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ASHBURN AND MASON

LAWYERS

A PROFESSIONAL CORPORATION

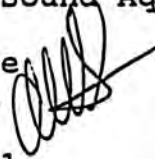
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MEMORANDUM

TO: John McMullen, President
Prince William Sound Aquaculture Corporation

FROM: A. William Saupe
Ashburn & Mason 

DATE: October 16, 1991

RE: Regulation of Private Hatcheries

I. Issues Presented

You have asked us to research several legal issues that go to heart of PWSAC's ability to conduct its business as it has for the past 14 years. First, you asked for the legal basis for of PWSAC's right to conduct broodstock and cost recovery harvests, and an analysis of the degree to which the Department of Fish and Game (the "Department") and the Board of Fisheries (the "Board") can regulate broodstock recovery and cost recovery by private non-profit hatcheries. In that connection, you requested an analysis of an Attorney General's Opinion by Stephen White (Op. No. 663-90-0327, August 1, 1990) and two other opinions on the same topic. One is a memorandum written to Senator Eliason by George Utermohle, Legislative Counsel, dated April 8, 1991, and the other is a

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February 28, 1991 memorandum from Michael A. D. Stanley to Kate Troll, Executive Director of the Southeast Alaska Seiners.

You also asked for an evaluation of the extent of the Board's authority to regulate hatchery production levels on a regional or individual hatchery basis, with specific reference to AS 16.05.440(b), regarding salmon egg take.

The analysis and arguments that we would make follow.

II. Brief Conclusion

Based upon the relevant provisions of the Alaska Constitution, applicable statutes, and related legislative history, we would argue that PWSAC has a constitutional and statutory right to continue a reasonable level of broodstock and cost recovery harvest. Any regulation by the Board or Department that significantly restricted PWSAC's ability to continue its present broodstock and cost recovery practices would be inconsistent with an extensive statutory scheme that explicitly authorizes broodstock and cost recovery by private non-profit hatcheries and regional aquaculture associations. Any such restriction would also conflict with Article VIII, Section 4, of the Alaska Constitution (requiring fish resources belonging to the State to be "utilized,

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developed, and maintained on the sustained yield principle"), Article VIII, Section 15 of the Alaska Constitution (prohibiting any exclusive right or special privilege of fishery, except insofar as limited entry may be imposed by the State "to promote the efficient development of aquaculture in the State").

On the related question of the Board's authority to restrict hatchery production (as distinct from its authority to regulate harvests), the Board is statutorily authorized to regulate such things as the "propagation and stocking of fish" (AS 16.05.251(7)), and the "source and number of salmon eggs" taken by a hatchery (AS 16.10.440(b)), which suggests that it might have some measure of control over individual hatchery output. However, the available legislative history strongly suggests that the legislature never intended to give the Board the power to limit hatchery production on either a local, regional or statewide basis. Nothing in the current law would permit regional production ceilings designed to restore historical market share percentages, which we understand to have been proposed.

If the Board does have power to regulate production, at some point it would come into conflict with the constitutional provisions mentioned above and the numerous other statutes, such as

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the statutes creating the FRED Division, the Limited Entry Act, and the State Hatchery Loan Program, which together evidence a strong policy in favor of hatchery development as well as enhancement and extension of the State's fisheries. Because there are no court decisions interpreting the Board's power to regulate propagation or egg take, and because the Alaska Supreme Court has not elucidated either the meaning of the constitutional reference to "efficient development of aquaculture," or the meaning and application of the sustained yield concept, there is no sure way to know precisely where the collision might occur until a specific restriction is imposed and challenged in court.

It would seem reasonable to conclude, however, that in the absence of a strong factual showing that hatchery production posed a serious genetic or disease threat to wild salmon stocks or perhaps was causing severe economic distress, neither the Department nor the Board could legally restrict PWSAC's output below a level necessary to sustain hatchery yields, to efficiently develop aquaculture, to repay state loans and to recover its costs.

III. Discussion

A. The Board And The Department Are Required By The

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Alaska Constitution And Numerous Statutes To Manage
For Broodstock Recovery

In its August 1990 opinion, the Attorney General's Office advanced the argument that the Board is obligated to manage Alaska's fisheries to provide for broodstock recovery by hatcheries. Analogizing broodstock fish to wild stock escapement, the Assistant Attorney General Stephen White reasoned that Article VIII, Section 4 of the Alaska Constitution mandates that conclusion. That section provides as follows:

Sustained Yield. Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses.

Alaska Const. Art. VIII, §4. White implicitly assumes that hatchery fish "belong to the State" and argues that without broodstock harvests, hatchery stocks obviously could not be sustained.

In an opinion on this subject requested by Senator Eliason, Legislative Counsel George Utermohle questioned White's conclusion that the sustained yield principle applies to hatchery

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fish, on the grounds that they may not "belong to the State." He bases his argument entirely on AS 16.10.440(a), which provides:

Fish released into the natural waters of the state by a hatchery operated under AS 16.10.400 - 16.10.470 are available to the people for common use and are subject to regulation under applicable law in the same way as fish occurring in their natural state until they return to the specific location designated by the department for harvest by the hatchery operator.

AS 16.10.440(a).

Utermohle points out that the phrase "occurring in their natural state" used in this section mirrors the language of the common use clause of the constitution (Art. VIII, Sec. 3).¹ He then argues that merely providing that hatchery fish are available for common use "neither implies state ownership of the hatchery fish nor entails a concomitant responsibility to manage hatchery fish for sustained yield, because the requirements for common use and sustained yield are separate provisions of the constitution." Next, Utermohle asserts that AS 16.10.440(a) does not use the phrase "belonging to the state," which would invoke the sustained

¹Article VIII, Sec. 3 provides: "Common Use. Wherever occurring in their natural state, fish, wildlife, and waters are reserved to the people for common use."

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yield clause. Instead, he argues that the statute requires only that hatchery fish be treated in the same way as fish occurring in their natural state until they return to the specific hatchery location. Utermohle Memo. p. 2.

From this phrasing in AS 16.10.440(a), Utermohle reasons that there may be "some form of lingering private property interest in the hatchery fish even after the hatchery releases the fish into the wild." Id. at 3. If the fish do not "belong to the State," Utermohle concludes that they are not subject to the sustained yield requirement and neither the Board nor the Department is required to manage hatchery fish to assure a sustained yield escapement to the hatcheries.

Utermohle's ownership argument does not stand up to closer analysis and is contradicted by the available legislative and constitutional history. Certainly PWSAC has understood since its creation in 1975 that once it releases its fish, it no longer owns or controls them. From the point of release forward, they are "fish occurring in their natural state" and, as Utermohle acknowledges, Article VIII, Section 3 of the constitution reserves them to the people for common use. This is consistent with the general rule, which he also cites, that salmon while in state water

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are property of the state and held in trust for the benefit of all people of the state. Metlakatla Indian Community v. Egan, 362 P.2d 901, 914-915 (Alaska 1961).

That hatchery fish belong to the State is also consistent with the views of the legislature that created the nonprofit hatchery program. In her July 31, 1991 memorandum to Senator Eliason, Linda J. Snow, a Legislative Analyst, wrote as follows:

Consensus is that the legislature had always intended that the fish from PNP hatcheries belong to the common property fishery until such time as they return to the hatchery, and then they belong to the hatchery for broodstock and cost recovery. Testimony by Senator Dick Eliason at a 1975. Senate Resources Committee hearing on SB 180 indicates that the initial concept of a private hatchery system considered profit-making corporate ownership. However, a profit-making corporation might advance a claim to exclusive ownership of everything it produced. Thus, it was felt that private, nonprofit ownership of hatcheries would be more consistent with the concept of publicly owned hatchery fish. This opinion is echoed by former Representative Terry Gardiner.

At a March 7, 1977 House Resources Committee hearing, Jack Milnes, executive director of Southern Southeast Regional Aquaculture Association testified: "I wish to recognize the fact that these are common property fish, that they belong to the state of Alaska and to the people of Alaska and therefore they should be protected by the representatives of the

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people of the state of Alaska." At a 1979 Senate Resources Committee hearing on HB 48, Don Clockson, an attorney with Alaska Legal Services discussed the question of ownership of hatchery fish. In his testimony, he asked "When are fish no longer common property fish?" He felt that constitutionally, they were considered to be common property at all times. Consequently, it appears there was never any question that hatchery fish were common property of the people of the state while in Alaska waters, and they may or may not be the property of the PNP hatchery operator at the hatchery, but that he is allowed to harvest a sufficient number for broodstock and cost recovery.

Snow Memo. p. 14 (attached as Attachment A) (emphasis added). These statements effectively answer the "ownership" issue. When the legislature created private hatcheries, it intended that the fish would belong to the State, contrary to Utermohle's supposition.

The commentary of the Committee on Resources of the Alaska Constitutional Convention is also significant on this point. Referring specifically to the "common use" clause, which Utermohle seeks to distinguish from the sustained yield clause, the commentary states in relevant part as follows:

Game fish, wildlife, fisheries, and water are recognized as belonging to the state so long as in a natural state. These resources are subject to a private right only when they have been acquired or utilized as provided by law.

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Alaska Constitutional Convention Proceedings, Part 6, p. 98 (emphasis added). Thus, the framers of the common use clause thought that the fish being reserved for common use "belonged" to the State. Hatchery fish are reserved for common use by AS 16.10.440(a) and the common use clause itself. Therefore, they must belong to the State and be subject to the sustained yield principle.

Also significant is the commentary to the sustained yield clause, which states in relevant part:

Sustained yield is recognized as a principle applicable to the administration of plant and animal life subject to the immediate authority of the state.

Id. (emphasis added). Because hatchery fish are subjected to the authority of the State by AS 16.10.440(a), among other provisions, it follows that they are subject to the sustained yield clause.

This conclusion also comports with common sense. If they did not belong to the State, it could not reserve hatchery fish for use by others without paying for them. Moreover, if the mere expectation that a hatchery will later be allowed to harvest some unidentified fraction of the returning fish constitutes an ownership interest in all of its fish, then every other limited entry permit holder could be said to have the same "lingering

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property interest," leading to the false conclusion that none of the fish in Alaska's waters ever belong to the State or are subject to the sustained yield principle of management.

A more reasonable interpretation of these related statutory and constitutional provisions is that, once released, hatchery fish become like wild stocks in every legal respect. They belong to the State, are reserved to the people for common use and must be managed for sustained yield. Therefore, broodstock recovery must be permitted by the Board and the Department at a level sufficient to produce a sustained yield of hatchery stocks.

Even if this is true, Utermohle goes on to argue that the sustained yield principle in Article VIII, Section 4 is not absolute and is "subject to preferences among beneficial uses." He suggests that this phrase implies the power on the part of State regulators to deny hatchery harvests altogether, in order to achieve a "more beneficial public purpose." According to Utermohle, the ability of the State to establish preferences among beneficial uses is reflected in AS 16.10.430(b), which allows the Commissioner of Fish and Game to terminate the operation of a

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hatchery if its adverse effects are irreversible and cannot be mitigated. Utermohle Memo., p. 4.²

A more plausible interpretation of AS 16.10.430(b) is that the listed conditions under which a hatchery operation may be terminated are the only bases upon which termination is permitted. In other words, unless there are irreversible adverse effects that cannot be mitigated, a licensed hatchery operation cannot be terminated, directly through a termination order, or indirectly through a denial of broodstock or cost recovery funds.

Utermohle's argument also overlooks, among other things, Article VIII, Section 15 of the constitution, which provides:

²AS 16.10.430(b) provides as follows: "If the commissioner finds that the operation of the hatchery is not in the best interests of the public, the commissioner may alter the conditions of the permit to mitigate the adverse effects of the operation, or, if the adverse effects are irreversible and cannot be mitigated sufficiently, initiate a termination of the operation under the permit over a reasonable period of time under the circumstances, not to exceed four years. During the period of time that the operation is being terminated, the permit holder may harvest salmon under the terms of the permit but may not release additional fish."

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No exclusive right or special privilege of fishery shall be created or authorized in the natural waters of the State. This section does not restrict the power of the State to limit entry into any fishery for purposes of resource conservation, to prevent economic distress among fishermen and those dependent upon them for a livelihood and to promote the efficient development of aquaculture in the State.

This provision strongly suggests that the framers of our constitution considered the efficient development of aquaculture to be an important value to be protected. It also indicates read to mean that the efficient development of aquaculture is one of the purposes of limited entry, a principle that is central to fisheries management in Alaska.

Hatchery harvests for broodstock (and cost recovery) are absolutely essential to conservation of the resource and to the efficient development of aquaculture. If deprived of broodstock (or the funds generated by cost recovery), PWSAC could not continue in existence, much less develop efficiently. Furthermore, other beneficial uses, such as the harvest of PWSAC produced fish by commercial, sport and subsistence users, would be seriously harmed, not helped by a restriction on broodstock harvest. Over the past 14 years, PWSAC has harvested an average of less than 30% of the

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salmon returning to its hatcheries. During the period from 1986 through 1990, PWSAC fish constituted 50 percent of the total commercial harvest. During that period PWSAC contributed an average of approximately \$15.4 million annually in value to the common property fishery, while costing the State little or nothing. PWSAC harvests have consistently sustained other user groups throughout the region, while causing no demonstrable harm to wild stocks. Short of the extreme situation envisioned by AS 16.10.430(b), it is hard to conceive how denial of a reasonable hatchery harvest in favor of other beneficial uses could achieve a greater public purpose.

Any regulation that severely limited or denied PWSAC's right to harvest a reasonable number of fish would violate both Section 4 (sustained yield) and infringe on the values reflected in Section 15 (limited entry and efficient development of aquaculture) of Article VIII and the Limited Entry Act, of which hatchery harvests are an integral part.

Utermohle's argument also overlooks an extensive web of statutory provisions that evidence an unwavering legislative intent to sustain and expand hatchery operations through hatchery harvests. A good example is the very provision that Utermohle

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cites, AS 16.10.440(a), which provides that hatchery fish are available for common use "until they return to the specific location designated by the department for harvest by the hatchery operator." This indicates a legislative expectation and intent that hatchery harvests are necessary.

The obligation of the Department to affirmatively assist with broodstock recovery is embodied in AS 16.10.443, which states:

Department assistance and cooperative. (a)
Before and after permit issuance under AS 16.10.440 - 16.10.470, the department shall make every effort, within the limits of time and resources, to advise and assist applicants or permit holders, as appropriate, in the planning, construction, or operation of salmon hatcheries.

As explained above, broodstock recovery is essential to hatchery operations. Without it, they could not exist. The Department is obligated under AS 16.10.443 to assist in the operation of hatcheries. Any departmental regulation, action or order that denied broodstock recovery would be inconsistent with this obligation and would be invalid.

Other relevant statutory provisions that establish the obligation of the Department and the Board to manage for hatchery harvests are discussed below, in relation to cost recovery.

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B. The Board And The Department Must Also
Manage For Cost Recovery Harvests

Assistant Attorney General White concluded that the Board and the Department "are authorized, and in fact directed, to manage fisheries so that broodstock returns to hatcheries." Both the reasons given by White and the additional reasons set forth above support this conclusion. On the related issue of whether the Board and the Department must manage for cost recovery, White is less certain. He believes that the arguments on both sides of the question "depend upon implication and analogy" and concludes that "the law does not clearly point to one answer or the other." White Memo., p. 7. However, we would argue that the Alaska Constitution and an extensive statutory scheme require the Board and the Department to manage for hatchery cost recovery.

As an initial matter, it is important to remember that the Board and the Department manage the fisheries primarily through regulations and orders. In order to be valid, a regulation must be within the scope of the authorizing statute and it must be "consistent with standards prescribed by other provisions of law." Beran v. State, 705 P.2d 1280 (Alaska App. 1985), citing AS 44.62.020. In Beran, the court struck down a Board regulation on

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the basis that it was inconsistent with other provisions of law and therefore invalid. Id. at 1289. If the Board or the Department were to issue regulations that curtailed PWSAC's ability to conduct a cost recovery harvest, the regulations would be inconsistent with numerous provisions of law and could be successfully challenged in court.

The first section of this memorandum focused on the requirements of Article VIII of our constitution. The same constitutional provisions that protect broodstock recovery also protect cost recovery, because cost recovery is also absolutely essential to sustain hatchery yields (Section 4) and to promote the efficient development of aquaculture (Section 15). This discussion will not repeat those arguments, but will focus instead on the legislative mandate for cost recovery. Numerous statutes express the legislative intent that hatcheries must be permitted to conduct cost recovery harvests in order to generate funds for operation, debt retirement, and expansion.

The most obvious such provision is AS 16.10.450(a), which could hardly be clearer on this point. It states:

Sale of salmon and salmon eggs by hatchery.
(a) Except as otherwise provided in a contract for the operation of a hatchery under

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AS 16.10.480, a hatchery operator who sells salmon returning from the natural waters of the state, or sells salmon eggs to another hatchery operating under AS 16.10.400 - 16.10.470, after utilizing the funds for reasonable operating costs, including debt retirement, expanding its facilities, salmon rehabilitation projects, fisheries research, or costs of operating the qualified regional association for the area in which the hatchery is located, shall expend the remaining funds on other fisheries activities of the qualified regional association.

AS 16.10.450(a).³

The Limited Entry Act, AS 16.43.400, et. seq., permits the Commercial Fisheries Entry Commission to issue "special harvest area entry permits" to holders of private, nonprofit hatchery permits issued by the Department. Section 420 of the Act, noted above in connection with the ownership issue, specifically authorizes cost recovery harvest by permit holders, such as PWSAC:

Disposition of fish. Fish caught under the authority of a special harvest area entry

³The intent of this provision is reiterated in AS 16.40.210, the recently enacted statute that bans mariculture. It provides in section (b)(2) that "this section does not restrict the ability of a nonprofit corporation that holds a salmon hatchery permit under 16.10.400 to sell salmon returning from the natural waters of the state, as authorized under 16.10.450, or surplus salmon eggs, as authorized under 16.10.420 and .450."

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permit are the property of the permit holder.
The permit holder may sell the fish if the
proceeds are used in the manner described in
AS 16.10.450.

AS 16.43.420. PWSAC, of course, holds a special harvest area entry permit under AS 16.43.400, and its cost recovery funds are used for the purposes listed in AS 16.10.450. It thus has a statutory right to cost recovery that cannot be curtailed through regulation.⁴

PWSAC also conducts cost recovery harvests at Main Bay and Cannery Creek under authority of contracts entered pursuant to AS 16.10.480, enacted by the legislature in 1988. That section authorizes the Department to enter into hatchery management contracts for certain state-owned hatcheries, which allow harvest of adult salmon "in a quantity sufficient to allow the contractor to recover all or part of the contractor's costs of operating the hatchery." While this provision is permissive, rather than

⁴It could also be argued that cost recovery is guaranteed to permit holders such as PWSAC by the Limited Entry Act itself. In Johns v. CFEC, 758 P.2d 1256, 1263 (Alaska 1988) the court stated: "The Limited Entry Act has two purposes - enabling fishermen to receive adequate remuneration and conserving the fishery," citing, Art. VIII, Sec. 15, Alaska Const., AS 16.43.010; CFEC v. Apokedak, 606 P.2d 1255, 1255 (Alaska 1980). Without cost recovery, PWSAC would not receive adequate remuneration or be able to help conserve the fishery.

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mandatory, it is further evidence of the legislature's expectation and intent to permit cost recovery harvests at state-owned but privately operated hatcheries.⁵

Another statutory provision that is quite clear on this point is AS 16.10.430(b), discussed above. This provision permits the Commissioner of Fish and Game to terminate a hatchery permit if he finds that continued operation is no longer in the public interest. Presumably, termination could be ordered if a hatchery failed to sustain itself economically, or more likely, if it produced diseased or genetically damaged fish that might threaten other stocks. See Snow Memo., pp. 12-13, 16. In any case, the relevant point is that termination is to be phased over time.

During the period of time that the operation is being terminated, the permit holder may harvest salmon under the terms of the permit but may not release additional fish.

AS 16.10.430(b). Logically, this provision can only contemplate cost recovery harvest. In the context of hatchery termination,

⁵Both the Main Bay and the Cannery Creek contracts provide that PWSAC shall have the right to conduct cost recovery harvests during the terms of the contracts.

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broodstock harvest would not be necessary since no new fish could be released.

Under AS 16.05.020, the Commissioner of Fish and Game is required to "manage, protect, maintain, improve, and extend the fish, game... of the state in the interest of the economy and general well-being of the State." The FRED Division has been charged with the duty, "through rehabilitation, enhancement and development programs" to do everything "necessary to insure perpetual and increasing production and use of the food resources of Alaska's waters and continental shelf areas." AS 16.05.092. Also significant is AS 16.10.443, cited above, which requires the Department to do everything possible to assist hatchery operations. Any regulation or order that prevents a reasonable level of cost recovery would hardly be consistent with the duties on the part of the Commissioner or with the intent of other statutes that authorize cost recovery harvests by hatcheries. Under Beran v. State, supra, and numerous other cases, regulations are invalid if they are inconsistent with other provisions of law.

The statutory provisions discussed above lead to the conclusion that the legislature intended cost recovery harvest to be the primary method of funding private nonprofit hatcheries. The

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Snow Memorandum on the legislative history of the hatchery program supports this conclusion:

At this time [1973-974], legislators were coming to the view that the private sector would be more efficient than the government in the operation of hatcheries. Also, nongovernmental hatcheries had much to recommend them from the perspective of public finance issues: the operation of private hatcheries could be funded from the harvest of returning fish and from tax assessments on the fishermen who had access to hatchery production, thus shifting the cost of the facilities from the shoulders of the general public to the people who derived benefits directly from them.

Snow Memo., p. 5. (emphasis added). Snow goes on to point out that in 1974 "there was great enthusiasm about the prospect of PNP hatcheries from fishermen's groups, education centers, Native corporations, and the legislature itself." Id.

An attorney for the Southeast Alaska Seiners, Michael D. Stanley, seems less enthusiastic about cost recovery. He has approached the issue from a different direction, acknowledging the Department's primary responsibility for control of hatchery harvests, but questioning whether the Board has the statutory authority to allocate fish to private hatcheries. See Memorandum from Michael Stanley to Kate Troll, Executive Director Southeast

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Alaska Seiners, dated February 28, 1991. Stanley bases his argument on AS 16.05.440(a), cited above at page 5. He focuses on the statutory language subjecting hatchery fish to regulation in the same manner as wild stocks, "until they return to the specific location designated by the department for harvest by the hatchery operator." From this he concludes (1) it is the Department, not the Board, which is responsible for "allocating" hatchery fish to a hatchery through designation of special harvest areas, and (2) such allocation occurs only after those fish have traversed the common property fisheries and returned to the specific location designated for hatchery harvest. Stanley Memo., p. 4.

One flaw in this reasoning is that it confuses allocation of fish to be harvested with designation of a special harvest area and harvest timing. There is no logical reason that the Board cannot allocate a portion of the return to a hatchery and the Department designate the specific time and place for the harvest of that allocation. In fact, my understanding is that that is how the system has always worked.

This scheme also appears to be in harmony with subsection (b) of AS 16.10.440, which gives the Board the authority "to amend by regulation... the terms of the permit relating to the harvest of

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fish by hatchery operators, and the specific locations designated by the department for harvest." This provision gives the Department primary responsibility to regulate cost recovery harvests, but also confers sufficient statutory authority on the Board to allocate fish to be harvested. The legislative history of AS 16.10.440, quoted at length below, indicates that the role of the Board extends to regulating the harvest of "those fish which are returning as a result of releases from natural systems and also from hatchery releases." House Journal, March 15, 1979, pp. 601-602.

Another difficulty with Stanley's theory that the Board does not have the power to allocate fish for hatchery harvest is that it seems to be inconsistent with two specific provisions of the Limited Entry Act, under which hatcheries are granted limited entry permits. AS 16.43.440 provides that: "use privileges granted under AS 16.43.400 - .440 are subject to the regulations of the Board of Fisheries." Also, AS 16.43.950 states that "... Holders of ... entry permits issued under this chapter are subject to all regulations adopted by the Board of Fisheries." These provisions

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also could be read to authorize the Board to allocate fish to hatcheries.⁶

As a final point in response to the Stanley Memorandum, the Board's primary authorizing statute, AS 16.05.251(a), is quite broad and seems to give the Board ample authority to allocate fish for cost recovery and broodstock harvest. Examples of the types of regulations the Board may adopt are found in Section 251(a)(6) (classifying as commercial fish, sport fish, personal use fish, subsistence fish, or predators or other categories essential for regulatory purposes); Section 251(a)(12) (regulating commercial, sport, subsistence, and personal use fishing as needed for the conservation, development, and utilization of fisheries); Section 251 (a)(14) (establishing nonexclusive, exclusive, and superexclusive registration and use areas for regulating commercial fishing.) See also, AS 16.05.251(e) (Board shall establish criteria for allocation of fishery resources among personal use,

⁶As we have argued elsewhere, the power of the Board to allocate to hatcheries does not include the power to deny a reasonable allocation altogether.

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sport and commercial fishing). These provisions are broad enough to allow the Board to allocate to hatcheries.

The idea that hatchery harvests do not qualify as "commercial fishing", and therefore not covered by these statutory sections, is directly contrary to the plain meaning of the definition found in the statute.

"Commercial fishing" means the taking, fishing for, or possession of fish... with the intent of disposing of them for profit, or by sale, barter, trade, or in commercial channels;

As 16.05.940(4). There can be no doubt that PWSAC takes and possesses fish with the intent of disposing of them by sale in commercial channels, and is thus engaged in commercial fishing within the meaning of AS 16.05.251. Commercial fishing is precisely what a cost recovery harvest is. PWSAC's conduct in this regard is indistinguishable from that of any other commercial fisherman. (Ironically, one of the objections that is raised by hatchery opponents is that it is inappropriate, for some reason, for hatcheries to "compete" in the commercial market with other fishermen trying to sell their fish to the same customers).

If PWSAC is engaged in commercial fishing, AS 16.05.251 and the case law cited in the White Memorandum (e.g., Meier v.

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State Bd. of Fisheries, 739 P.2d 172 (Alaska App. 1987)) support the conclusion that the Board has ample power to make allocations for hatchery harvests. The Board not only has the authority, but it also has an obligation to do so. See, AS 16.05.251(d) (requiring the Board to provide a fair and reasonable opportunity for the taking of fishery resources by personal use, sport and commercial fishermen).

C. The Board's Power To Restrict Hatchery Output Is Unclear, But Must Be Limited By The Same Constitutional And Statutory Restrictions That Apply To Cost Recovery

Your second question concerns the extent of the Board's authority to regulate hatchery output, as opposed to allocation of harvests. The Snow Memorandum (Attachment A) addresses this issue. It directly responds to a question posed by Senator Eliason as to whether the legislature ever considered limiting hatchery production because of: (1) adverse impacts on wild stocks; or (2) adverse impacts on salmon market prices. Snow's answer is revealing. Her memorandum states as follows:

We found no discussion in the legislative record that hatchery production should be restrained to a predetermined level for either biological or economic reasons. While the legislature was presumably prepared to take whatever corrective measures were necessary in the face of persuasive evidence that the hatchery program

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was causing serious biological problems, there appears to have been no discussion of establishing a ceiling on the production of fish from hatcheries.

There also appears to have been no contemplation of imposing a ceiling on the production of hatchery fish to support market prices. According to Terry Gardiner, salmon stocks were so depressed in the 1970's that there was no thought given to the possibility of oversupply.

* * * *
Clem Tillion told us that the legislature did not anticipate dependence on hatchery salmon by Alaska's commercial fishermen, and if adverse impacts on salmon market price were suspected by any legislators, it was not a widespread feeling, for they did not take steps to be able to limit production if that occurred.

Snow Memo., pp. 13-14 (emphasis added).

Consistent with Snow's conclusions, a review of the Board's authorizing statute as well as the other statutes relating to hatcheries finds little or no basis for regulation of hatchery output by the Board.

You specifically asked whether AS 16.10.440(b), which provides, among other things, that the Board has the authority to regulate "the terms of [a hatchery] permit relating to the source and number of salmon eggs...",⁷ authorizes the Board to limit

⁷Section 440(b) goes on to say that the Board may not "adopt regulations or take any action regarding the issuance or denial of any permits required in AS 16.10.400 - 16.10.470." This suggests that the Board does not have the power to completely deny a cost

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hatchery production levels. The legislative history of this provision indicates that it does not. The Resources Committee's letter of intent on HB 359, which included the language in question, states as follows:

There are three other major changes made by the bill:

(1) Section 2 of the bill amends AS 16.10.440(a)(b). The amendment clarifies the role of the Board of Fisheries. The role of the Board of Fisheries as envisioned by the original legislation was to regulate the harvest of salmon returning to the waters of the state. That role extends to regulating those fish which are returning as a result of releases from natural systems and also from hatchery releases. There are provisions in other portions of the non-profit hatchery Act which allow the designation of specific locations for the harvest of salmon by the hatchery operator for sale, and use of the money from that sale, for the specific purposes as stated in AS 16.10.450. The added language clarifies that the Board of Fisheries may adopt regulations relating to the harvest of the fish by hatchery operators at the specifically designated locations. The Board of Fisheries in the past year or two has enacted regulations relating to those harvests for several of the private non-profit hatcheries in the state.

recovery harvest permit.

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House Journal, March 15, 1979, pp. 601-602 (emphasis added). The exclusive reference to regulation of harvest, and the absence of any mention of production controls, corroborates the conclusion reached by the Snow Memorandum that the legislature never intended to authorize the Board to limit hatchery production. The Board's traditional function has always been to allocate harvests.

The only other statutory provision that suggests otherwise is found at AS 16.05.251(7), which authorizes the Board to regulate the "propagation and stocking of fish," which tends to suggest the power to regulate production, not just harvest levels and allocations. The most plausible explanation of this language is that it was included to permit regulation of such activities as stocking lakes with trout or perhaps even raising fish in ponds. There is regrettably no legislative history available to aid in the interpretation of this language. Because it runs counter to the Board's traditional role and is inconsistent with the conclusions in the Snow Memorandum, it would be wrong to assign much importance to this provision.

Apart from the issue of whether the Board could regulate hatchery output on a local basis, you have asked also whether the Board has the authority to set regional production limits for the

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purpose of adjusting relative market shares between different regions of the State. Can the Board, for example, legally cap hatchery sockeye output in Prince William Sound to keep it at the historical position it has held in relation to Bristol Bay sockeye production?

There is no short and simple legal answer to this question. The authority to regulate propagation and stocking is a very slender thread from which to hang an unprecedented, statewide regulatory program of production allocation, which has not been specifically authorized or even contemplated by the legislature. Certainly any such regulatory regime would raise serious questions as to its consistency with the Board's statutory duty to "conserve and develop" the State's fisheries. Such a policy might further conflict with a number of the other statutory provisions already discussed. It would also run up against the sustained yield concept (Section 4) and the maximum use (Section 1) and maximum benefit (Section 2) policies at the heart of Article VIII of our constitution.

Perhaps more significant than the legal impediments, which are considerable, there would be serious practical and policy problems with any attempt by the Board to allocate production

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between regions of the State. For example, which historical moment would serve as the reference point for assignment of regional quotas? Would it be before or after establishment of the hatchery program? Would new hatchery programs (such as the Main Bay sockeye facility) be automatically precluded if they would alter the historical balance of harvest levels between regions? How could hatcheries plan their budgets and production levels from year to year, given the inherent unpredictability of natural returns? Would a direct consequence of such a policy be to reward stagnant regions and to stifle initiative on the part of any region that is efficient, well-organized and capable of growth? Would the anticompetitive aspects of regional limits outweigh the asserted benefits? What are the asserted benefits? Do they go beyond mere regional jealousy and have some statewide economic rationale? While the answers to these questions are unknown, it may be very difficult for the Board to identify a defensible, rational basis for any such plan.

SCOMM

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Alaska State Legislature

Legislative Research Agency



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September 11, 1991

MEMORANDUM

TO: Senator Lloyd Jones
FROM: Glenn T. Gray^{CT6}
Legislative Analyst
RE: Effect of Hatchery Salmon on Wild Salmon
Research Request 91.303

You requested information about how hatchery-produced salmon affect wild stocks. You asked us to address five specific questions relating to this issue:

- 1) Do hatchery-produced fish cause genetic dilution of natural stocks?
- 2) Does the harvest of hatchery salmon result in unintended harvest of wild stocks?
- 3) Do hatchery salmon compete with wild stocks for food?
- 4) Is predation by hatchery salmon on wild salmon a significant threat to wild stocks?
- 5) Are wild stocks vulnerable to diseases that originate with hatchery-produced fish?

For this memorandum we reviewed studies by scientists from Alaska, other states, Canada, Japan, the Soviet Far East and Europe. We also reviewed abstracts of papers presented at recent conferences concerning the genetic implications of interaction between enhanced and wild fish. We then discussed these studies and related topics with several scientists and personnel from the Alaska Department of Fish and Game (ADF&G).

This memorandum begins by defining some important terms which are commonly used in discussions of salmon biology. Next, an introduction provides an overview of current knowledge of the effects of hatchery salmon on wild fish. Then each of the five questions you posed are addressed. We also identify other possible biological effects of hatchery salmon on wild stocks. This is followed by a discussion of how management can minimize possible negative effects of hatcheries. The memorandum ends with a summary of concerns voiced by biologists about hatcheries and research needs for the future.

DEFINITIONS

Biologists have traditionally recognized six species of Pacific salmon: coho (*Oncorhynchus kisutch*), chum (*Oncorhynchus keta*), chinook (*Oncorhynchus tshawytscha*), pink (*Oncorhynchus gorbuscha*), sockeye (*Oncorhynchus nerka*), and masu (*Oncorhynchus masu*). All but masu salmon may be found in Alaska waters. Recently, cutthroat trout (*Oncorhynchus clarki*) and steelhead (*Oncorhynchus mykiss*) have been reclassified as Pacific salmon. Atlantic salmon (*Salmo salar*) are not native to the Pacific, but some of them have escaped from fish farms in British Columbia.¹ Salmonids are a biological grouping which includes salmon species as well as related fish such as trout, char and whitefish. Most salmon are anadromous, that is they have both freshwater and saltwater residencies during different periods of their life. Some Pacific salmon spend their whole life in fresh water: Kokanee salmon are sockeye salmon that remain in lakes, rainbow trout are steelhead that live in lakes or streams, and cutthroat trout may also spend their life in fresh water.

We use the term stock to refer to groups of fish of the same species with a similar genetic background that return to spawn in the same locality, and do not generally interbreed with other groups of fish.² Some watersheds may have two or more salmon stocks, but these stocks usually spawn at different times or at different parts of the watershed.³ Fish of a particular stock have a unique genetic make-up because wild salmon generally do not interbreed with other stocks. (As a result of natural straying, stocks spawning near each other would be expected to have more similar traits than stocks located further apart.) Some fishery experts prefer the term population because the term stock is often used in many different contexts. Alaska statutes, for example, define fish stocks less precisely.⁴

A wild stock, as used in this memorandum, is a distinct group of fish descended from a population of fish historically found in a particular area that have not bred to a significant degree with fish from another area.⁵ A natural run is a self-sustaining group of "wild" fish in a natural environment that may or may not have genetic influence from hatchery or farmed fish.

¹Although Atlantic salmon have been caught in Alaska waters, there have been no reports of naturally reproducing populations.

²The term stock generally refers to wild fish because hatchery fish may have originated from several different stocks.

³Larkin (1981) notes that in some instances the "differences among the tributaries of a single river are greater than those among comparable tributaries of different rivers" p. 1460.

⁴Alaska Statute 16.05.940(15) defines a fish stock as "a species, subspecies, geographic grouping or other category of fish manageable as a unit."

⁵The Oregon Wild Fish Management Policy defines a wild fish as one that is descended from a population present in the same area since 1800.

A mixed stock fishery occurs when fish of different wild stocks or hatchery and wild stocks intermingle during commercial harvest. Many of the fisheries in Alaska are mixed stock fisheries. Fisheries that occur after stocks separate are known as terminal fisheries. In watersheds where several stocks spawn, individual stocks may not completely separate until they reach up-water spawning grounds. While terminal fisheries are desirable from a management perspective because stocks may be harvested selectively, they may not be economically desirable because the quality of the flesh deteriorates as the fish approach fresh water.

Genetic variability is measured by the "number, frequency, and diversity of alleles present. Alleles are the variant forms of the gene" (Kelly et al. 1989, p. 60). A procedure known as protein electrophoresis measures allele frequencies and can be used to identify different stocks as well as genetic changes these fish may experience.⁶ Electrophoresis may also be used to measure heterozygosity (an indication of the variation of genes) to determine whether hatchery fish have lost genetic variability. Although electrophoresis is useful to determine a difference between some salmon stocks, the test does not reveal differences between all salmon stocks. Salmon stocks that cannot be differentiated by electrophoresis may be marked through a process known as genetic tagging.

Fisheries enhancement includes a variety of methods to augment natural runs. Hatcheries, construction of spawning channels, and lake fertilization are several examples of enhancement. Hatchery-produced fish are released to open water and are known as ranched fish; while fish raised in net pens and never released are known as farmed fish.

Fitness is the ability of fish to survive competition, predation and disease and return to native spawning streams. Some scientists suspect that wild fish are more fit than hatchery fish because wild fish have evolved through thousands of years of natural selection.

Brood stock are the fish used to start or maintain a hatchery. After salmon eggs hatch and their yolk sacs are consumed, the young fish are known as fry. When immature salmon migrate to the sea they are called smolts.

INTRODUCTION

Hatcheries have become a major contributor to commercial fisheries in the Pacific during the past two decades. As the numbers of wild salmon have decreased, Pacific Northwest states have become increasingly dependent on salmon produced by hatcheries. Except for masu and kokanee salmon, Japan depends almost entirely on hatchery stocks to supply its commercial fisheries

⁶Electrophoresis works better with chinook and chum salmon than with sockeye, pink, or coho salmon (Seeb, personal communication).

(Kelly et al. 1989).⁷ Although the Soviet Far East and Alaska still have many wild stocks, both have ambitious hatchery programs. For example, in recent years hatchery fish have comprised up to 98 percent of the total pink salmon harvest in Prince William Sound (Geiger et al. 1991). Despite the increasing contribution of salmon hatcheries, much is still unknown about the effect hatchery fish have on wild stocks. Additionally, some fear that the long-term productivity of hatcheries cannot be sustained (Hilborn 1990).

Each of the questions addressed in this memorandum are discussed separately, but they may actually be related, and addressing them separately may overlook cumulative impacts. For example, the genetic impact of straying salmon may be greater for a stock that has been reduced by over-fishing than for a healthy stock. Likewise, other influences of hatchery fish may have a detrimental cumulative effect when combined with practices destructive to wild fish (e.g., over-fishing and habitat destruction).

Most of the issues addressed in this memorandum ultimately relate to a concern about a reduction of genetic variability in wild salmon stocks. Genetic variability of a specific stock may be reduced when the size of that stock is significantly diminished. The numbers of a specific stock may be reduced by habitat loss, over-fishing, predation, disease, competition, and possibly by disturbance of wild fish nests (redds) by later-spawning salmon. Some geneticists believe that genetic integrity of a stock could also be at risk because of "genetic pollution" which occurs when hatchery fish breed with wild fish and introduce traits that may not be suited to a particular stream. Genetics most likely determine such traits as the timing of smolting, disease resistance, temperature tolerance, size of eggs, size of fish, timing of return, and possibly the ability of a salmon to find its natal stream. Because the brood stock for hatcheries are often obtained from distant watersheds, hatchery salmon may not be genetically suited for rivers near the hatchery. Hatchery fish which stray to local streams and spawn with wild stocks might introduce traits that would reduce the ability of wild salmon fry to survive in their natal stream.

During the 1970s, when Alaska's current hatchery program began, some biologists expressed concern about the risk to wild salmon of large numbers of hatchery salmon.⁸ These concerns have been amplified in recent years. Several scientific conferences have convened to discuss the interactions of wild and hatchery salmon. A recent article by the American Fisheries Society's Endangered Species Committee identifies 159 West Coast salmon stocks at risk of extinction and 54 additional stocks of special concern (Nehlsen et al.

⁷Attempts to develop natural runs of coho, chinook, and sockeye salmon in Japan have been unsuccessful.

⁸The Alaska District of the American Institute of Fishery Research Biologists issued a position paper concerned with genetic implications of hatcheries in 1975 (Attachment A). This organization was concerned that legislation creating private, nonprofit hatcheries did not address genetic issues.

1991).⁹ Habitat loss, over-fishing, and negative interactions with hatchery fish were cited as the major threats to the wild stocks. The article notes that there is a high probability that 104 of these wild stocks have suffered genetic changes from the presence of hatchery fish.

Although researchers have recently placed more emphasis on studying the possible impacts of hatchery salmon on wild salmon, scientists debate the results of these studies. Many factors could be responsible for the decline of a salmon stock. Weak runs may result from habitat disturbance, over-fishing, disease, competition with other fish, or unsatisfactory environmental conditions, as well as a reduction in fitness from the influence of hatchery fish.

Even when evidence suggests that hatchery fish may have adversely affected a specific wild stock, it is difficult to generalize from that evidence about other stocks. First, each species of salmon has a different life history, different lengths of time in freshwater and marine environments, and different preferences for habitat and feeding.¹⁰ Second, a study in one area may produce different results than if it was conducted in another environment or using different research methods. Third, the same study completed during separate years could have different results because of changing environmental conditions from year-to-year. Fourth, the location of a hatchery and its operating procedures will influence the effects of hatchery fish on wild populations. Fifth, the source of hatchery brood stock may determine the effect on local wild salmon. Sixth, different researchers may reach different conclusions from the same data. Lastly, there is often a shortage of baseline data on wild stocks (many significant stocks may not yet be identified), so it is difficult to measure changes that may occur.

Despite the gaps in scientific knowledge, there is consensus on at least two major points. First, fishery experts agree that in mixed stock fisheries where there are strong hatchery returns and weak wild stocks, wild stocks are likely to be over-harvested. Second, fishery geneticists generally agree that hatchery salmon have the potential to alter the genetics of wild fish. Researchers do not agree, however, if interbreeding between hatchery and wild fish will reduce the long-term fitness of wild salmon stocks. Likewise, there is not a consensus about how hatchery fish affect wild fish through competition, transmission of disease, and predation. Large-scale releases of hatchery salmon, however, are more likely to result in more profound effects on wild salmon than are releases of smaller numbers of fish.

⁹Salmon stocks in California, Oregon, Idaho and Washington were examined in this study.

¹⁰Reimers (1979) reports that life histories of juvenile chinook salmon vary both within and among stocks although many managers fail to recognize such variation.

GENETIC DILUTION OF NATURAL FISH STOCKS BY HATCHERY-PRODUCED FISH

The genetic diversity of wild salmon populations in Alaska is the result of ten thousand years of natural selection.¹¹ Biologists assume that specific salmon stocks are best suited to their immediate native environment and that wide genetic diversity permits the stock to withstand extreme changes in environmental conditions. Wild stocks are "adapted to their local habitats, yet flexible enough to respond to future changes in these habitats" (Oregon 1990). The consensus among geneticists is that "fitness (reproductive potential) is enhanced by heterozygosity (genetic variability)" (ADF&G 1985, p. 14).

The subject of genetic dilution is further addressed under several subheadings: the lack of scientific consensus, evidence of reduced genetic variability, causes of reduced variability, interbreeding of hatchery and wild salmon, and evidence of a loss of fitness.

Lack of Scientific Consensus

While there is a general consensus among biologists that hatchery strays can affect the genetic make-up of wild fish, it is difficult to prove that such changes will reduce the fitness of a naturally spawning salmon stock. Kelly et al. (1989) surveyed salmon experts and found no "solid data base which could support a documented position (either pro or con) regarding the effects of interbreeding among wild and hatchery fish" (p. 83). Waples et al. (1990) state that compared to other management problems, there has been little effort to address the genetic aspects of salmon management. The current state of scientific knowledge is unable to bridge the gap between the ardent proponents of aquaculture and those who recommend a more cautious approach. Chettleburgh (1991) states that genetic pollution

has become a rallying point for the opponents of aquaculture, particularly commercial fishermen and environmentalists who use the issue with impunity since it is almost impossible to prove or disprove. The effects, if any, may take centuries to occur. (p. 3)

Many scientists agree that literature on genetic impacts is not conclusive and "is largely speculative in nature and without much hard evidence" (Smoker 1985, p. 3). Poor returns can be blamed on over-fishing or bad environmental conditions (Helle 1981). Yet the increased attention given to the topic during the past few years reflects a growing concern by fisheries managers and

¹¹Two levels of genetic variation occur: differences between fish of the same stock and differences between different stocks (Oregon 1990).

scientists.¹² Those who encourage a conservative approach point out that loss of genetic variability that has evolved for thousands of years may be irreplaceable.

While some scientists are critical of hatcheries because of a fear that they may reduce fitness by altering genetic diversity, others are willing to accept some risks as long as production is increased (Mathisen 1991). As a result, different jurisdictions approach salmon enhancement from different perspectives. For example, while the Alaska Department of Fish and Game (ADF&G) Genetic Policy gives priority to wild stocks, Japan gives priority to enhanced fish.

Evidence of a Reduction in Genetic Variability

Several methods are used to determine the difference between hatchery and wild fish, including scale pattern analyses and starch gel electrophoresis of tissue proteins. Periodic genetic monitoring using electrophoresis can determine if there has been a change in allelic frequencies and therefore a reduction in genetic variability. These studies can reveal if there has been gene flow between a hatchery and wild population and if the genetic variability has been reduced. This process, however, does not reveal if hatchery-wild hybrids are more or less fit than the wild fish. In other words, geneticists can use electrophoresis to determine if a fish is a hatchery fish or a wild fish or if salmon stocks, such as hatchery fish, have lost genetic variability (assuming that the test recognizes a genetic difference between hatchery and wild fish and that electrophoresis data is available for the stocks before hatchery fish entered the gene pool).¹³ With salmon stocks that do not show a discernable difference using electrophoresis, it may be necessary to use a marking program such as coded wire tagging to determine if hatchery fish are spawning with native fish.

Researchers from around the world have found a reduction of genetic variability in enhanced salmon. In Ireland, Whelan and McGinnity (1991) found that a rare allele has been lost in hatchery fish. Japanese researchers found that concerns about a reduction of genetic variability are supported by a decrease in the number of late run chums and odd-year pinks, reduction of variations in

¹²The 1980 FAO-UNEP Expert Consultation on the Conservation of Genetic Resources of Fish, sponsored by the United Nations, was one of the first major conferences to deal with this topic. Several recent conferences include the April 1990 conference in Loen, Norway; the June 1990 NATO-sponsored Genetic Conservation of Salmonid Fishes in Moscow, Idaho; and the International Symposium on Biological Interactions of Enhanced and Wild Salmonids in Nanaimo, British Columbia. Dr. Ole Mathisen is planning a workshop on this topic to be held in Alaska this fall, and Dr. Tony Gharrett is organizing a panel discussion at the November 1991 meeting of the Alaska Chapter of the American Fisheries Society.

¹³According to Steer et al. (1991), there is a scarcity of data for wild stocks compared to enhanced fish.

the timing and duration of maturation of individual fish, and a reduction in the proportion of the effective number of breeding to total number of returning fish (Kaeriyama 1991). A Soviet Far East study of the Ochepukha watershed found that although selected breeding practices reduce the genetic potential of the hatchery salmon, researchers have not been able to detect any significant differences in abundance, size, weight or fertility of males between streams with only natural runs and those with both wild and enhanced stock (Shubin and Kaevo 1991). Ryman and Stahl (1981) report strong evidence suggesting that hatchery fish in Scandinavia have drastically changed the genetic composition of wild brown trout.

Causes of Reductions in Genetic Variability

Hatchery practices can lead to a reduction of genetic variability. For example, poor hatchery management could reduce the genetic variability through inbreeding or as a result of inadvertent or purposeful selection.

Inbreeding

Crossing salmon that are directly related to one another can result in a loss of genetic variability known as inbreeding. According to Smoker (1985), studies have shown that inbreeding is a distinct possibility in a hatchery.¹⁴ Practices such as the use of a low male to female ratio or too few fish for brood stock may increase the possibility of inbred fish in future generations. The use of local wild stocks to periodically refresh hatchery populations is one way to avoid inbreeding. Studies have not yet documented inbreeding for Pacific salmon hatchery stocks. Riddell et al. (1991), however, speculate that inbreeding could account for reductions in body size of cohos. Waples et al. (1990) note that there have been no comprehensive attempts to determine if hatcheries have been successful in their attempts to prevent inbreeding. Inbreeding depression (loss of vigor) has been documented for some hatchery-raised trout species and Atlantic salmon (Kelly et al. 1989). This may be the result of using a small number of fish to start these hatcheries.

Additionally, studies have not documented a reduction in the average heterozygosity of a Pacific salmon hatchery stock when compared to the whole species (Kelly et al. 1989, Smoker 1985).¹⁵ A lower value of heterozygosity

¹⁴Smoker (1985) reports that a study has shown that with 50 spawners, a hatchery would lose 10 percent variability after ten generations and 25 percent after 20 to 30 generations.

¹⁵Unless studies have been completed for wild fish before genetic interaction with hatchery fish, comparing average heterozygosity of hatchery fish to that of "wild" fish may not be valid.

in Japanese chum salmon when compared with U.S. chum salmon suggests a loss of genetic variability for chum salmon in Japan.¹⁶

Selection

The rate of genetic change may increase dramatically in hatcheries through selection, which may be either deliberate or unintentional. Selection of large males and earlier-run salmon for hatchery brood stock has resulted in earlier runs of Sakhalin Island chum salmon. The fish are bigger but the rate of reproduction has decreased (Khorevin 1991). Larkin (1981) suggests that a change in traits of hatchery salmon is likely and selection over generations may explain a perceived decline in the fitness of hatchery stocks.

Some scientists recommend against intentional selection for hatchery fish for specific characteristics such as size, growth, and color (Krueger et al. 1981). The ADF&G's Genetic Policy recommends that brood stock represent a broad cross section of the genetic diversity of a run. However, Larkin (1981) suggests that selected hatchery stocks could improve wild stocks and that the "truth may well be that wild stocks improve hatchery strains rather than that hatchery strains dilute wild stocks" (p. 1473). He suggests that deliberate selection could also offset selection by the fishery, perfect transplanting techniques, and determine the timing of hatchery runs. Smoker (1985) also suggests that hatchery salmon could increase genetic diversity in stocks that have been decimated through over-fishing or as a result of natural population crashes. This is because a small escapement of such a stock could lead to inbreeding.

Actions of hatchery personnel or hatchery conditions may result in inadvertent selection. Hatchery-produced salmon may adapt to hatchery conditions which differ from conditions in the wild. To avoid selection of fish tolerant of hatchery conditions Krueger et al. (1981) recommend release of fish at an early age.

Spawning behavior in the wild involves an elaborate courtship ritual and an establishment of a hierarchy of males. Pink salmon tend to mate with similar sized mates and these progeny tend to be more viable than matings between fish of different sizes, as often occurs in hatcheries (Chebanov 1991). Thus, even random pairing of hatchery fish are likely to produce different pairings than what would occur naturally (Helle 1981).

Natural selection in hatcheries produce fish adapted to hatchery conditions which may not have survived in freshwater conditions (for those salmon that do not migrate immediately). If these salmon survive ocean conditions, they could stray to local streams and if successful at reproduction they could reduce fitness.

¹⁶Japanese fisheries are almost completely dependent on hatchery production.

Interbreeding of Hatchery and Wild Fish

The increased straying of hatchery salmon, especially transplanted fish, can result in the transfer of ill-adapted genes. Large-scale hatcheries can be expected to have more strays than small-scale hatcheries (Smoker 1985).

Although it is known that salmon will stray to some degree, scientists do not agree about the degree straying occurs. We were unable to find many studies that predict a specific percentage of strays for either wild, hatchery or farmed salmon.¹⁷ Gritsenko (1991) found that there is a significant increase in spawners due to straying from large rivers in the Okhotsk Sea coast of Sakhalin Island, but that there is poor survival of their progeny. Using a mathematical model, Zhivotovsky et al. (1991) found that straying between stocks had a significant influence on the dynamics of pink salmon populations. On the other hand, an Alaska study at Auke Creek suggests that pink salmon do not ordinarily stray in large numbers to nearby streams, and that there may be some degree of genetic isolation between runs that spawn at different times in the same stream (Gharrett and McGregor 1991). Other studies may not consider that pink salmon are known to test various streams before ultimately spawning in their natal stream (Gharrett, personal communication). Therefore, the extent of straying suggested by some researchers may be exaggerated.

Many authors report that transplanted and hatchery salmon stray more often than wild salmon. Helle (1981) reports that transplanted salmon have a reduced homing ability. Waples et al. (1990) think that straying rates may be higher for hatchery fish. Gausen and Moen (1991) found that greater numbers of escaped farm salmon spawn in rivers within twenty kilometers of a net pen facility. Bams (1976) conducted an experiment in British Columbia using transplanted pink salmon, hybrids of transplanted males and wild females, and wild salmon. He found that for a stream in British Columbia, transplanted salmon were the least likely to return to spawn. The hybrids were more likely to return, but the wild salmon had the best chances of returning. In a similar experiment, Smoker (1985) found that transplanted salmon may be more fit than transplanted-wild hybrids. The propensity of transplants to stray may mean that genetics play a role in the ability of pink salmon to return to their natal streams. Larkin (1981) suggests that the straying of hatchery fish may be due to rearing conditions instead of or in addition to genetics.

Although hatchery salmon may stray more than wild salmon, Soviet scientists Gritsenko and Kovtun (1991) think that locating a hatchery away from natural spawning areas can reduce straying and the impact of straying on the gene pool of wild stocks. The authors maintain that wild and enhanced fish can co-exist as two reproductively isolated groups.

¹⁷A 1991 study by Hard and Heard that studied chinook returns from a fish hatchery in Little Port Walter that used transplanted salmon. Of the 1.1 percent of the fish that strayed, approximately 1/3 of them strayed within 7 kilometers, almost 2/3 strayed less than 25 kilometers, and the most distant stray was 500 kilometers away. Curiously, none of them strayed to their original rivers which were 250 kilometers from the hatchery.

The ADF&G Genetic Policy acknowledges the potential of straying hatchery fish to reduce the fitness of the naturally spawning fish, but it also suggests that hatchery strays may have little impact on wild stocks.

The degree of interbreeding between hatchery and wild fish can only be detected if there is a significant genetic difference between the two. Studies have revealed little contributions by hatchery steelhead fish to wild fish in the Skagit River after twenty years of stocking. On the Yakima River, considerable introgression (introduction of genetic material from one gene pool to another) between hatchery and nonanadromous wild steelhead occurred, yet anadromous steelhead have shown little introgression with hatchery fish (Campton 1991). Hindar et al. (1991) cite several other studies that reveal introgression between hatchery or farmed salmonids and wild stocks.

Evidence of a Loss of Fitness

Some studies have shown that hybrids of wild and nonlocal salmon are less fit than their wild counterparts (Waples et al. 1990). Because many traits are thought to be inherited, biologists fear that hybrids will be less able to compete, less resistant to disease, and more vulnerable to predation. Allendorf (1991) points to the growing evidence of a loss of local adaptations. Larkin (1981) reports that some people suspect that declining success of hatcheries after a decade or so may be due to genetic changes. Hindar et al. (1991) state that a "considerable body of relevant indirect evidence" points to adaptive changes resulting from interbreeding (p. 950).

On the other hand, according to Kelly et al. (1989), some fishery specialists do not think that hatchery-wild hybrids will detrimentally affect wild stocks. Additionally, there is speculation that in some cases of over-fished wild salmon stocks, hatchery fish may actually increase the fitness of the wild stocks (Kelly et al. 1989; Larkin 1981). However, according to Davis and Burkett (1989), "[a]ny loss of genetic variation results in a loss of fitness, but any gain in genetic variation may or may not improve fitness" (p. 4).

Some researchers have found that wild smolts are more likely to survive than hatchery smolts (Hilborn et al. 1991; Whelan and McGinnity 1991). Swain and Riddell (1991) suggest that if hatchery fish mate with wild stocks, the offspring may be less fit than the wild fish, but that throughout time, wild fish stocks would likely regain fitness.

A study in Norway found that farmed brown trout males do not survive well in wild streams and that only a limited amount of spawning occurred between wild males and farmed females (Skaala et al. 1991). Flemming and Gross (1991) found similar results with hatchery-reared coho salmon in Vancouver Island, British Columbia. Hatchery salmon, especially males, did not reproduce well unless there were no fish in the stream. As the density of spawners increased, the reproductive success of the hatchery fish decreased. Hatchery fish that do breed in the wild could produce a genetically inferior fish. Reisenbichler and McIntyre (1977) revealed that hatchery steelhead were genetically different from wild steelhead and that they did not survive as well as wild fish.

Some studies using hatchery and wild fish from the same parents have found that the hatchery fish do not survive as well as wild fish in natural conditions. These results suggest that a reduction in fitness is a response to hatchery conditions rather than caused by genetics. A study using progeny of the same parents reared one group naturally and the other in the hatchery found that the hatchery group had a reduced osmoregulatory ability (i.e., diffusion of water through cell walls). Because both came from same stock, the difference was probably a response to the rearing environment (Shrimpton et al. 1991). Ward et al. (1991) found that pen-reared steelhead from wild parents survived at lower rates than wild steelhead.

Transplants

Hatchery salmon bred from salmon transplanted from long distances have a greater chance of being less fit than those bred from a local stock. The ADF&G Genetic Policy assumes that hatchery stock from a different geographic area could reduce fitness of a salmon stock, but it is not known if this reduction is critical (Davis and Burkett 1989). The policy suggests that it may be safe to transfer stocks from within the same region for brood stock (ADF&G 1985).

Many states, including Alaska, restrict the transport of live fish or gametes (eggs or sperm) to decrease the chance of spreading disease and to be sure fish used in hatchery operations are similar to local stocks. Recently, however, an increase of fish smuggling by aquacultural operators was reported in California (CAA 1990).

INCREASED FISHING PRESSURE ON WILD STOCKS

In a survey of fishery professionals about the effect of hatchery fish on wild fish, Kelly et al. (1989) found that the greatest consensus was that large-scale releases of hatchery fish can be detrimental to wild fish stocks if there is no feasible way to separate the fish before harvest. "Almost all hatchery-produced salmon in Alaska have the potential for engendering mixed-stock fishery management problems" (Smoker 1985, 14). Mixed stock fisheries are difficult to manage because there is a danger that the smaller stocks will be over-harvested. The state's mixed stock policy encourages terminal fisheries whenever possible (fisheries that occur after the stocks separate). It is not economically feasible to fish at many terminal fisheries because once salmon near their spawning area, the quality of their flesh declines as they adopt spawning characteristics.

While there is danger of over-exploitation of a weak stock in mixed stock fisheries, the problem is compounded with the addition of hatchery stocks (Smoker 1985). Hatchery stocks need less brood stock than wild fish, so it is

possible to have a higher harvest rate for hatchery fish than for wild fish.¹⁸ Especially with large-scale hatcheries, it is difficult to estimate the numbers of wild fish returning (unless they are separated physically or at the time of return). A certain number of wild fish are needed to sustain a stock's genetic variability.

The director of ADF&G's Division of Commercial Fisheries in 1982 explained that with fisheries enhancement, "[w]e may not be able to fully develop some sites and stocks without declines in natural stocks or foregoing harvests of enhanced stock unless we modify our current way of managing" (Pennoyer 1982, p. 113). Under mixed stock fisheries "stocks which are of consistently lower productivity will probably have consistently lower escapements and sooner or later will decline, often drastically, even with 'good management'" (Pennoyer 1982, p. 112).

Many examples document that optimum harvest of hatchery fish in mixed stock fisheries has occurred at the expense of wild fish. Because hatchery fish can withstand a higher exploitation rate than wild fish, wild stocks will be over-harvested unless the entire fishery is limited (Waples et al. 1990). An Oregon study found that the decline in abundance of wild coho salmon in the Columbia river coincided with a sharp increase in harvest rates. The study suggests that current harvest rates will result in the extinction of wild coho (Cramer 1991).

In the Baltic Sea, the number of natural Atlantic salmon drastically declined as a result of an off-shore fishery on mixed stocks (Eriksson and Eriksson 1991). Hilborn (1990) reports that high harvest rates of hatchery fish in the waters between British Columbia's Vancouver Island and the mainland has resulted in an increase in hatchery production, a decline in wild stocks "and the Canadians have no more coho now than they did fifteen years ago" (p. 3). Enhancement activities (new spawning channels) in Babine Lake of British Columbia's Skeena River basin significantly increased production at the expense of other basin stocks (Smoker 1985).

The risks inherent in mixed-stock fishing may be reduced if hatchery and wild fish spawn at different times. Although original hatchery stocks in Prince William Sound were selected to be later or earlier than the wild runs, there is some overlap. Wild stocks can be easily over-harvested at the entrance to the sound in areas where stocks are mixed, such as happened during 1990 (Geiger et al. 1991). According to Eggers et al. (1991), the recent decline in wild pink salmon in Prince William Sound is believed to be a result of low escapement due to over-fishing of wild stocks. Hatchery and wild stocks are harvested together "in the near-terminal mixed-stocks fishing areas and as cost

¹⁸Optimum harvest rates for hatchery fish are 90 to 95 percent while optimum rates of harvest for wild fish are between 60 to 75 percent (Kelly et al. 1989). Hatchery production results in fewer mortalities than wild production because wild fish are subject to changing environmental conditions, competition and disturbance of redds by other fish.

recovery in the hatchery terminal harvest areas" (p. 4). The authors ascribe the low escapement of wild fish to "a weak implementation of the fixed escapement goal policy" (p. 27). In other words, in order to harvest the high numbers of hatchery-reared salmon before they lose quality, harvest rates of wild salmon in these fisheries have reduced the number of wild salmon escapement to levels lower than before the hatcheries were built.

To assess the pressure exerted upon wild fish, some method of identifying the numbers of wild and hatchery salmon must be used. Coded wire tags are sometimes inserted in juvenile fish. The coded wire tag program in Prince William Sound, however, doubled the cost of managing that fishery. A recently introduced marking method, known as thermo-marking, relies on distinctive markings on the fish's otolith (ear bone) as a result of different water temperatures in the hatchery. Each hatchery using this method uses a different sequence of water temperatures. Electrophoresis is another technique that can be used to separate stocks, although it has limitations. The lack of a marking program for hatchery fish from the Gastineau hatchery in Juneau made it impossible to determine if poor returns in 1989 were due to over-harvesting (Geiger et al. 1991).

Smoker (1985) recommends several possible solutions to reduce over-fishing of mixed hatchery-wild stocks: 1) identify the percentage of wild fish in the mixed-stock fishery and reduce catch levels to permit sufficient escapement of the wild stocks, 2) establish annual catch quotas for the fishery, 3) use hatchery stock that return at a different time than wild fish, and 4) restrict the numbers of hatchery fish produced. Smoker acknowledges the problems with each of these solutions.

COMPETITION FOR FOOD BETWEEN WILD AND HATCHERY-PRODUCED FISH

The issue of carrying capacity (the number of fish that can be supported in a given area) of salmon is still contentious. Inhibited growth of salmon due to competition with other fish is known as density-dependent growth. It is difficult to determine if density dependency is the cause of a reduced average size of salmon or if this reduction is a result of poor environmental conditions (e.g., less food sources due to colder water temperatures), or a combination of factors. It should be noted that even if density dependency is found to be an important factor in one area, it may not be as important in another area or at another time. Environmental conditions may be different during different years and in different places. Also, salmon of the same species may have different migration patterns in different areas.¹⁹ Different

¹⁹In the Soviet Far East, salmon from East and West Kamchatka spend about three months in coastal waters while those in southwestern Sakhalin Island spend up to five months in coastal waters (Karpenko 1991).

life histories of Pacific salmon species makes it difficult to generalize about density-dependency factors for all salmon.²⁰

According to Peterman (1984), "[d]ensity-dependent growth or survival has been well documented for the freshwater life phase of Pacific salmon," but less is known about such limitations in marine waters. Given the lack of knowledge of density-dependent growth among wild fish, it is even more difficult to determine how important competition between hatchery and wild fish is. Many scientists suspect, however, that hatchery and wild salmon may compete for food in freshwater, in estuaries, in saltwater nearshore areas, and in the open ocean. Hatchery fish may also displace wild fish from their habitat during juvenile freshwater residence and during spawning (Hindar et al. 1991). Additionally, Kelly et al. (1989) report that some scientists believe that hatchery-wild hybrids may be less able to compete with other fish for food. The density-dependency dispute will only be answered by studies that span many years and consider a variety of factors including fluctuations in environmental conditions and the numbers of hatchery fish released. The discussion below centers on existing studies on this subject.

Competition in Freshwater

A Washington study in two rivers suggests that hatchery coho fry were better able to compete than wild fry. The production of hatchery fry increased, but the total number of fry living to smolts stayed the same. While the number of hatchery smolts increased, the number of wild smolts decreased (Seiler et al. 1991). Reisenbichler and McIntyre (1977) also found that hatchery fish released into stream systems may affect wild fish through competition for food and space. Lichatowich and McIntyre (1987) report that hatchery coho smolts displaced wild fry. Another Washington study, however, found that neither wild nor hatchery coho (from native stock) fry were affected by the presence of the other when released into four streams (Wampler et al. 1991). A study in France showed that if prey density is low, coho salmon escaped from farms could affect the density and growth rate of native Atlantic salmon (Beall and Heland 1991).

Competition in Estuaries

Some evidence points to density dependence in estuaries. Larkin (1981) notes that the unnaturally high numbers of hatchery salmon released at one time may displace wild fish at the site of release as well as in the estuaries and offshore rearing areas. Preliminary research in British Columbia estuaries reveals that migration of large numbers of hatchery-raised sockeye smolts may affect the growth and distribution of wild chinook fry in some estuaries. The researchers suspect that the limitations in the estuary may be due to space and food (McAllister and Levings 1991).

²⁰For example, pink and chum salmon immediately migrate to salt water and do not have competition pressures in freshwater. On the other hand, sockeye coho salmon may spend several years in freshwater and are therefore subject to different types of competition.

Competition in Nearshore Areas

Ocean survival may depend on nearshore competition. Bob Burkett, chief of technology and development for the FRED division places a high priority on studies concerning the nearshore carrying capacity (Gay 1991). Some salmon spend the early portion of their marine life in nearshore areas. Ivanikov and Volkov (1991) found that competition for food is an important factor in early marine life survival for juvenile salmon. Karpenko (1991) found that the availability of food, determined in part by the numbers of juveniles, is a major factor determining survival of juveniles. An Oregon study that involved the review of demographic records of salmon stocks suggests that the carrying capacity of nearshore areas may be exceeded during some years. However, according to Smoker (1985), other authors have interpreted the same data and reached the opposite conclusion.

Eggers et al. (1991) acknowledge that it is possible that the nearshore carrying capacity of Prince William Sound may be nearly reached, but there "does not appear to be any competitive interaction between hatchery and wild stocks" (p. 23). Some people speculate, however, that the reduced size in salmon during the 1991 season was due to competition as a result of high hatchery production (Miller 1991).

Competition in the Ocean

Studies suggest that there may be density-dependent growth in the Gulf of Alaska. Peterman (1984) revealed that significant reductions in body sizes of adult sockeye salmon occurred during years of high numbers of sockeye salmon in the Gulf of Alaska. This study suggests that growth in the gulf is slowed during early ocean life and most likely results from "competition for food among similar-sized sockeye."²¹ Eggers et al. (1991) report that a trend in decreasing average weight suggests that pink salmon growth in the Gulf of Alaska may also be density dependent, affected in part to increasing hatchery returns.

Studies in other parts of the world also suggest a relationship between high numbers of salmon and reduced growth. A Japanese study found that during the last decade of increased chum salmon hatchery production, salmon have decreased in size along with a decrease of the mean age at maturity. Stunted growth during the first year in the ocean suggests that the rate of growth decreased because of increased numbers of fish competing for food (Hayashizaki and Hitoshi 1991). Kaeriyama (1991) also suggests that a reduction in size and average age of adult chum results from density-dependent growth, but found little evidence that survival has declined (Kaeriyama 1991).

²¹According to Peterman (1984) 80 percent of the sockeye in the Gulf of Alaska are from British Columbia and Bristol Bay. The density-dependent growth appears to be between fish of the same stocks as well as among sockeye from different origins.

Smoker (1985) modeled factors affecting ocean survival and found that large releases of hatchery salmon could not only result in a reduction of survival and growth but also could lead to increased variability of salmon abundance from generation to generation. While salmon may have more food available than they need in many areas, food may be patchy during their first summer at sea and "transitory limits to carrying capacity" may be important. Production of salmon has been more variable as hatchery production has increased in Hokkaido Island, Japan and in Oregon (Smoker 1985).

Ricker (1981) notes a decrease in the average size and age of Pacific salmon since the 1920s. He attributes this decrease to eight possible causes, including the possibility that some aspect of artificial propagation has caused slower growth.

Other studies suggest that density-dependent growth is unlikely. Smoker (1985) reports several studies that show no evidence that ocean growth is limited by density of the salmon. One of these studies simulated the growth and survival of salmon during the first six months of ocean life and found that more food is available to Pacific salmon than is consumed.

Should nearshore density-dependency growth be a threat, possible solutions include staggering the release of stocks and rearing salmon to a larger size before release. Future monitoring of growth, age and survival records will help determine where density-dependent growth appears to be a problem.

PREDATION ON WILD STOCKS BY HATCHERY PRODUCED FISH

Little is known about predation by hatchery fish. Generalities based on individual studies are problematic because of differences in the life histories of different salmon species (e.g., differences in freshwater residency, time spent in nearshore areas and ocean migration patterns). While there is evidence of predation by hatchery fish on wild salmon, wild salmon also target hatchery fry.

Ivankov and Volkov (1991) found that predation was an important factor in early marine life survival for juvenile salmon. Most knowledge of predation is in freshwater, estuaries and nearshore areas, and few studies quantify the loss of wild salmon by predation of hatchery fish (Smoker 1985). Hilborn (1990) states that hatchery fish pose a possible threat to wild fish by predation upon them. Smoker (1985) also suspects that enhanced fish may prey upon wild fish. Correlations between releases of hatchery salmon and declines in wild stocks have been observed. Hatchery releases of coho have been found to be coincident with decreases in pink and chum stocks in Washington. In another part of the state, delaying the release of hatchery coho until pink salmon migrated resulted in greater survival of pink salmon (Smoker 1985).

Coho salmon raised as smolts are known to feed on hatchery-produced pink salmon, and early predation in estuaries may be heavier than later predation. Additionally, large numbers of hatchery-released fry may attract coho salmon, which will feed on hatchery as well as wild salmon fry (Smoker 1985, Hindar et al. 1991).

Wood et al. (1991) found that declining sockeye returns to four lakes on Vancouver Island, British Columbia, were not a result of predation by hatchery smolts during the downstream migration. The researchers suspect that marine survival may be affected by predators attracted to nearshore areas because of the large numbers of juvenile salmon present there.

Karpenko (1991) reports that mortality of salmon due to predation varies from 1.5 to 52 percent in coastal waters of various regions. Fish, birds and marine mammals feed on juvenile salmon, but other species of fish (e.g., smelt, Arctic char and Siberian Char) are the most significant predators. Predation was found to be highest during the peak period of downstream out-migration for pink and chum salmon.

Some authors report predation upon hatchery fish as a reason for a reduction in hatchery fish. Beamish and Thomson (1991) report that in the Strait of Georgia, British Columbia, the average survival of hatchery coho and chinook were initially higher than that for wild fish, but after five years the survival rate decreased below historic levels for wild fish. The authors speculate that the cause of the decline in the survival rate may be due to a cyclic decrease in other food for predators so that they target hatchery fish. A Washington study suggests that hatchery fish may be more vulnerable than wild fish to predation by squawfish although the researchers concede that the higher predation may be because the hatchery fish were the most abundant prey (Fresh et al. 1991). One laboratory revealed that under pressure of predation hatchery chum had reduced feeding when compared to wild chum (Tompkins 1991).

THREAT OF DISEASE FROM HATCHERY-PRODUCED FISH ON WILD STOCKS

The threat of disease and parasites is twofold. First, a possible reduction of genetic diversity resulting from interbreeding with hatchery fish could make a natural population of salmon more susceptible to disease. Second, diseased hatchery stock could transmit the illness to wild stocks.

Few studies document the transmission of disease between hatchery and wild fish. However, Kitchell (1991) reports that hatchery-transmitted diseases may have led to the death of thousands of salmon in the Great Lakes. In a California hatchery, an unintentional cross between chinook and coho resulted in a hybrid that may have resulted in the first outbreak of IHN in coho (a viral disease lethal to hatchery chinook not normally found in coho salmon). None of these crossbreeds have been found returning to a hatchery, however (Bragg 1991). The ADF&G fisheries pathologist Ted Meyers knows of no instances in Alaska where hatchery fish have transmitted diseases to wild fish (personal communication). The ADF&G policy about the control of disease prescribes methods to reduce the transmittal of disease from hatchery-fish to wild fish (Attachment B).

The use of transplanted fish from one area to another can increase the chance of disease outbreak in the wild fish. For example, 23 wild stocks in Norway were decimated after the introduction of fish from the Baltic spread a parasite (Menke 1990). Smoker (1985) reports that researchers in Oregon speculate that transplanted coho may have weakened the ability of wild coho to resist the

pathogen *Ceratomyxa shasta* in Nehalem Bay. Although transplanting fish from outside of Alaska is prohibited now, during the 1970s out-of-state chinook stock were raised in Ketchikan's Crystal Lake hatchery and in the Dredge Lake area in Juneau. The ADF&G terminated this project after the IHN virus infested the transplanted chinook salmon (Burkett, personal communication).

Captive fish are more susceptible to disease because of stress caused by the hatchery environment (FFTF 1990). There is some speculation that hatchery-wild hybrids may be less resistant to disease than wild fish (Kelly et al. 1989).

OTHER EFFECTS

Hatchery salmon may affect wild salmon in other ways not addressed above. Some professionals theorize that wild fish may follow hatchery fish as a result of a chemical (pheromonal) attraction (Kelly et al. 1989). A detrimental effect of hatchery salmon may result when late-spawning hatchery strays dig up the redds of the wild fish (Menke 1990). Additionally, in Pacific Northwest states some hatcheries that fail to produce adults must use wild stocks for a source of eggs and thereby present a net drain to already dwindling numbers of wild stocks (Hilborn et al. 1991). Over-exploitation of wild brood stock for a hatchery on Sakhalin Island in the Soviet Far East also resulted in destroying chum salmon runs from small brooks of the Tym River (Gritsenko and Kovtun 1991).

Recent experiments with gene transfer techniques could someday be used in commercial salmon hatcheries to produce faster-growing fish or ones with greater environmental tolerance. The American Fisheries Society has recommended that such fish not be used in aquaculture facilities without completion of risk assessment studies (Kapusinski and Hallerman 1990).

An additional consideration relates to the effect large unharvested returns of hatchery salmon may have on wild salmon. During the 1991 season, a significantly large return of hatchery pink salmon returned later than normal but matured earlier than normal. As a result of market saturation, millions of these fish were not harvested. The effect of this large unharvested return is unknown and a few questions remain unanswered. Did hatchery fish displace wild salmon in local streams? Will there be a subsequent reduction of wild salmon in future years? Will there be a larger number of hatchery-wild hybrids? Although there are no funds allocated to study these questions, tissue samples from Prince William Sound rivers are being preserved for possible study in the future.

HATCHERY MANAGEMENT IMPLICATIONS FOR WILD SALMON

Proper siting of a hatchery along with good hatchery management and effective management of the commercial fisheries will reduce the potential for adverse biological interaction between hatcheries and wild fish. Conversely, improper siting and poor management practices will increase the risks of adverse interaction. The following discussion considers the effects of management in

general and then provides an overview of management programs in Alaska and Pacific Northwest states.

Sound Hatchery Management Practices

According to Helle (1981), the location of a hatchery is the most important factor that will help maintain wild populations. Hatcheries must be able to separate wild and enhanced stocks either through time or space. General consensus among biologists is that large-scale hatcheries can potentially wield more damage to wild stocks than smaller facilities. Larkin (1981), however, notes that in some cases large centralized hatchery facilities may be practical.

Other potential problems resulting from hatcheries may be minimized by following specific procedures. The risk of losing genetic variability in hatchery salmon can be reduced by using a large founder population, random pairing representing a wide cross section of the local run, avoiding intentional selection, and crossing wild and hatchery fish every season (Kelly et al. 1989). Although there is no official policy for renewing hatchery stocks Menke (1990) claims that

Alaska fisheries officials agree that it may be a good idea to renew hatchery production with wild eggs and sperm on a frequent cyclic basis, perhaps every four years or so (p. 50).

Some scientists recommend that wild salmon mating behavior be emulated as much as possible (e.g., use as high a ratio of male to female fish as occurs in the wild). Hatchery and wild fish can be kept genetically similar by initially using local brood stock and by periodically renewing hatchery stock with local fish.

Maitland et al. (1981) recommend the establishment of a worldwide system to identify and monitor wild salmonids. They suggest that a group such as the International Union of Nature and Natural Resources (IUCN) undertake this project. Others advocate the creation of areas known as genetic sanctuaries to protect significant salmon stocks. Enhancement activities would be prohibited in these areas (FFTF 1990; Helle 1981, ADF&G 1985).²²

Waples et al. (1990) recommend that programs be expanded to identify different genetic stocks, monitor genetic changes in hatcheries, and evaluate the consequences of proposed large-scale enhancement programs. Kelly et al. (1989) recommend meticulous record keeping for hatcheries about such topics as breeding practices, disease resistance and average heterozygosity. Use of recently developed thermo-marking techniques may eventually make it feasible to mark all hatchery fish and determine the extent to which salmon stray.

²²No gene bank programs for salmon are officially recognized in the U.S. (Kelly et al. 1989).

Other management initiatives may become important in the future. Release of sterile hatchery salmon may be used to prevent hatchery fish from affecting the gene pools of wild stocks.²³ Sperm from fish can be stored (cryopreserved), but preservation of eggs or embryos has not yet been accomplished (Thorgaard and Cloud 1991).²⁴ Wildt and Rall (1991) warn that such techniques should not be used as a "quick-fix" but instead be used along with other conservation techniques. Norway's gene bank program involves the deep freeze of sperm and establishment of living gene banks in brook stock-stations. The program began in an effort to preserve genetic material before the genetic make-up of wild fish were negatively affected by fish farm strays (Gausen 1991). Gene banks have also been established in the Soviet Union (Helle 1983).

A paper by the American Fisheries Society recommends federal regulation of salmon and steelhead hatchery programs to preserve existing genetic diversity (Nehlsen et al. 1991). The authors think that federal regulation now could reduce future listings of stocks as required by the Endangered Species Act.

Alaska Hatchery Management

Because management can minimize or exacerbate the negative impacts of hatcheries, some discussion of Alaska statutes, regulations and policies is appropriate. However, a critique Alaska's hatchery program is beyond the scope of this memorandum.

The intent language of the 1974 legislation authorizing private nonprofit hatcheries reflects a priority for wild stocks.

The program shall be operated without adversely affecting natural stocks of fish in the state and under a policy of management which allows reasonable segregation of returning hatchery-reared salmon from naturally occurring stocks (Chapter 111 SLA 1974).

Alaska Statute 16.10.400 states that the ADF&G commissioner will not issue a hatchery permit unless the hatchery "would result in substantial public benefits and would not jeopardize natural stocks." Other statutes do not show a clear preference for management of wild stocks over hatchery salmon (White, personal communication; Utermohle, personal communication).

Alaska statutes direct ADF&G's Division of Fisheries Rehabilitation, Enhancement and Development (FRED) to complete state and regional plans. Alaska Statute 16.05.092(1) requires the FRED division to "develop and

²³Sterile triploid brook trout are recommended by Corely-Smith et al. (1991) to protect their genetic material. Triploid fish can be created by using heat treatments or by crossing tetraploid females with diploid males. Seeb (1991) reports that the British Columbia government is considering the use of sterile net pen fish to prevent escapees from spawning with wild fish.

²⁴Alaska is using sperm cryopreservation for fish on the Chilcat River (Seeb 1991).

continually maintain a comprehensive, coordinated state plan for the orderly present and long-range rehabilitation, enhancement and development of all aspects of the state's fisheries . . . and revise and update this plan annually." Alaska Statute 16.10.375 mandates the completion of comprehensive salmon plans by regional planning teams. State statutes also require each hatchery to complete an annual report including information about the brood stock used (AS 16.10.470).

The ADF&G regulations seek to minimize adverse impacts of hatcheries. For example, regulations specify that during the application phase for hatchery construction, regional planning teams review permit applications including provisions to protect natural stocks (5 AAC 40.170), a public hearing is held, and the department reviews the permit to be sure that hatchery returns will not "unreasonably or adversely affect management of natural stocks" (5 AAC 40.220). Regulations also mandate that hatcheries complete an annual management plan that outlines production goals, brood stock management and the management of the harvest of hatchery returns (5 AAC 40.840). A performance review is also required that evaluates the effect of the hatchery on natural stocks (5 AAC 40.860). Regulations require that a fish transport permit be obtained before transporting live fish within the state (5 AAC 41.005), and prohibit the importation of live fish from outside the state (5 AAC 41.070). Regulations also mandate disease control and inspection (5 AAC 41.310).

The ADF&G policies also address hatchery management. A 1982 draft manual of policies and procedures for the nonprofit hatchery program was never approved, but some of the policies were codified in regulation (ADF&G 1982). The Genetics Policy, is one of the most important current policies about hatcheries. This policy, a policy about disease and a policy about permitting nonprofit salmon hatcheries in Alaska are contained in Attachment B.

The ADF&G's Genetic Policy was created to "protect the genetic integrity of important wild stocks."²⁵ An eight-member team of public and private salmon experts produced the most recent version in 1985, but the policy is currently being reevaluated. The policy gives first priority "to protection of wild stocks from possible harmful interactions with introduced stocks." Comments by ADF&G officials have, however, indicated that preference could be given to

²⁵The Finfish Farming Task Force (1990) alleged that the policy is not always rigorously enforced and recommended that an ad hoc committee be appointed to assess compliance with this policy. The task force also recommended that guidelines in the policy be codified in statute.

hatchery stocks in certain situations.²⁶ The Genetic Policy also recommends that:

- stocks should not be transported between the large geographical areas of the state (no maximum distance is identified),
- donor stock should be physically similar to local stocks but local stocks are preferred,
- significant wild stocks should be identified, and watersheds with such stocks should only be stocked with progeny from indigenous fish,²⁷
- wild stock sanctuaries should be established where enhancement would be prohibited,²⁸
- a single donor stock should not be used for more than three hatchery stocks, and
- a minimum effective population of 400 brood stock should be used to develop and maintain hatchery stocks.

The second portion of the policy describes current knowledge and uncertainties about the effects of hatchery fish on wild fish.

The State of Alaska addresses the impact of hatcheries on wild stocks through statutes, regulations and policy, but some ADF&G commercial fisheries personnel have suggested changes. Geiger et al. (1991) recommend establishment of clear guiding principles for the hatchery program. The authors suggest that production-based objectives are in conflict with preservation of the genetic integrity of wild stocks and the reduction of fishing effort on specific wild stocks. Eggers et al. (1991) argue for an integrated management system "to

²⁶Kelly et al. (1989) report that the commissioner of ADF&G in 1981 stated that "... in some instances ADF&G would consider carrying out a program to purposely alter a wild stock for the benefit of a hatchery stock, provided circumstances indicate that the best interests of both the public and the resources would be served" (p. 30). The director of the Division of Commercial Fisheries in 1981 stated that "[c]onscious trade-offs of weak or smaller natural stocks may be justified by the magnitude of enhancement opportunity, but this cost must be carefully measured" (Pennoyer 1982, p. 113).

²⁷The team did not define "significant stocks" but instead left it to the Salmon Enhancement Regional Planning Teams to define this term. To date, significant stocks have not been identified.

²⁸At this time, there have been no formal designations of wild stock sanctuaries or conservation areas. A formal policy is currently being written that will outline procedures to establish such sanctuaries (Burkett personal communication).

meet dual objectives of protecting wild stocks and hatchery cost recovery/brood stock needs" (p. 30).

Wild Salmon Management in Other West Coast States

Severely depleted runs of wild salmon in Pacific Northwest states have prompted proposals to classify some of these stocks as endangered species. Fishery scientists there have a growing concern about the role of hatcheries in the depletion of natural runs. Accordingly, Oregon responded to the decrease in wild salmon by creating its Wild Fish Management Policy in 1990 (Attachment C).²⁹ The policy mandates that the Department of Fish and Wildlife identify all salmon populations (stocks) in the state. The policy also prescribes specific standards to protect wild salmon,

Other jurisdictions approach wild fish management in a variety of ways. Idaho gives first consideration to wild fish if there is a conflict between the two, and it gives priority to preserving genetic integrity over maximizing harvest potential. Washington has allocated 25 percent of Puget Sound for hatchery salmon, but the rest of the sound is managed for wild fish (Hindar et al. 1991). British Columbia classifies streams in three categories ranging from management for wild salmon (with some hatchery production) to streams managed for hatchery fish (Kelly et al 1991).

SUMMARY

The cumulative effect of habitat destruction, over-fishing and large-scale hatcheries has lead to the decimation of many wild salmon stocks in Pacific Northwest states. Biologists in states with a long history of hatchery programs are generally less enthusiastic about these programs than biologists in areas such as Alaska and British Columbia with comparatively recent programs. Although poor hatchery practices can clearly endanger wild salmon populations, scientists do not agree on the extent to which hatcheries with sound practices can coexist with sustained healthy runs of wild salmon.

Current Knowledge About the Effect of Hatcheries

Little is known about the interactions of hatchery and wild fish, but most scientists agree that hatcheries can complicate mixed stock fisheries and affect the genetics of wild fish stocks. Scientists do not agree on the degree such genetic changes will affect the fitness of wild stocks or if long-term fitness will be affected at all. Those who think that hatcheries negatively affect wild salmon generally agree that small-scale, strategically located facilities using local stocks will minimize the effects. Many biologists think that the biggest threat to wild fish occurs in areas where there are extremely

²⁹The policy, written in the form of regulations by the Oregon Fish and Wildlife Commission, is an enforceable standard of law.

large releases of hatchery fish that will compete with, predate upon, or mate with wild fish.

The lack of consensus among scientists results from a lack of data and research, but even where information exists, it is often subject to different interpretations. To complicate matters, results of specific studies may not be transferable to other areas or other salmon species, and year-to-year environmental changes may affect the results of these studies.

Genetic Ramifications

Scientific knowledge about the genetic impact on wild stocks of hatchery fish is still incomplete. Reduction in the fitness of salmon stocks, to the extent it has been documented, may involve numerous factors. Many studies report that hatchery fish are not as fit as wild fish both in juvenile residence in freshwater and during spawning. However, it is unknown if the long-term fitness of wild stocks will be affected, and some researchers think that observed reductions in hatchery fish may be the result of rearing conditions rather than genetics. Without baseline studies and adequate long-term monitoring, genetic changes are difficult to prove. Many researchers have noted a lack of emphasis in genetic studies, especially those that compare hatchery fish to wild fish. For many areas, including Alaska, not all significant wild stocks have been identified.

Scientists assume that wild stocks are the best suited to their stream of origin. Because many traits are thought to be inherited, biologists fear that hybrids will be less able to compete, less resistant to disease, and more vulnerable to predation. Such traits as egg size (evolved to reflect local conditions of stream substrate) and temperature tolerance are thought to be inherited. Some geneticists speculate that the homing ability of salmon may be a heritable quality. Thus, it may be important to keep hatchery salmon as genetically similar to local wild salmon as possible, and the practice of transporting brood stock even within a region may be detrimental. Additionally, the location of hatcheries where enhanced fish can easily stray to native streams may be detrimental to wild stocks (hatchery fish appear to be more likely to stray than wild fish).

Studies of hatchery salmon that measure genetic variability by average heterozygosity fail to show a significant loss of variability. The average heterozygosity of Japanese salmon, however, is below the U.S. average and this may indicate a loss of variability. Additionally, inbreeding has resulted in a reduction of variability for some other hatchery salmonids.

To complicate matters, some scientists doubt that hatcheries cause a loss in fitness of wild salmon. Some speculate that hatchery salmon could add variability to some wild salmon stocks.

Over-harvest of Wild Stocks

There is a general consensus among scientists that large-scale releases of hatchery salmon endanger wild stocks when returning hatchery fish are harvested in mixed stock fisheries with wild salmon. Some speculate that wild fish may be chemically attracted to hatchery fish and therefore school with them. Almost all Alaska fisheries had some degree of mixed stocks even before current hatcheries began operation. Smaller stocks are always in danger of depletion in mixed stock fisheries because there is a tendency to optimally harvest the larger stocks before they lose commercial quality at the terminal fisheries.

Competition

Some scientists suspect that the carrying capacity of freshwater rearing areas, nearshore waters, and on the high seas for salmon may be exceeded by the large-scale releases of hatchery salmon. A reduction in the average size of salmon has been reported throughout the Pacific, but various factors may be responsible. Some researchers believe ocean conditions affect the size of salmon more than competition. Much evidence, however, supports the theory of density-dependent growth for some salmon species during their rearing in freshwater. Some researchers also suggest that density-dependent growth occurs in estuaries, nearshore areas and in the ocean. Several studies suggest that density-dependent growth of sockeye and pink salmon occurs in the Gulf of Alaska.

Predation

Much is unknown about predation by hatchery salmon, but the greatest potential danger appears to be from the release of large numbers of coho smolts. There is speculation that large releases of hatchery fry may attract wild coho that will also feed upon wild fry.

Disease

Few studies document the transmittal of diseases between hatchery and wild salmon and there is no documentation of such transmittal in Alaska. Where transmittal of a disease by hatchery salmon has been documented, it occurred after fish were transplanted long distances. Hatchery fish appear to be more vulnerable to disease than wild fish because of the stress of hatchery conditions and large concentrations of eggs and fry.

Other Effects

Hatcheries may affect wild stocks in several other ways. Late-spawning hatchery strays may disturb the redds of wild fish. In the Pacific Northwest, there is some concern that unsuccessful hatcheries are resulting in a net drain when they use brood stock from depleted wild stocks. In the future, the use of salmon genetically altered to provide certain characteristics may affect

wild stocks. Lastly, the long-term effects of millions of unharvested hatchery pink salmon is unknown.

Tasks for the Future

Many tasks face scientists, managers, and policy makers during the coming decade. Such challenges include setting research priorities, minimizing possible impacts, and reviewing current practices and policies.

Setting Research Priorities

A major challenge for the next decade will be to obtain a consensus about research priorities concerning the interaction of hatchery and wild fish in Alaska. Coordination of studies among university researchers, commercial fisheries managers, federal and state government scientists, hatchery personnel, and fishermen may also be useful.

The current lack of knowledge includes an absence of information about a variety of issues: the degree that wild stocks school with hatchery fish, migration patterns of wild and hatchery fish, the percentage of hatchery and wild fish that stray, the reproductive success of these strays, the carrying capacity of marine and freshwater environments, harvest alternatives for mixed stock fisheries, ways to emulate mating behavior of wild salmon in a hatchery setting, cryopreservation techniques for eggs and embryos, and the effects of large-scale escapement of hatchery salmon. Without a better inventory of significant wild stocks and constant monitoring of their fitness, the long-term effects of enhancement may not be known until it is too late to correct them. Cataloguing genetic characteristics of significant stocks will provide baseline data for future study of the effects of hatchery salmon. Better knowledge in these areas will permit policy makers to make informed decisions and to consider the risks associated with various decisions.

Minimizing Impacts

Although the effects of hatcheries on wild fish are uncertain, the risk of such effects warrant a cautious approach. Rather than more studies, Hindar et al. (1991) think that the current knowledge of the effects of cultured fish on wild fish is enough to call for immediate action. The authors cite recommendations from symposiums on this subject. Practices that will reduce such impacts include siting hatcheries where hatchery fish will have minimal opportunities to interact with wild fish as well as specific prescriptions that will keep hatchery fish as genetically similar to wild fish as possible.

Senator Jones
September 11, 1991
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Reviewing Current Practices and Policies

Some fishery specialists recommend approval of new or expanded hatchery operations on a case-by-case basis only after a thorough examination of possible effects. Many researchers emphasize that hatcheries should strive for an optimum annual production rather than maximum production. Others suggest that further expansion of hatchery programs be delayed until more is known about their effects (Mathisen 1991). Hilborn (1990) recommends that there be a moratorium on the construction of new hatcheries and that hatcheries that cause adverse impacts on wild fish be closed.

Alaska statutes, ADF&G regulations and department policies contain many procedures to protect wild stocks. However, we were unable to locate any thorough studies that evaluate how well the current hatchery program protects wild salmon from possible negative effects of hatchery salmon. Such a review would help policy makers determine the risk of various alternatives for the future of Alaska's hatchery program.

I hope this information is useful. If you have any questions or want additional information, please contact this agency.

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ATTACHMENT A
1975 Position Paper of the Alaska District of the
American Institute of Fishery Research Biologists

GENETIC CONSIDERATIONS IN
ARTIFICIAL PROPAGATION OF SALMONIDS

WHEREAS throughout North America there is an accelerating interest in artificial propagation as a means of supplementing our natural salmonid stocks, and an urgent need exists for special planning regarding genetic considerations in artificial propagation of salmonid fishes; and

WHEREAS need for genetic planning exists in all salmonid enhancement programs in North America; and

WHEREAS it is desirable to maintain existing wild stocks in concert with artificially propagated stock through:

- (1) location of sites for artificial propagation with regard to indigenous wild stocks, so that the adaptive genetic diversity of wild stocks will not be lost or diluted by chance interbreeding with cultured stocks,
- (2) management of fishing pressure so as not to endanger reproduction of wild stocks,
- (3) recognition of the potential behavioral and genetic stresses on native fishes caused by transplant stocks; and

WHEREAS it is also desirable to maintain adaptive genetic diversity in most artificially propagated stocks through:

- (1) use of sufficient numbers of females and males in brood stock to avoid inbreeding depression problems,
- (2) avoidance of selective breeding except in special situations or when used as a research technique: Now, therefore, be it

RESOLVED, That enhancement or rehabilitation of salmonid stocks in a stream or lake system should utilize native stocks already present; and be it further

RESOLVED, That in special situations where no alternative to transplantation exists, the characteristics of the donor stock be carefully matched so as to be compatible with the new environment; and be it further

RESOLVED, That the biological impact of transplantation on stocks of fish present in the recipient and surrounding watersheds be thoroughly evaluated; and be it further

RESOLVED, That artificially propagated stocks should be isolated (in time and in space) from wild stocks to allow effective management of fishing pressure on both types; and be it further

RESOLVED, That all agencies involved in enhancement and management of wild and cultured stocks of salmonids evaluate their present policies with respect to conservation of genetic diversity in wild stocks; and be it further

RESOLVED, That copies of this resolution be forwarded to agencies involved in artificial propagation and enhancement of salmonid fishes.

RESOLUTION

AMERICAN FISHERIES SOCIETY

Presented at American Fisheries Society
Detroit, Michigan September 22, 1976

Genetic Considerations in Artificial Propagation of Fishes

WHEREAS throughout North America there is an accelerating interest in artificial propagation as a means of supplementing our natural stocks, and an urgent need exists for special planning regarding genetic considerations in artificial propagation of fishes; and

WHEREAS need for genetic planning exists in all fish enhancement programs in North America; and

WHEREAS it is desirable to maintain existing wild stocks in concert with artificially propagated stocks through:

- (1) location of sites for artificial propagation with regard to indigenous wild stocks, so that the adaptive genetic diversity of wild stocks will not be lost or diluted by chance interbreeding with cultured stocks,
- (2) management of fishing pressure so as not to endanger reproduction of wild stocks,
- (3) recognition of the potential behavioral and genetic stresses on native fishes caused by transplant stocks; and

WHEREAS it is also desirable to maintain adaptive genetic diversity in most artificially propagated stocks through:

- (1) use of sufficient numbers of females and males in brood stock to avoid inbreeding depression problems,
- (2) avoidance of deleterious selective breeding: Now, therefore be it

RESOLVED, That all agencies involved in enhancement and management of wild and cultured fish stocks evaluate their present policies and implement appropriate practices with respect to conservation of genetic diversity in wild stocks; and be it further

RESOLVED, That copies of this resolution be forwarded to all state, provincial, and federal agencies involved in artificial propagation and enhancement of fishes.

ATTACHMENT B
ADF&G Policies Relating to Hatcheries

Alaska Department of Fish & Game
GENETIC POLICY

by

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6.11.85

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INTRODUCTION

Alaska's valuable salmon industry relies on production from wild systems and, increasingly, on fish produced by aquaculture programs. The importance of maintaining healthy wild stocks and implementing successful enhancement activities underlies the need for an effective genetic policy. The genetic guidelines created to steer Alaska's aquaculture efforts were established in the mid-70's and have been reviewed to ensure that they reflect current knowledge, and goals. A revised genetic policy has been established that contains guidelines, supporting information and recommendations.

The genetic policy contains restrictions that will serve to protect the genetic integrity of important wild stocks. Certainly in Alaska where wild stocks are the mainstay of the commercial fishery economy, it is necessary to protect these stocks through careful consideration of the impacts of enhancement activities. Another important aspect of the genetic policy is the orientation towards increasing the productivity of enhancement programs in the state. Adherence to the guidelines will help maintain adequate genetic variability ensuring that the enhanced stock will be able to adapt to changing environmental conditions. The policy also includes considerations for selective breeding for desirable characteristics.

Due to the limited amount of information available on the genetic impacts of salmon enhancement on wild stocks, much of the basis for these guidelines is theoretical or based on work done with other species. Consequently, the most important considerations used in writing the guidelines are presented as a mechanism for illustrating the intent of the policy. An understanding of the rationale behind the policy is imperative to its effective application to individual cases under the very diverse conditions found in Alaska.

The importance of the genetic guidelines will continue to increase as aquaculture activities expand their production. This policy represents a consensus of opinion and should continue to be periodically reviewed to ensure that the guidelines are consistent with current knowledge. By doing so, we will be able to meet the goal of greater fish production through enhancement while maintaining healthy wild stocks.

POLICY STATEMENT

I. Stock Transport

- A. Interstate: Live salmonids, including gametes, will not be imported from sources outside the state. Exceptions may be allowed for trans-boundary rivers.
- B. Inter-regional: Stocks will not be transported between major geographic areas: Southeast, Kodiak Island, Prince William Sound, Cook Inlet, Bristol Bay, AYK and Interior.
- C. Regional: Acceptability of transport within regions will be judged on the following criteria.
 - 1. Phenotypic characteristics of the donor stock must be shown to be appropriate for the proposed fish culture regions and the goals set in the management plan.
 - 2. No distance is set or specified for transport within a region. It is recognized that transplants occurring over greater distances may result in increased straying and reduce the likelihood of a successful transplant. Although the risk of failure affects the agency transporting the fish, transplants with high probability of failure will be denied. Proposals for long distance transport should be accompanied by adequate justification for using nonlocal stock.

II. Protection of Wild Stocks

- A. Gene flow from hatchery fish straying and intermingling with wild stocks may have significant detrimental effects on wild stocks. First priority will be given to protection of wild stocks from possible harmful interactions with introduced stocks. Stocks cannot be introduced to sites where the introduced stock may have significant interaction or impact on significant or unique wild stocks.
- B. Significant or unique wild stocks must be identified on a regional and species basis so as to define sensitive and nonsensitive areas for movement of stocks.
- C. Stock Rehabilitation and Enhancement
 - 1. A watershed with a significant wild stock can only be stocked with progeny from the indigenous stocks.
 - 2. Gametes may be removed, placed in a hatchery, and subsequently returned to the donor system at the appropriate life history state (eyed egg, fry or fingerling). However, no more than one generation of separation from the donor system to stocking of the progeny will be allowed.
- D. Drainages should be established as wild stock sanctuaries on a regional and species basis. These sanctuaries will be areas in which no enhancement activity is permitted except gamete removal for broodstock development. Use of such reservoirs for broodstock development should be considered on a case-by-case basis, and sliding egg take removal schedules applied to such systems should be conservative.

- E. Fish releases at sites where no interaction with, or impact on significant or unique wild stocks will occur, and which are not for the purpose of developing, rehabilitation of, or enhancement of a stock (e.g., release for terminal harvest or in landlocked lakes) will not produce a detrimental genetic effect. Such releases need not be restricted by genetic concerns.

III. Maintenance of Genetic Variance

A. Genetic diversity among hatcheries

1. A single donor stock cannot be used to establish or contribute to more than three hatchery stocks.
2. Off-site releases for terminal harvest rather than development or enhancement of a stock need not be restricted by III.A.1, if such release sites are selected so that they do not impact significant wild stocks, wild stock sanctuaries, or other hatchery stocks.

B. Genetic diversity within hatcheries and from donor stocks

1. A minimum effective population (N_e) of 400 should be used for broodstock development and maintained in hatchery stocks. However, small population sizes may be unavoidable with chinook and steelhead.
2. To ensure all segments of the run have the opportunity to spawn, sliding egg take scales for donor stock transplants will not allocate more than 90% of any segment of the run for broodstock.

GUIDELINES AND JUSTIFICATIONS

I. Stock Transport

- A. Interstate: It is generally accepted that population of salmonids which have existed over many generations in a given watershed have evolved traits that make them best adapted for survival in that environment. The greater the distance that a population is transferred from its native environment or the greater the difference in environmental conditions between the donor and transplant stream, the less likely the genetic characteristics of the population will fit the new environment. If the fitness of the population is indeed reduced in the new environment, then the probability of the transplant succeeding would be affected. In addition, interbreeding of a transferred stock with indigenous stocks could transfer gene traits that would reduce the fitness of the native populations. In many states, discrete stocks cannot be identified because excessive movement and interbreeding have already occurred. The State of Alaska, therefore, desires to protect and develop local stocks by restricting the movement of live fish or eggs into the state. There are, however, several trans-boundary rivers penetrating British Columbia, Canada, that flow into the state of Alaska. In some instances, donors from these stocks might fit a well-designed management plan.
- B. Inter-regional: The environment can vary greatly from one region to another in a state as large as Alaska. For similar reasons given in I.A. above, the transfer of fish from one region to another is restricted. Consideration may be given to regional border areas, especially when no suitable donor stock is available within a region.

C. Regional: Although it is recognized that indigenous stocks are best for donor stock development, there have been numerous successful transplants, especially if the environment at the new site is similar to that of the donor stock and distance between the sites is not great. There is insufficient scientific data to predict how far or how diverse the environment must be before a negative impact will occur. However, it is believed that within a region site matching opportunities may be available. As site matching characteristics decrease and transplant distance increases within the regional borders greater justification is required for the proposed transplant. The following should be considered when selecting a donor stock:

1. Matching: Phenotypic characteristics of the donor stock should be matched to the environment at the site and to the management goals. Water chemistry and temperature profiles should be considered. Island stocks should be matched to other islands or to short rivers of comparable characteristics where possible. Time of spawning and fry emergence should be matched or compensated with the hatchery temperature required. Any deviations should be addressed and justified in the permit application or the annual management plan.
2. Migration Routes: The probable migration routes and potential user groups should be identified. The applicant must determine a probable migration route based on the migration route of the proposed stock and characteristics (topography) of the transplant site. Coded wire tagging of hatchery releases can determine the accuracy of migration route predictions as well as assess possible impact on local stocks.

II. Protection of Wild Stocks

A. Prevention of detrimental effects of gene flow from hatchery fish straying and interbreeding with wild fish.

Straying of hatchery fish released at the hatchery or off-station can potentially impact the fitness of wild fish populations through interbreeding of wild and hatchery fish. This assumes that hatchery and wild fish are adapted to different environments and either would presumably be less fit in the environment of the other and that hybrids would be less fit for either environment. Wild stocks have presumably been rigorously adapted to their native environment. Because of the large number of loci involved in the adaptation, many "successful" combinations of genetic information are possible along with the enormous number of "unsuccessful" combinations. Hybridization between discrete populations may produce a stock that has reduced fitness and therefore reduced production. Hatchery fish have been subjected to selection pressure for survival within artificial culture regimes, and may also have been originally derived from another stock adapted to totally different conditions than the impacted wild stock. Continued influx of hatchery fish together with the return of hybrids may alter the wild gene pool, reduce stock fitness, and thus threaten the survival of the wild population.

An alternative perspective is that hatchery strays will have little genetic impact on wild stocks. The influx of new genetic material through straying is a natural process in the development and expansion of salmon populations. If adaptation of the natural population is indeed very specific and selection is intense, then

selection will favor and maintain the genetic complex of the wild populations. If adaptation is less specific and less intensive, then the genetic impacts from gene flow are insignificant. It is true that some straying occurs among adjacent wild populations and in most cases has occurred for a long enough time that such populations are quite similar genetically. However, situations in which transplanted stocks are involved are not analogous, as transplanted stocks would be less similar and gene flow would have a more profound effect. It is also true that the impact of introgression into the wild gene pool of genes from fish transplanted from a radically different environment may be limited by natural selection. Again the situations of concern do not necessarily lie near this extreme; hybrids and strays may be fit enough to dilute or replace the wild genome. Inherent homeostatic mechanisms for gene expression may compensate for some genetic influx.

The magnitude of straying relative to the size of the wild run is the most important criterion, as massive spawning by hatchery strays may jeopardize a wild population by displacement on spawning habitat and superimposition of redds, as well as, genetic influx. A conservative management approach dictates avoiding release sites where large numbers of hatchery strays can be expected to interact with significant or unique wild stocks. This approach can be achieved by spatial or temporal isolation of the hatchery and wild stock.

B. Regional designation of significant and unique wild stocks.

The magnitude of salmon populations varies between watersheds from intermittent runs maintained by