Proportionate Natural Influence (PNI): a Genetic Risk Management Tool for Salmon and Steelhead Hatcheries

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The Problem: Hatchery Operations Pose Domestication Selection Risks to Natural Salmon and Steelhead Populations

Hatchery rearing environments differ greatly from the natural environment, exerting different selection pressures.

Cultured populations become more adapted to the hatchery environment and less to the natural environment.

Interbreeding between cultured and naturally produced fish cause natural populations to be less fit in the wild environment.

The Problem: Hatchery Operations Pose Domestication Selection Risks to Natural Salmon and Steelhead Populations

The domesticating effect of hatcheries is now widely accepted conceptually.

Dealing with it is a major part of hatchery reform activities being undertaken in Washington as part of the recovery effort under the Endangered Species Act.

Solutions

Reduce selection pressures imposed by hatchery programs

Reduce duration of exposure to hatchery environment

Manage interbreeding between cultured and naturally produced fish

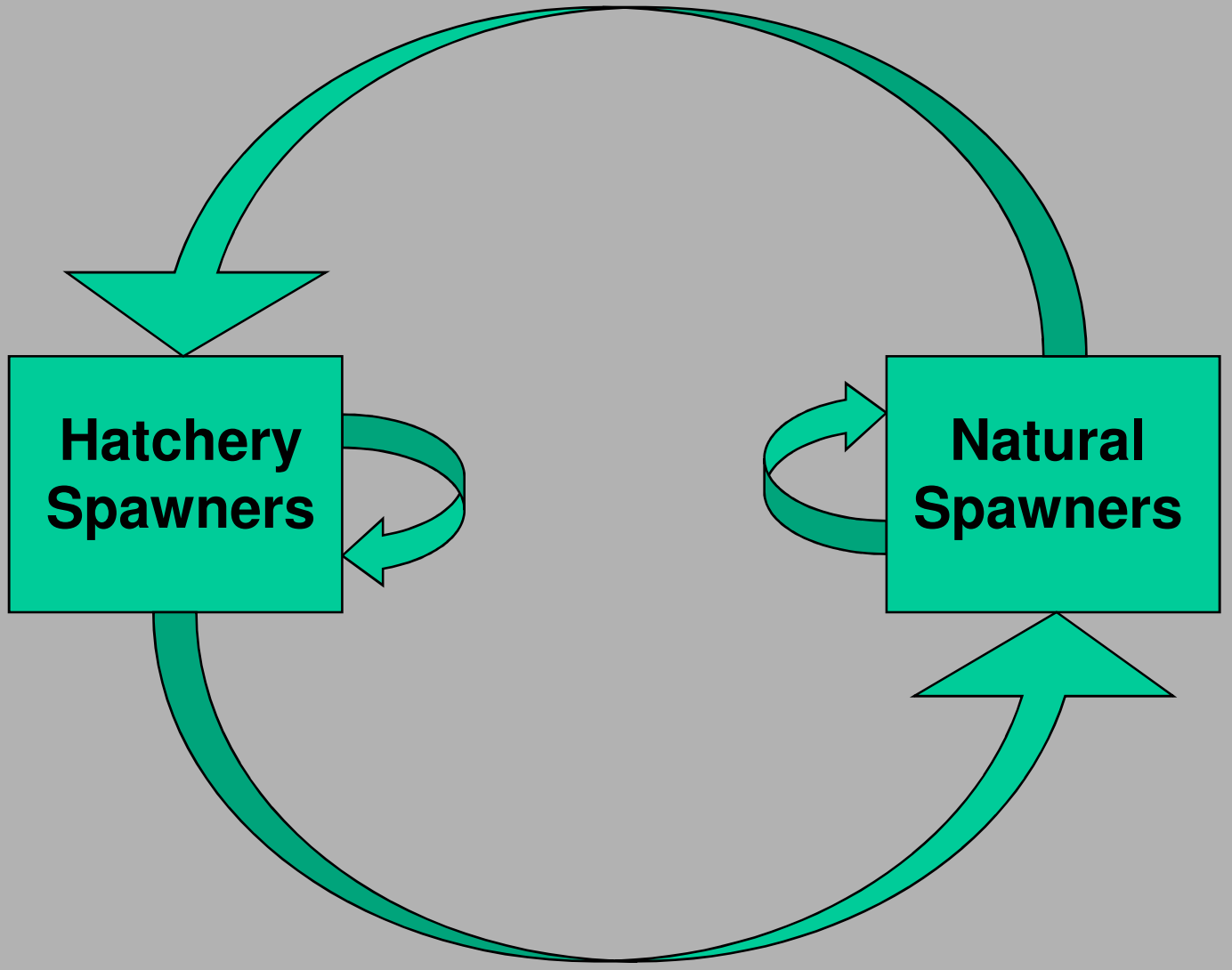
Hatchery Program Types for Managing Gene Flow (based on HSRG Recommendations)

1) *Segregated (isolated) programs.* Minimal gene flow (ideally to zero) between cultured and naturally produced fish. Highly desirable in all cases except supplementation, but difficult to achieve.

2) *Integrated programs.* Managed gene flow between cultured and naturally produced fish to limit domestication. Many existing hatchery programs are "poorly integrated", with much unregulated gene flow.

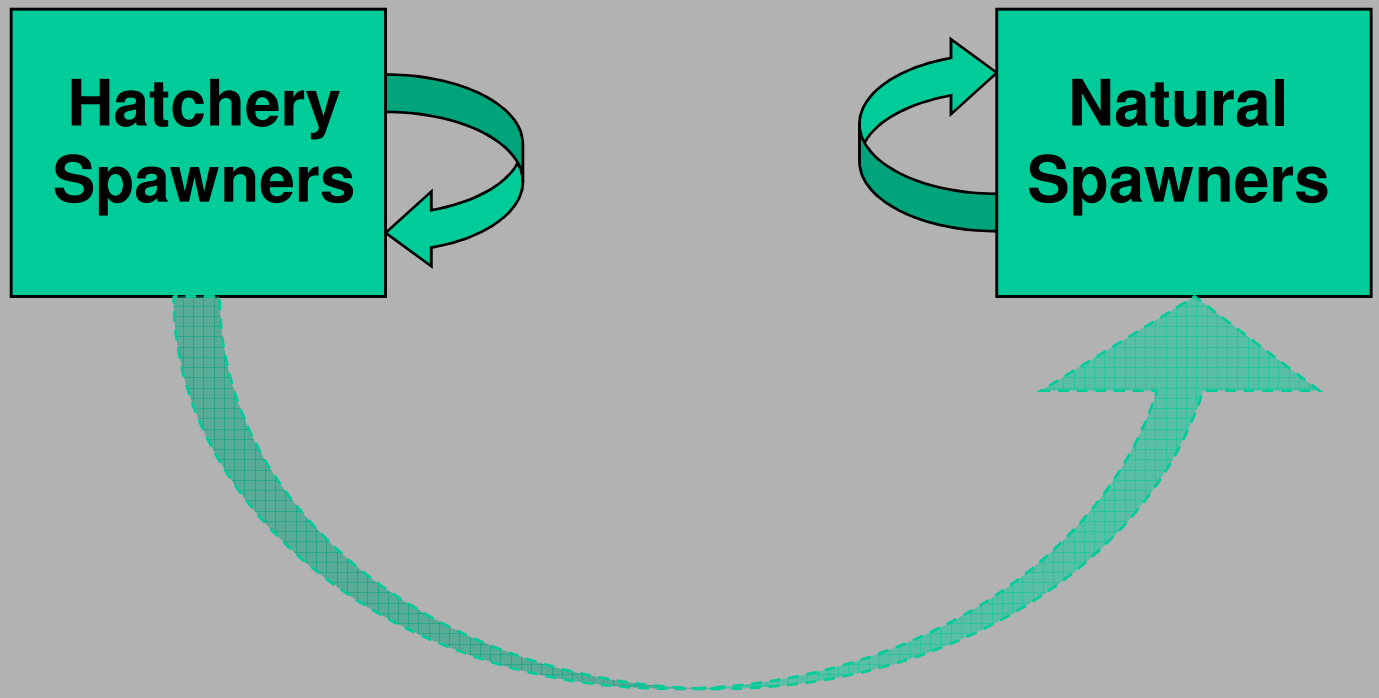
Genetic Relationship Between Hatchery and Natural Components of a Population

(modified from Lynch and O'Hely, 2001)



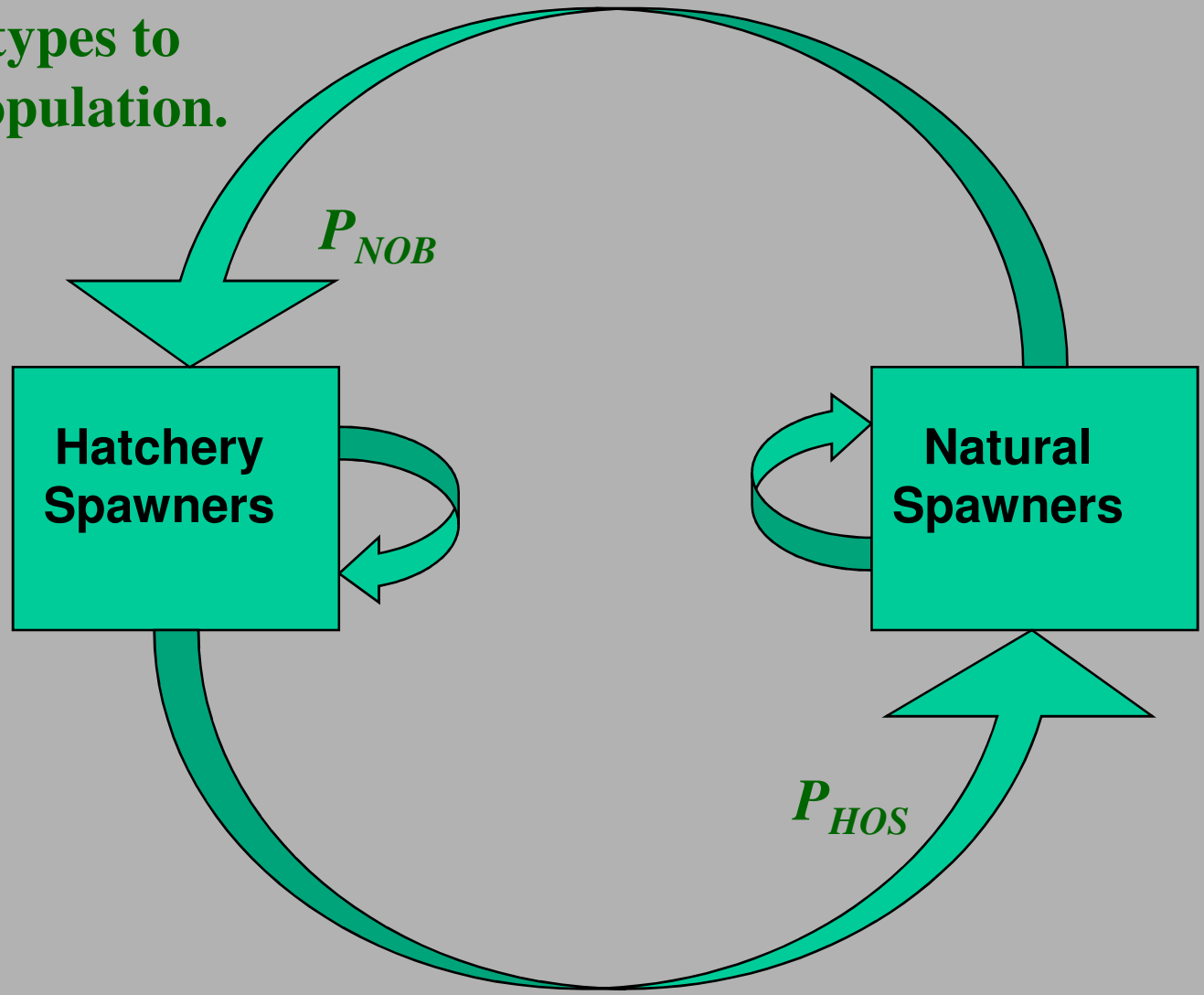
Segregated Program

Intent is to have the two production be isolated populations



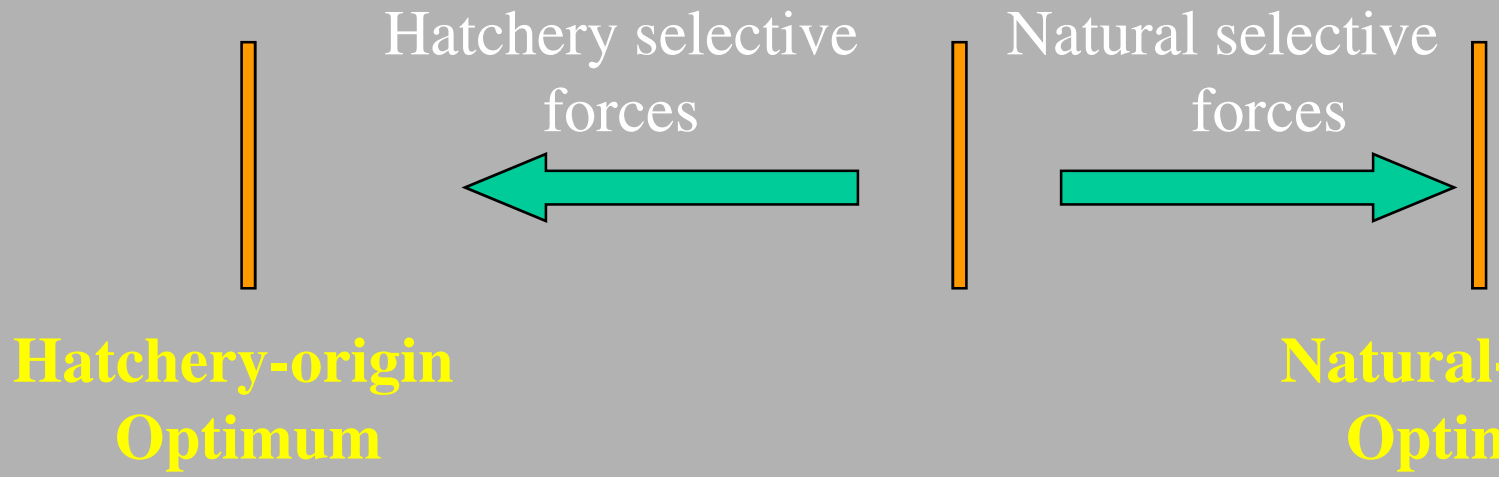
Integrated Program

Gene flow connects the two production types to make a single population.



Ford's (2002) Domestication Model

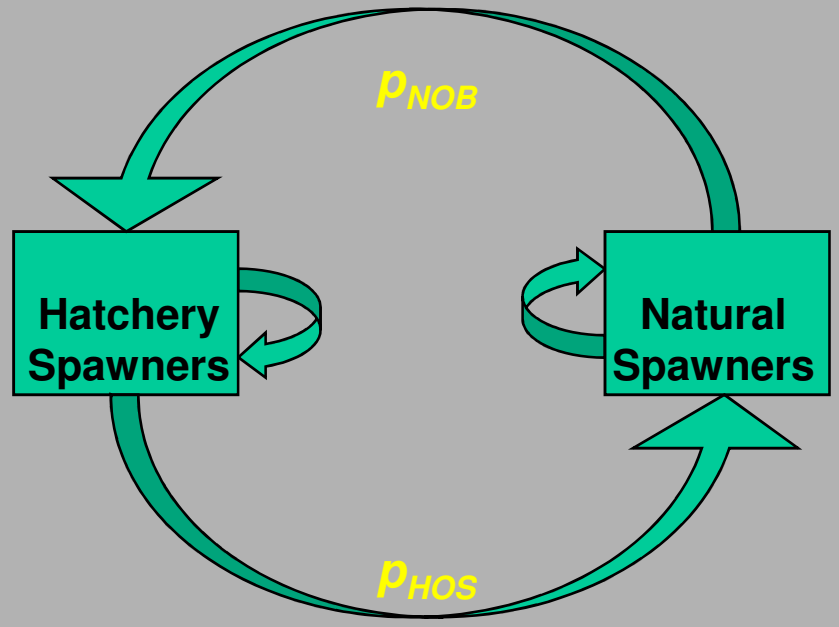
An "integrated" population lives in two environments, and natural selection in each tugs the population toward that optimum.



The mean of any population trait will eventually equilibrate at a point z*, which is expressed as a proportion of the distance from the hatchery-origin optimum to the natural-origin optimum.

z^* is approximated well by the ratio

$$\frac{p_{NOB}}{p_{NOB} + p_{HOS}}$$

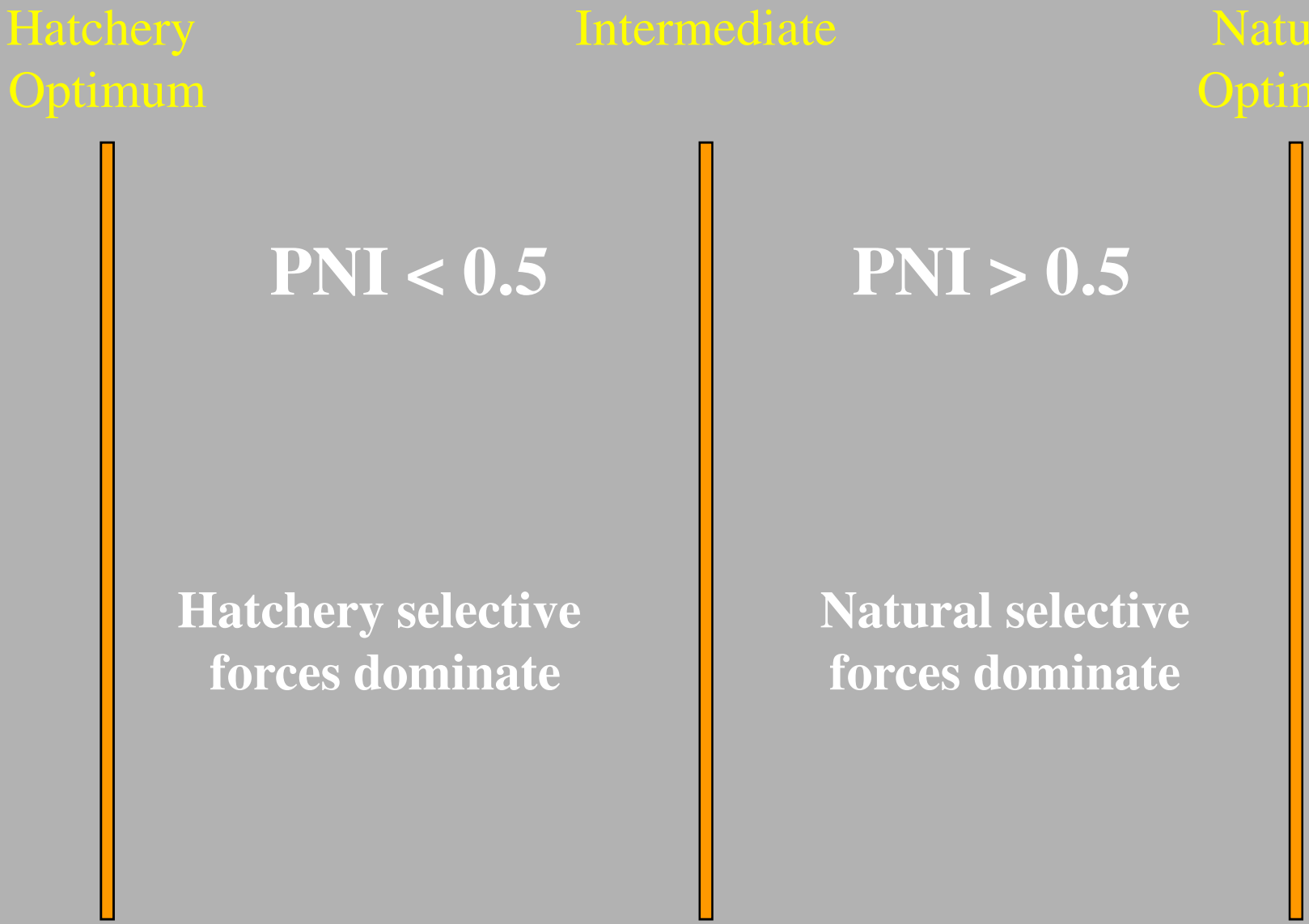


p_{NOB} = proportion of broodstock consisting of natural-origin fish

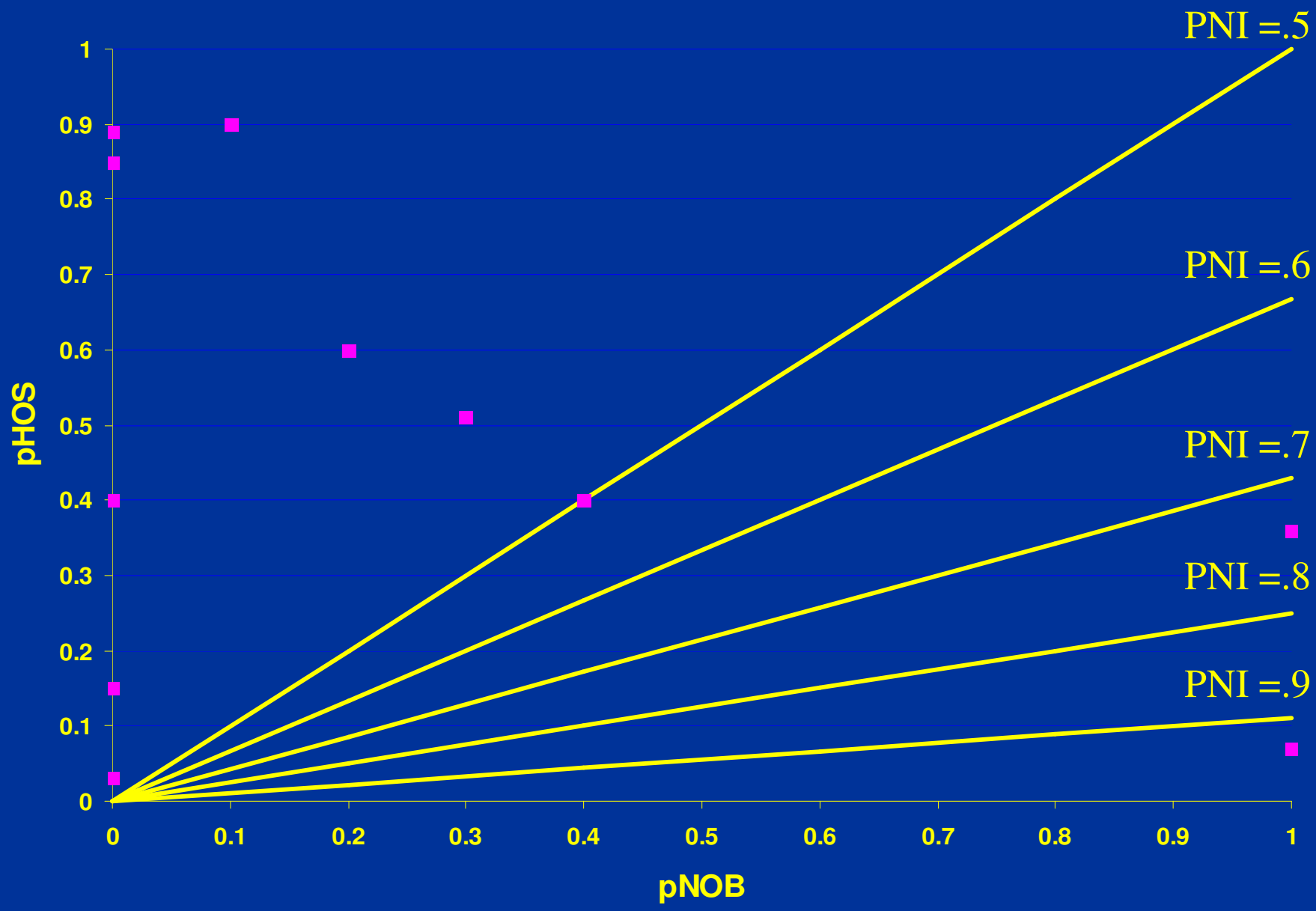
p_{HOS} = proportion of fish spawning naturally consisting of hatchery-origin fish

This ratio is called *proportionate natural influence* or PNI.

Trait Equilibria in Integrated Hatchery Programs



Recent PNI in Some Puget Sound Chinook Programs



Major Considerations in Achieving Properly Integrated Programs

Ability to identify fish by origin

Ability to control P_{NOB} and P_{HOS}

Scaling program size and harvest rates to basin productivity and capacity

Choosing appropriate population unit for integration

Importance of PNI Concept

Unifying element for management of integrated hatchery programs, regardless of program purpose

Has led to more wholistic approach to hatchery planning, integrating ideas about harvest, hatchery production, and habitat capacity and productivity (all-H approach).

Closing Thoughts: Caveats

PNI is a tool to limit domestication, not eliminate it

PNI is not a direct fitness measure

PNI is not a total theory of domestication

Domestication is not the only type of genetic risk

Genetic risk is not the only concern; hatchery programs may also pose ecological risks