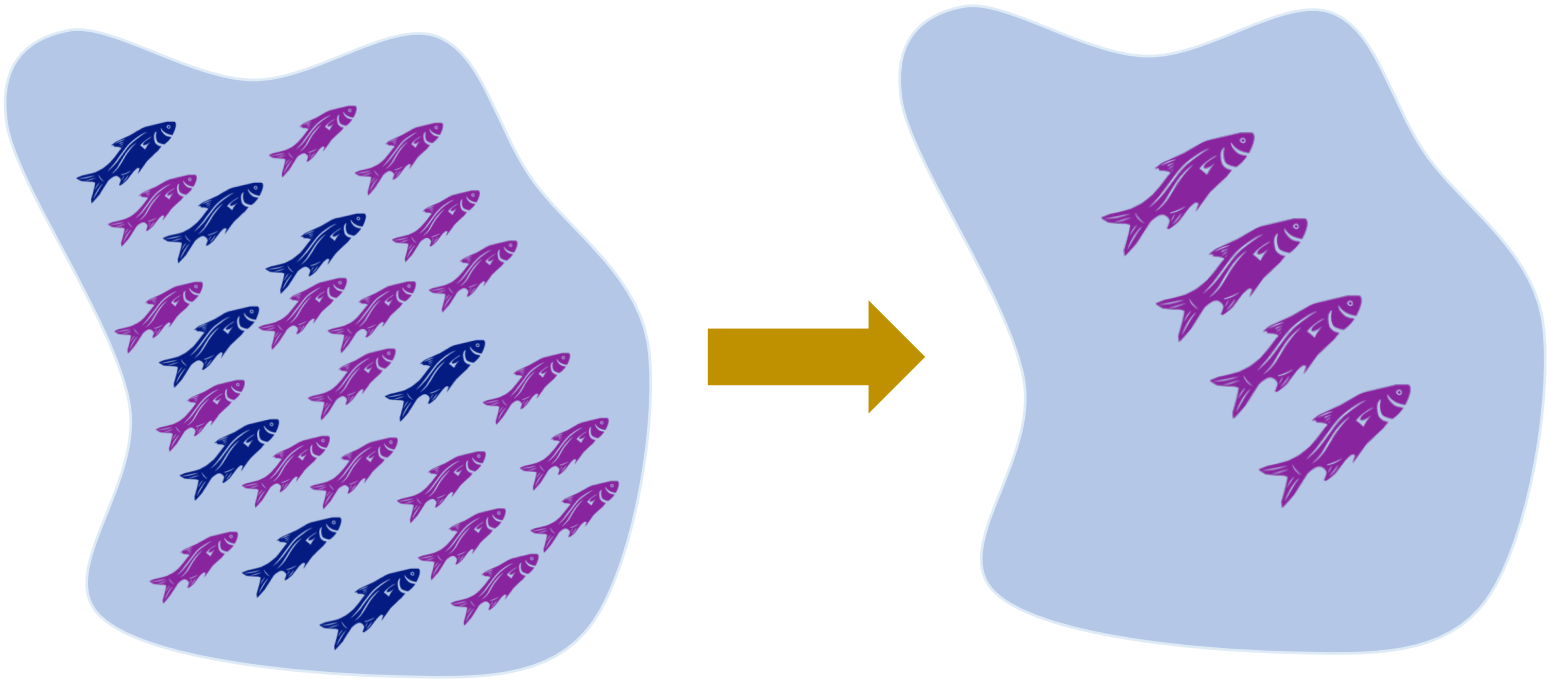
COMPETITION

Usually – stocking numbers are much higher than native numbers.



COMPETITION

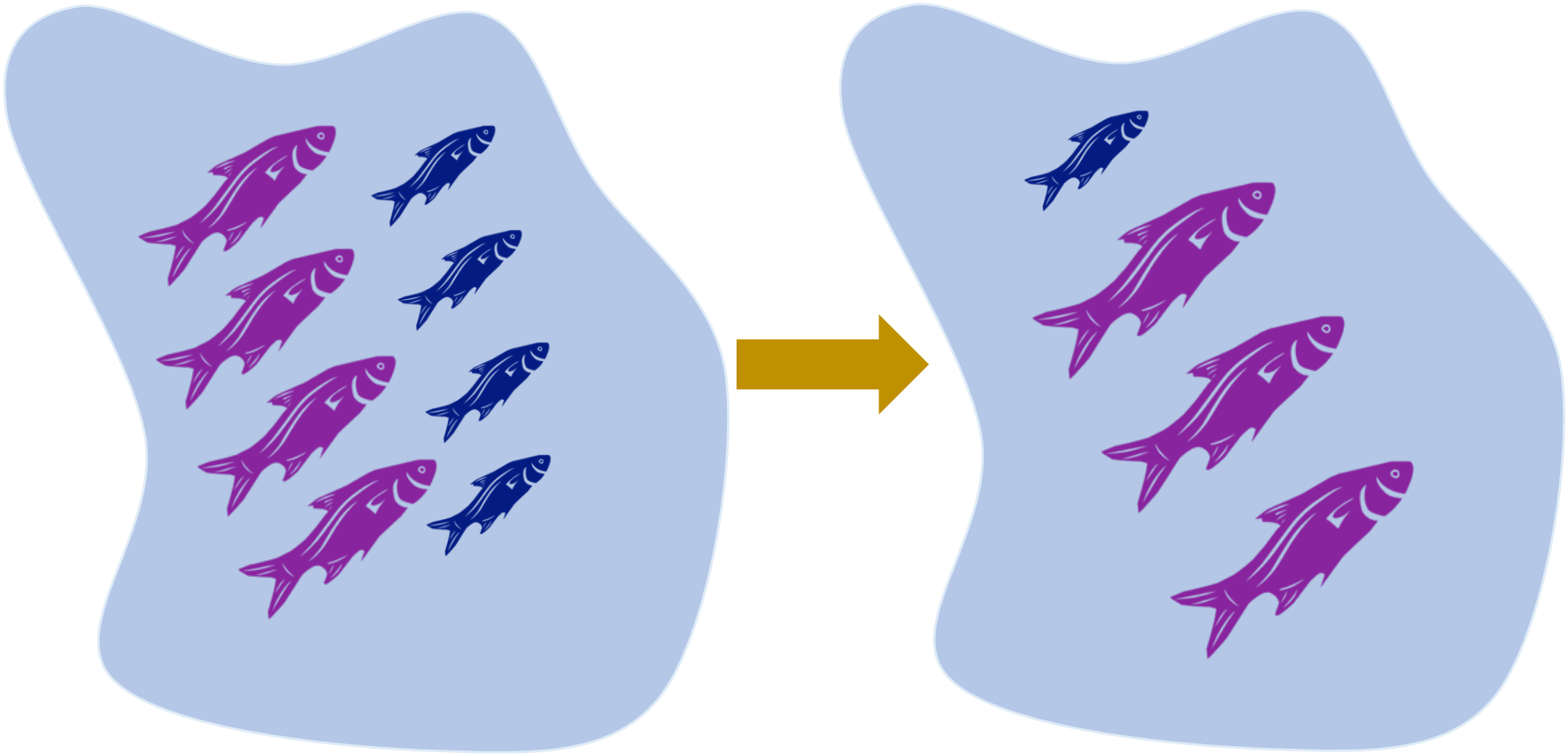
Result: hatchery fish REPLACE native fish.



ECOLOGICAL RISKS

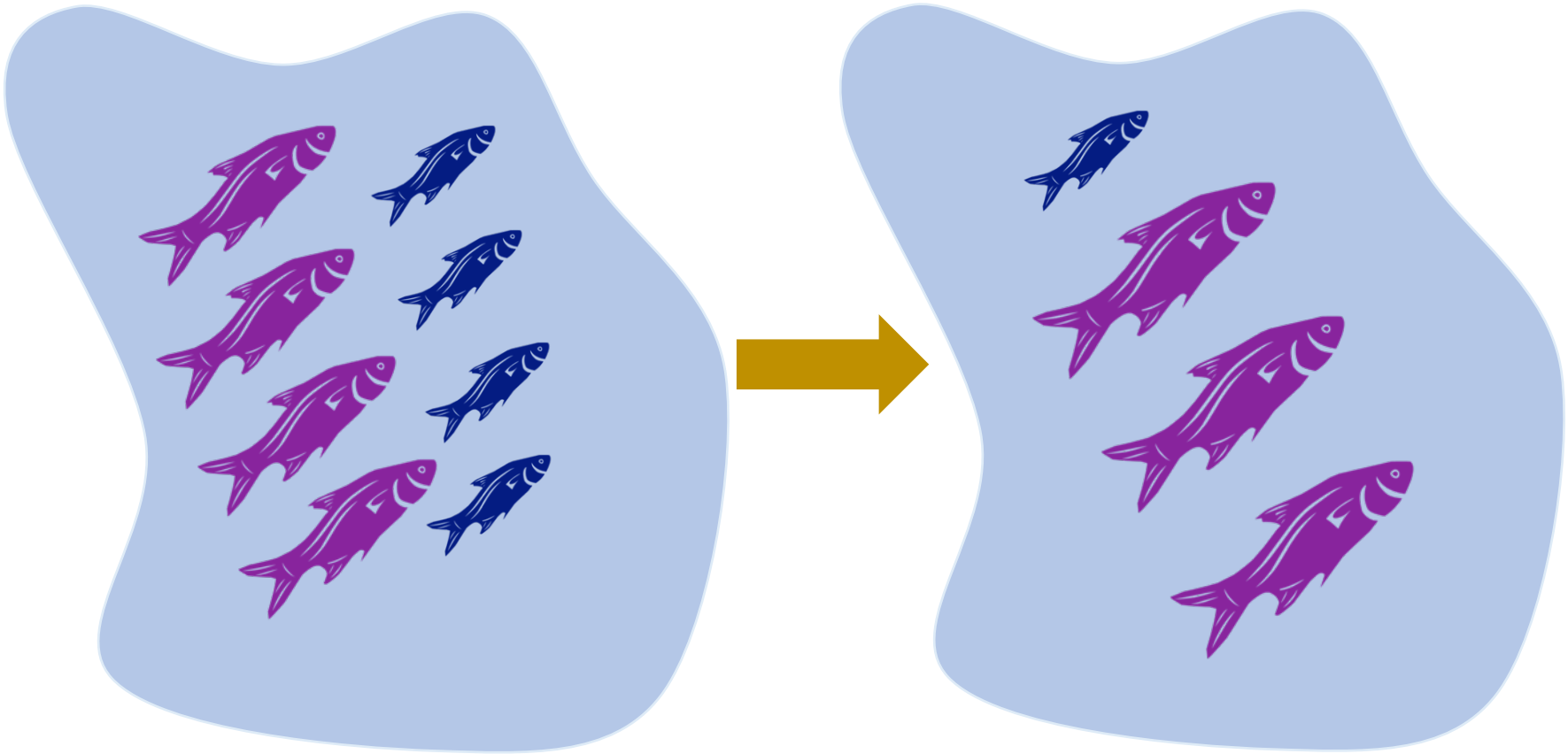
COMPETITION:

Hatchery fish are often stocked at large sizes than fish in the wild.



COMPETITION AND PREDATION:

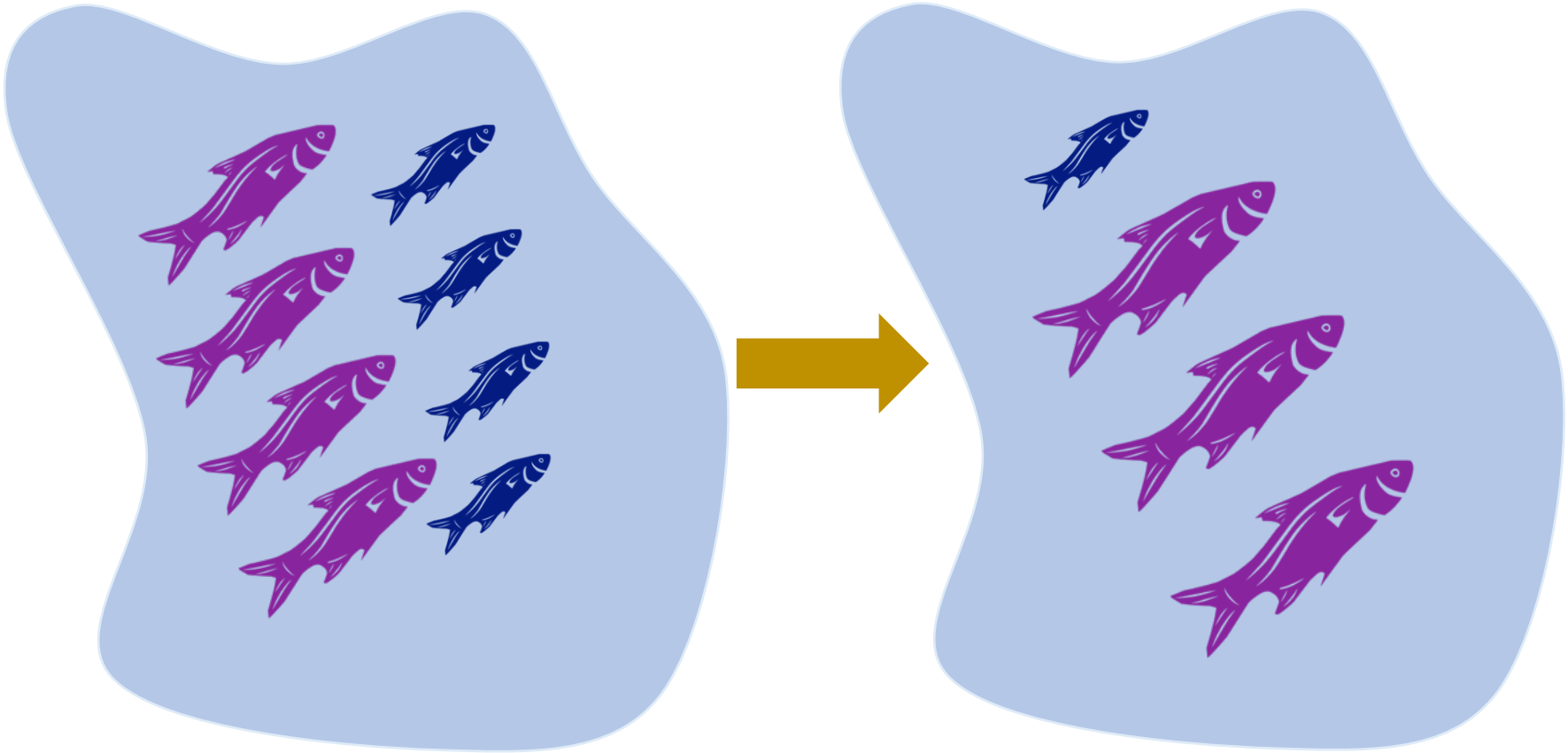
Larger stocked fish actually EAT the smaller native fish.



COMPETITION AND PREDATION:

Larger stocked fish actually EAT the smaller native fish.

Does that really happen?



HATCHERIES

Pink salmon in Prince William Sound, Alaska

Commercial fishing crashed the population (<10%)

Supplemental stocking was suggested and debated.

Competing hypotheses predicted the outcome differently:

A. stocking would augment wild production

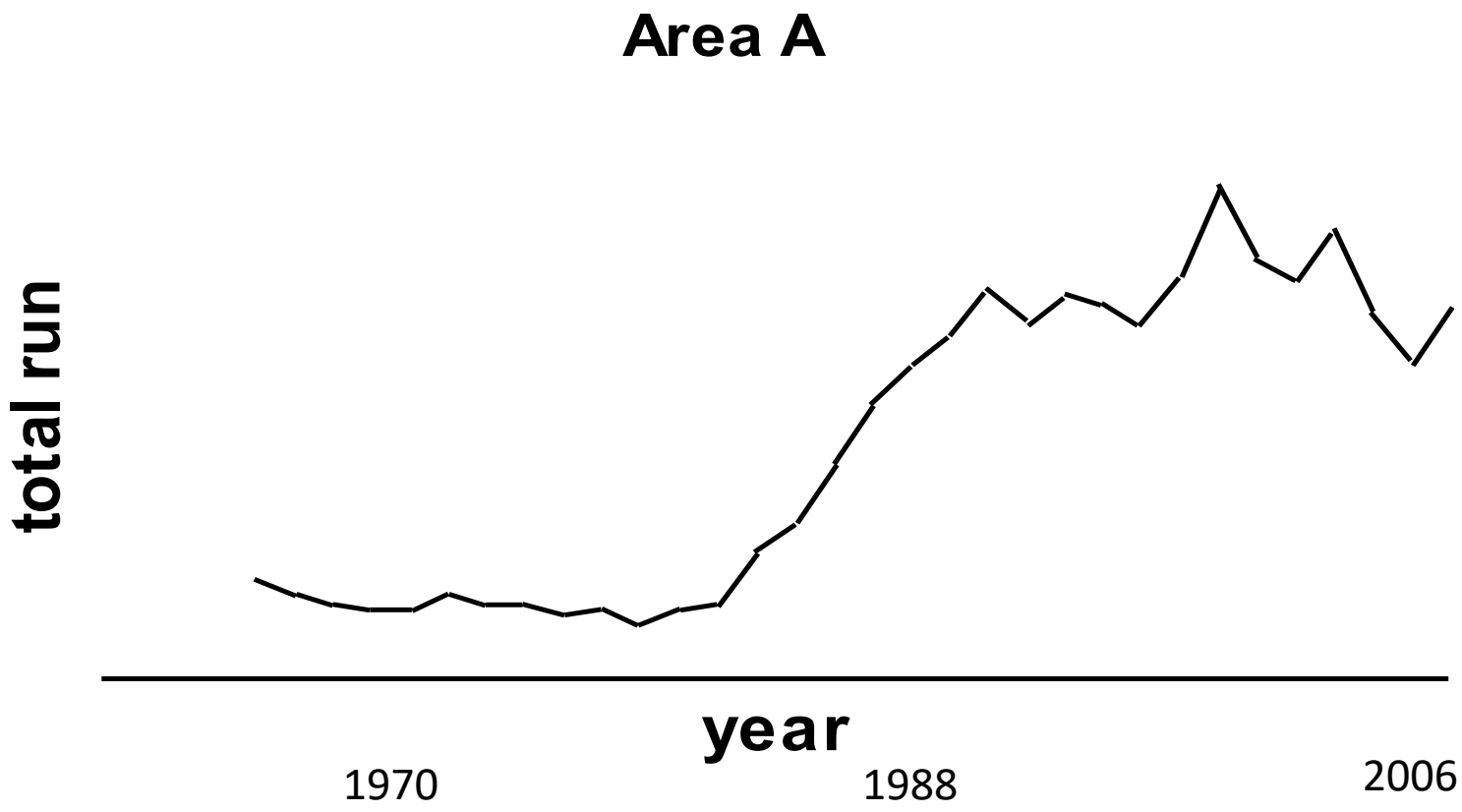
B. stocking would replace wild production

Result: In 1971 US began largest hatchery stocking program in North America.

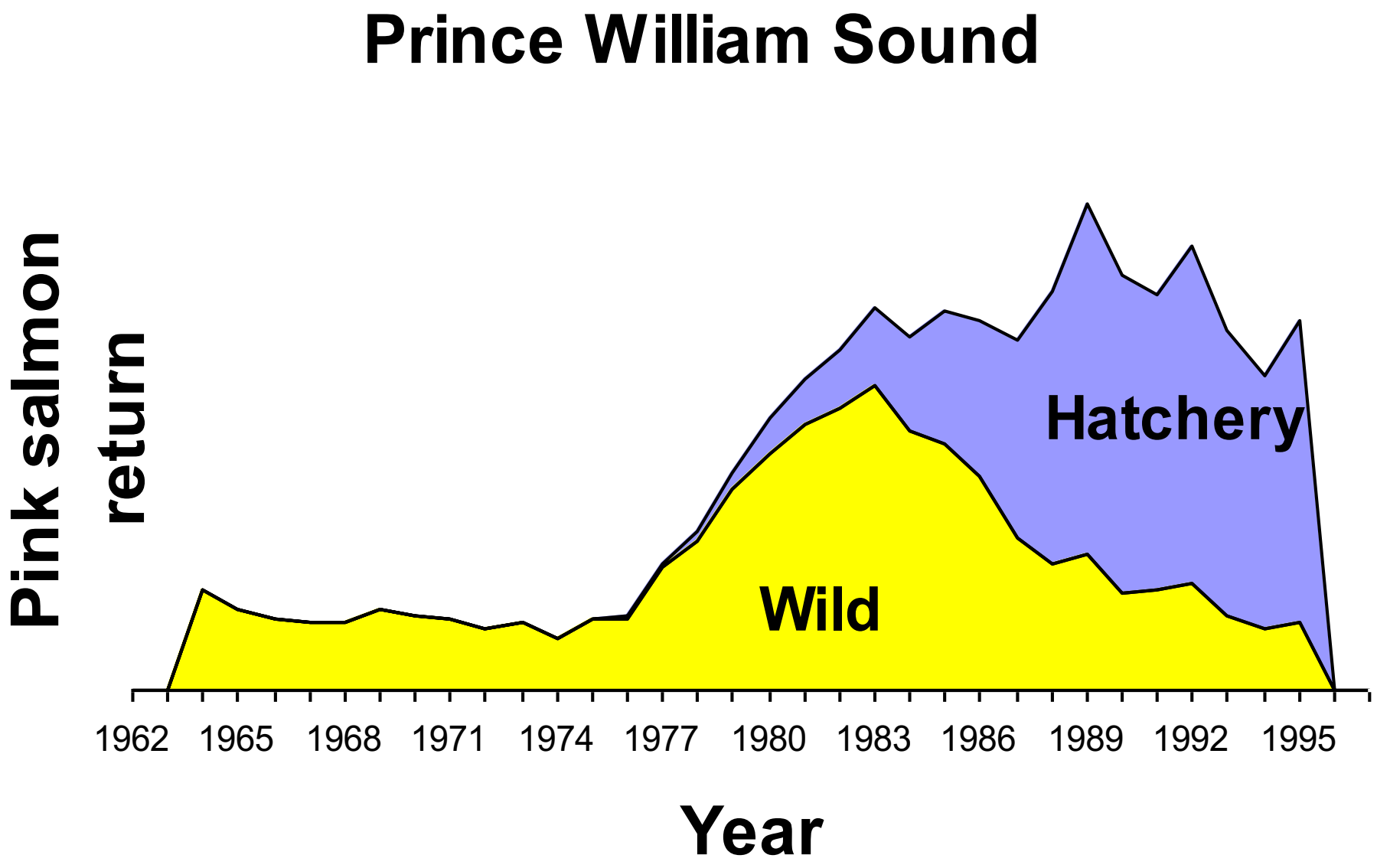
…slow at first then up to 600 million fish stocked each year.

HATCHERIES

Pink salmon in Prince William Sound, Alaska



HATCHERIES


Prince William Sound
Pink salmon return
Hatchery
Wild
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
Year

FOOD FOR THOUGHT

$40 Million Later, A Pioneering Plan To Boost Wild Fish Stocks Shows Little Success

February 15, 2018 · 8:00 AM ET

CLARE LESCHIN-HOAR

RISKS ASSOCIATED WITH STOCKING

ECOLOGICAL RISKS

GENETIC RISKS

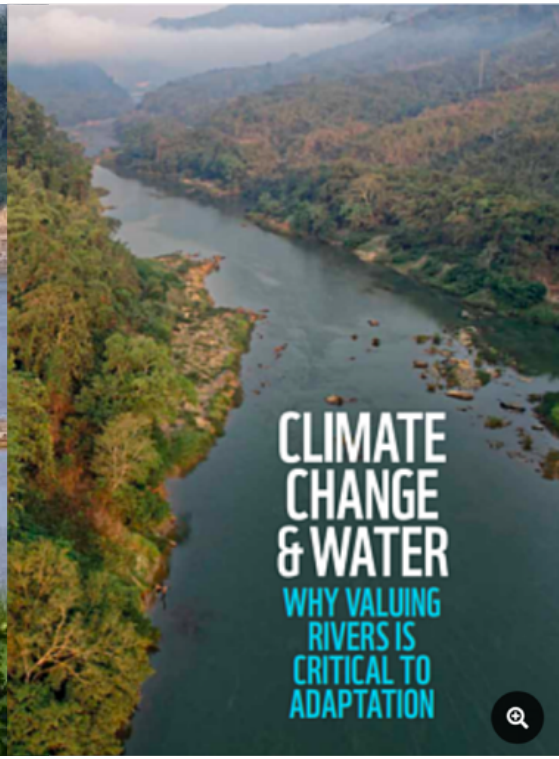
1. Loss of Genetic Variation
2. Inbreeding Depression
3. Outbreeding Depression
4. Domestication Selection

LOSS OF GENETIC VARIATION

IN A HATCHERY → Ne RARELY HIGH

With Loss of Genetic Variation:

Fish populations will not be able to adapt to changing future conditions.



Inbreeding Depression:

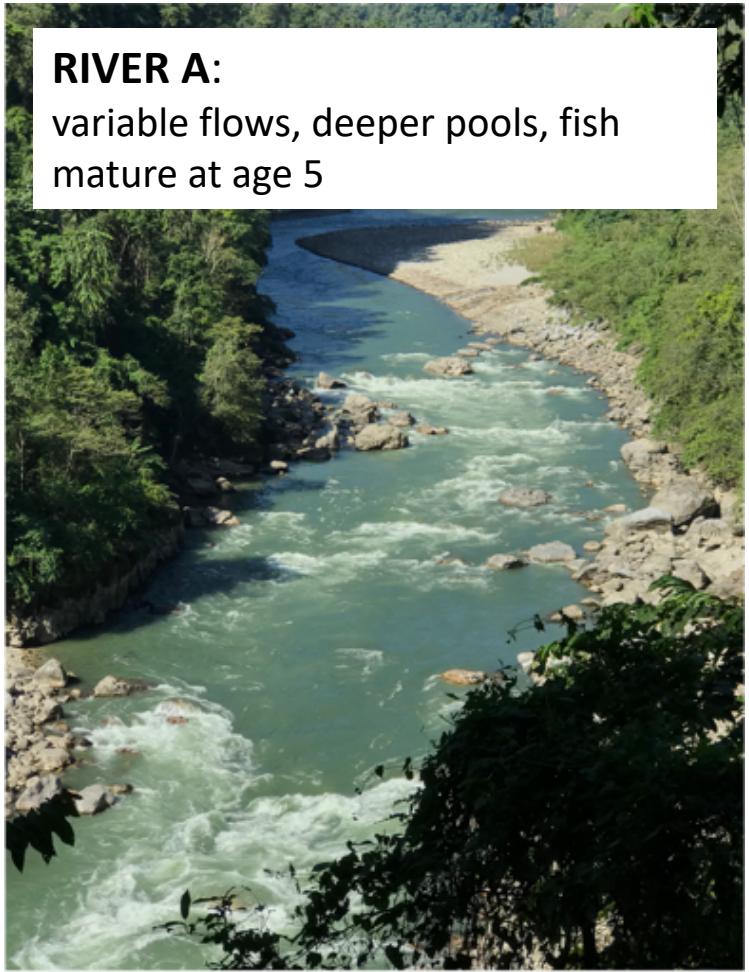
Reduction in fitness due to the unmasking of harmful recessive alleles
…because parents too closely related.

Inbreeding Depression:

- All fish carry harmful alleles as heterozygotes at many genes, but they survive because of dominance.
- BUT - If one male X one female produces lots of offspring in a hatchery and they are stocked….
- Most matings are brother X sister and in those offspring, LOTS of harmful alleles are now homozygous – fitness crashes.

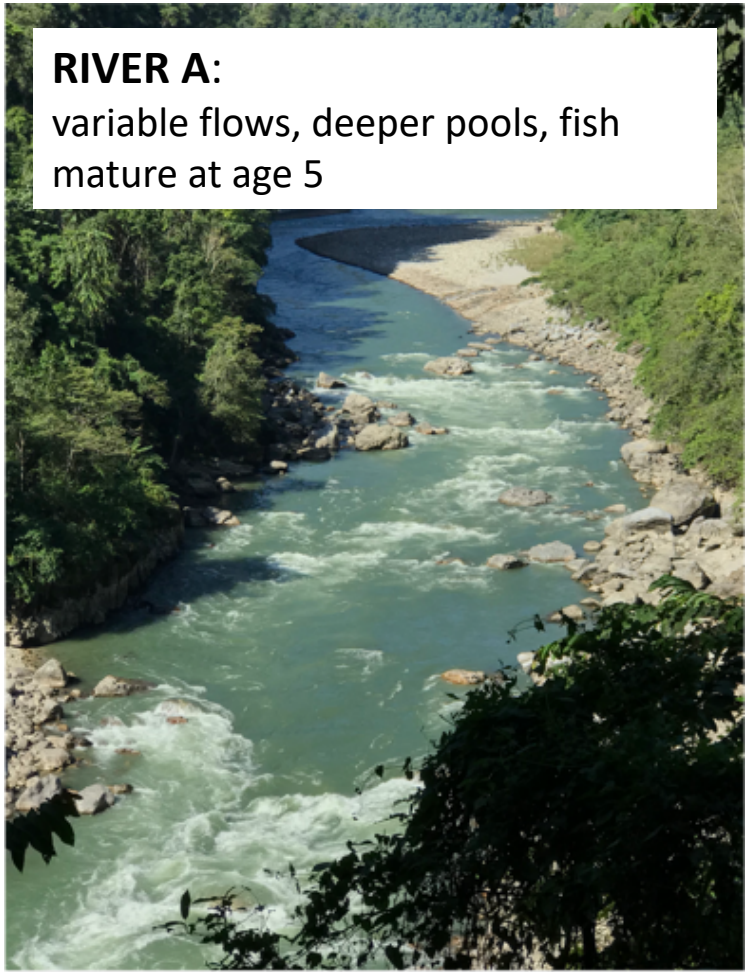
Outbreeding Depression

Reduction in fitness due to the breakdown of co-adapted gene complexes
…because parents too closely related.



Outbreeding Depression

- In the wild, fish in River A and River B have adapted to different hydrological regimes
- If hatcheries cross parents from different populations, the co-adapted gene complexes that have evolved those adaptations are now all jumbled in their offspring.
- When these fish are stocked in the wild, they are not adapted to either hydrology and are less fit than wild fish.



Evolutionary Applications ISSN 1752-4571

SYNTHESIS

Fitness of hatchery-reared salmonids in the wild

Hitoshi Araki,[1,2] Barry A. Berejikian,[3] Michael J. Ford[4] and Michael S. Blouin[1]

1 Department of Zoology, Oregon State University, Corvallis, OR, USA
2 Eawag, The Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum, Switzerland
3 NOAA, Northwest Fisheries Science Center, Manchester, WA, USA
4 NOAA, Northwest Fisheries Science Center, Seattle, WA, USA

Keywords
adaptation, captive breeding, conservation genetics, selection.

Correspondence
Michael Blouin, Department of Zoology, Oregon State University, 3029 Cordley Hall, Corvallis, OR 97331, USA.
Tel.: 541 737 2362; fax: 541 737 0501;
e-mail: blouinm@science.oregonstate.edu

Received: 7 November 2007
Accepted: 2 February 2008

doi:10.1111/j.1752-4571.2008.00026.x

Abstract

Accumulating data indicate that hatchery fish have lower fitness in natural environments than wild fish. This fitness decline can occur very quickly, sometimes following only one or two generations of captive rearing. In this review, we summarize existing data on the fitness of hatchery fish in the wild, and we investigate the conditions under which rapid fitness declines can occur. The summary of studies to date suggests: nonlocal hatchery stocks consistently reproduce very poorly in the wild; hatchery stocks that use wild, local fish for captive propagation generally perform better than nonlocal stocks, but often worse than wild fish. However, the data above are from a limited number of studies and species, and more studies are needed before one can generalize further. We used a simple quantitative genetic model to evaluate whether domestication selection is a sufficient explanation for some observed rapid fitness declines. We show that if selection acts on a single trait, such rapid effects can be explained only when selection is very strong, both in captivity and in the wild, and when the heritability of the trait under selection is high. If selection acts on multiple traits throughout the life cycle, rapid fitness declines are plausible.

Domestication Selection:

The unintentional selection for traits that are advantageous for a hatchery environment, but not advantageous if they are stocked into the wild.

Domestication Selection:

Example: Egg size

ARTICLE

Received 29 Jun 2015 | Accepted 7 Jan 2016 | Published 17 Feb 2016

DOI: 10.1038/ncomms10676 OPEN

A single generation of domestication heritably alters the expression of hundreds of genes

Mark R. Christie[1,2,3], Melanie L. Marine[3], Samuel E. Fox[3,4], Rod A. French[5] & Michael S. Blouin[3]

The genetic underpinnings associated with the earliest stages of plant and animal domestication have remained elusive. Because a genome-wide response to selection can take many generations, the earliest detectable changes associated with domestication may first manifest as heritable changes to global patterns of gene expression. Here, to test this hypothesis, we measured differential gene expression in the offspring of wild and first-generation hatchery steelhead trout (*Oncorhynchus mykiss*) reared in a common environment. Remarkably, we find that there were 723 genes differentially expressed between the two groups of offspring. Reciprocal crosses reveal that the differentially expressed genes could not be explained by maternal effects or by chance differences in the background levels of gene expression among unrelated families. Gene-enrichment analyses reveal that adaptation to the novel hatchery environment involved responses in wound healing, immunity and metabolism. These findings suggest that the earliest stages of domestication may involve adaptation to highly crowded conditions.

TO STOCK OR NOT TO STOCK?

HOW DO WE MAKE THAT DECISION?

TO STOCK OR NOT TO STOCK?

HOW DO WE MAKE THAT DECISION?

A NATIONAL STOCKING POLICY

THE PROCESS:

A DOCUMENT THAT DESCRIBES PROPOSED ACTIONS

EVALUATION PROCESS – TO WEIGH COSTS/BENEFITS

PROPOSAL CONTENTS:

WHY

WHAT
HOW
WHERE
WHEN

COST ANALYSIS

MONITORING & EVALUATION

IF THE STOCKING INVOLVES PUTTING FISH INTO THE WILD

THEN THE PLAN NEEDS TO:

DEFINE THE ISSUE

STATE THE OBJECTIVES AND EXPECTED OUTCOMES

MONITORING AND EVALUATION:

PLAN FOR DETERMINING SUCCESS OR FAILURE OF THE STOCKING

IF A FAILURE, PLAN FOR TERMINATING OR EVEN REVERSING THE STOCKING

QUESTIONS AND DISCUSSION