

**A FRAMEWORK OF CONSERVATION HATCHERY PROTOCOLS  
FOR PACIFIC SALMON**

Thomas A. Flagg,  
Robert N. Iwamoto, and Conrad V.W. Mahnken  
National Marine Fisheries Services (NMFS), Northwest Fisheries Science  
Center, Resource Enhancement and Utilization Technologies Division

Contact primary author at:  
NMFS Manchester Research Station  
PO Box 130 Manchester, Washington, USA 98353  
Phone: (360-871-8306) Fax: (206-842-8364)  
Email: [tom.flagg@noaa.gov](mailto:tom.flagg@noaa.gov)

**EXTENDED ABSTRACT – DO NOT CITE**

Artificial propagation has potential to quickly amplify population numbers to aid recovery of U.S. Endangered Species Act (ESA)-listed stocks of Pacific salmon. However, there are a number of impacts that hatcheries may have on wild populations. These include alteration of life history patterns, introgression from non-indigenous stocks, swamping effects of massive hatchery release numbers, and harvest impacts (ca., Flagg et al. 1995). Although the protective nature of hatchery rearing increases egg-to-smolt survival, the postrelease survival and reproductive success of cultured salmonids are often considerably lower than that of wild-reared fish. To provide direction for the use of hatcheries in ESA recovery processes, we<sup>1</sup> reviewed documented impacts of artificial propagation on the biology and behavior of wild fish and developed a framework for Conservation Hatchery strategies to help mitigate the unnatural conditioning provided by conventional hatchery rearing.

A review of over 300 references on ecological and behavioral impacts of artificial production provided very little specific numerical information on wild

---

<sup>1</sup> This paper summarizes concepts detailed by NMFS Northwest Fisheries Science Center, Resource Enhancement and Utilization Technologies Division staff in two NOAA Technical Memorandums (Flagg and Nash 1999, Flagg et al. 2000) that include contribution of 14 coauthors.

fish abundance dynamics (number and productivity trend) and interactive factors, such as competition, predation, migration, and health. However, assessments were able to provide general directional trends (Table 1). In addition to genetic change (domestication, drift, etc.), environmental factors that disrupt health, physiology, and behavior appear to play a major role in the reduced performance of hatchery fish after release.

Literature was in general agreement that increasing either fry-juvenile or smolt release numbers of conventionally-reared fish could affect natural cohorts through swamping effects on interactive dynamics of competition and predation and (less certain) health; although the reciprocal case could be found for every conclusion. The literature was equivocal on whether the use of local broodstock provided benefits. However, release of local broodstock was the only strategy examined that associated any positive adult number and productivity trend effects.

Implementation of Conservation Hatchery strategies was theorized to provide benefits at all life stages; but only limited evidence was found and only for a limited number of strategies. For instance, rearing in raceways enriched with cover, structure, and substrate has been documented to increase juvenile competitive dynamics and outmigration survival (Maynard et al. 1996), but other rearing and release scenarios and overall effects on natural stock productivity remain to be evaluated.

Salmon restoration in the Pacific Northwest has focused hope on the use of Conservation Hatchery strategies to aid run restoration (Brannon et al. 1998). The lack of studies leading toward complete evaluation of Conservation Hatchery scenarios was disturbing, as was the fact that no true Conservation Hatcheries appear to be in existence in the Northwest at the present time.

Rather it appears that various production hatcheries are applying some individual conservation strategies in an attempt to improve fitness and increase stock survival and that these strategies are:

- 1) not being uniformly applied,
- 2) not covering the full spectrum of potential strategies, and
- 3) only in select cases receiving adequate monitoring and evaluation.

Unfortunately, this approach does not offer the serious test of Conservation Hatchery strategies that is required to determine if they are a proper focus for salmon restoration.

Table 1.—Assessment of the effects of hatchery stocks of chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*) on the population abundance and trends of wild cohorts.

	<b><u>Effects on natural population abundance</u></b>			
	<b>Juvenile-smolt effects</b>		<b>Adult effects</b>	
<b>Hatchery influence</b>	Juvenile release	Smolt release	F1 Adult number	Productivity trend
<b>A. Production strategy</b>				
i) increasing release numbers	NEG/a	NEG/a	---	---
ii) Supplementation strategy using:				
a. out-of-basin hatchery stock	NEG/a	NEG/a	NEG	NEG
b. locally adapted stock	NEG/a	NEG/a	NEG - POS	AL +
<b>B. Competition</b>				
i) Exclusion from				
a) key habitat resources	NEG/b	NEG - NEU	NEG - NEU	AL (-, 0)
b) food resources	NEG/c	NEU	NEU	NEU
<b>C. Predation</b>				
i) Direct predation	NEU	NEG - POS	AL-	AL-
ii) Changes in predator/prey dynamics	NEG/b	NEG/b	AL-	UNK-
<b>D. Health status</b>				
i) Direct interactions	AL-	AL-	AL-	AL-
ii) Contact through other vectors	AL-	AL-	AL-	AL-
<b>E. Migration</b>				
	---	NEG - NEU	UNK	UNK
<b>F. Implementation of Conservation Hatchery Strategies</b>				
	AL+	AL+	UNK+	UNK+
NEG: literature indicates negative effect at selected life stage POS: literature indicates positive effect at selected life stage NEU: literature indicates no effect at selected life stage a relationship could be positive at low population densities b relationship could be neutral at low release densities UNK: approach theoretical, relationship probably positive (+), neutral (0), or negative (-), studies have not been conducted AL: only ancillary literature available, theoretical evidence of positive (+), neutral (0), or negative (-) directional effect at selected life stage				

To fully test the Conservation Hatchery concept, hatcheries must utilize as near as possible the complete range of potential conservation strategies available; these are summarized below and address issues of:

- 1) Avoiding inbreeding, outbreeding, domestic selection, and other genetic alterations through collection, mating, and rearing designs that provide minimal genetic divergence from their wild counterparts to maintain long-term adaptive traits. Conservation hatcheries should use only wild or locally adapted broodstock.
- 2) Simulating natural rearing conditions through incubation and rearing techniques that approximate natural profiles and provide options for habitat complexity such as cover, structure, and substrate in rearing vessels to produce fish more wild-like in appearance, and with natural behaviors and higher survival. Goals for growth patterns of hatchery fish and size at emigration should be based on natural population parameters. Fish should be reared at low densities to improve juvenile survival during rearing and increase adult return percentage. Techniques such as anti-predator conditioning should be employed to increase behavioral fitness.
- 3) Optimizing health and physiology through monitoring and release at a size, stage, and condition which equals distribution in the wild population. Smolts should be released on their own volition and out-migrate during windows for natural downstream migration of the stock. Release practices should be adopted to reduce straying, such as on-site rearing and release, and other promising imprinting or homing techniques. Releases should be programmed to accommodate the natural spatial and temporal patterns of abundance in wild fish populations.
- 4) Providing aggressive monitoring and evaluation to determine success of Conservation Hatchery approaches. High priority must be given to basic scientific research to meet three principal goals: 1) maintain genetic integrity of the population, 2) increase juvenile quality and behavioral fitness, 3) increase adult quality.

## References

- Brannon, E., and six coauthors. 1998. Review of salmonid artificial production in the Columbia River Basin. Report 98-33, Northwest Power Planning Council. Portland, OR., 77 p.
- Flagg, T.A., F.W. Waknitz, D.J. Maynard, G.B. Milner, and C.V.W. Mahnken. 1995. Impact of hatcheries on native coho salmon populations in the lower Columbia River. *Am. Fish. Soc. Symp.* 15:366-375.
- Flagg, T.A., and C.E. Nash, (editors). 1999. A conceptual framework for conservation hatchery strategies for Pacific salmonids. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-38.
- Flagg, T. A., and nine coauthors. 2000. Ecological and behavioral impacts of artificial production strategies on the abundance of wild salmon populations. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-41, 91 p.
- Maynard, D.J., T.A. Flagg, and C.V.W. Mahnken. 1995. A review of innovative culture strategies for enhancing the post-release survival of anadromous salmonids. *Am. Fish. Soc. Symp.* 15:307-314.

