UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
PROGRAM PLANNING AND INTEGRATION
Silver Spring, Maryland 20910

James A. Hanlon, Director Office of Wastewater
Environmental Protection Agency
Water Docket
Mailcode:4101T
1200 Pennsylvania Ave., NW
Washington D.C. 20460

FEB 15 2006

Attention: Docket ID No. OW-2005-0007

Dear Mr. Hanlon,

The National Marine Fisheries Service (NOAA Fisheries Service) has reviewed the Environmental Protection Agency's (EPA) proposed National Pollutant Discharge Elimination System (NPDES) multi-sector general permit for stormwater discharges associated with industrial activities. The permit proposes to authorize the industrial discharges of stormwater for industrial facilities, comprising 30 "sectors" of industry, in areas of the United States that are not currently authorized to administer the NPDES permit program. We offer the following comments and recommendations (attached) on the proposed permit pursuant to our role as providers of biological and technical assistance to EPA under the Fish and Wildlife Coordination Act (16 USC 661 et seq.) and the Endangered Species Act (16 USC 1531 et seq.), as amended.

We appreciate EPA's task of permitting thousands of industrial dischargers, reducing the discharge of contaminated stormwater from industrial activities into waters of the United States, while protecting fish and wildlife resources including threatened and endangered species. As such we support your effort and look forward to assisting you in meeting your goals. However, NOAA Fisheries Service believes that the multisector general permit (permit or MSGP), as currently proposed, will authorize stormwater discharges into waters of the United States that have more than a minor detrimental adverse effect on fish and wildlife resources. Waters affected by the MSGP are important to the ecology of trust resources under our jurisdiction, including species that our agency has listed as threatened or endangered pursuant to the Endangered Species Act (ESA). Based on the body of scientific evidence available, these discharges are likely to produce water quality conditions that have behavioral and physiological consequences for these species that are likely to reduce the viability of populations exposed to those conditions.

To illustrate this point we examined the consequences of several general assumptions of the proposed MSGP and the whether these assumptions are true for Pacific salmon and shortnose sturgeon. We chose Pacific salmon (*Oncorhynchus* spp.) because these fish are indicators of the quality of freshwater and estuarine ecosystems in states along the Pacific coast, from California to Alaska. Similarly, we chose shortnose sturgeon (*Acipenser brevirostrum*.)

Boatyards Appeal
Exhibit 58

EXHIBIT ZZ

Notice of Intent to Sue -
Attachment 34

because they are indicators of freshwater and estuarine ecosystems along the Atlantic coast, from Florida to Maine. These species also co-occur (occupy the same general geographic area) with the discharge of industrial pollutants authorized by the MSGP in freshwater areas and estuarine waters, a significant amount of literature is available on the effects of toxic pollutants on these species, and these species represent the probable consequences of the proposed general permit for threatened and endangered species. Populations that are not listed pursuant to the ESA are, nonetheless, aquatic species of national importance.

We have not assessed the cumulative or total environmental impact of the MSGP in this analysis because doing so would require EPA's assistance in examining a) the distribution of existing and past impacts of discharges permitted under the program, and b) ascertaining reasonable assumptions of the number and distribution of new discharges expected under the MSGP. Nonetheless we provide evidence that the MSGP will have more than a minor detrimental effect on aquatic resources of national importance and threatened and endangered species. As such, a more comprehensive evaluation of the effects of the proposed action on threatened and endangered species is warranted.

Adverse impacts to the estuarine, riverine and marine waters of these regions resulting from inadequate regulatory protection will lead to direct and indirect adverse impacts to the fish, wildlife, and their habitats including spawning and foraging areas. Over the 5 years the proposed permit is in effect, the MSGP as presently drafted is likely to accelerate direct loss of fish and wildlife habitat and exacerbate water quality problems in waters of the United States. These impacts will in turn contribute to declines in populations of migratory fish, shellfish and submerged aquatic vegetation.

NOAA Fisheries Service is vested with the authority and obligation to protect, conserve, restore and enhance the Nation's fish, wildlife, and habitats. These matters fall within our jurisdiction under the Fish and Wildlife Coordination Act, and the ESA as amended. Issuance of the MSGP as proposed will provide inadequate Federal regulatory protection in estuarine, riverine, and nearshore marine waters for NOAA Fisheries Service trust resources. This inadequate protection will result from the re-issuance of a permit authorization process applicable to waters of the United States occurring in 7 of the 10 EPA designated regions.

Because we fully support development of an effective MSGP for these regions we have provided some suggestions for minimizing the effects of the MSGP on aquatic species. Furthermore, since our analysis does not comprehensively address all listed species potentially affected by the MSGP, we look forward to working with you to minimize the effects of the permit and the discharges it authorizes in waters of the United States that contain listed species and their designated critical habitat.

Sincerely,

Angela Somma
Chief, Endangered Species Division

Attachment

ATTACHMENT A: NOAA FISHERIES SERVICE'REVIEW OF THE NPDES MULTI-SECTOR GENERAL PERMIT FOR STORMWATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY

Waters affected by the MSGP are important to the ecology of trust resources under our jurisdiction, including species that our agency has listed as threatened or endangered pursuant to the Endangered Species Act of 1973, as amended (ESA). Based on the body of scientific evidence available, these discharges are likely to produce water quality conditions that have behavioral and physiological consequences for aquatic resources of national importance that are likely to reduce the viability of populations exposed to those conditions. The purpose of this attachment is to describe and substantiate this conclusion with available scientific and commercial information. Our review considers EPA's issuance of the multisector general permit for industrial stormwater, which we have described below. This is followed by a brief but informative analysis of the effects of the MSGP and the stormwater discharges it authorizes on aquatic resources of national importance.

DESCRIPTION OF THE PERMIT

An unintended byproduct of industrial activities is the discharge of various pollutants into waters of the United States. The NPDES program was created as a means to controlling the pollutants discharged from point sources into the nation's waters except as allowed under a permit. Later amendments to the program emphasized toxic pollutants and the monitoring and reporting to ensure that water quality standards were not just on paper, but were being realized in the nation's waters (GAO 1994). The general permit is one of the key features of the NPDES program for limiting "point source" stormwater discharges to waters of the United States. As such, the Multi-Sector General Permit (general permit or MSGP) is designed to minimize the effects of toxic pollutants that threaten the biological integrity of the nation's waters.

The proposed MSGP would authorize discharges of stormwater from facilities in 30 general categories of industrial activity to waters of the United States. The MSGP will replace the existing permit covering industrial sites in EPA Regions 1, 2, 3, 5, 6, 9, and 10. Stormwater discharges from the following general categories of industrial activities are eligible for coverage under this permit (specific eligible subsectors are addressed in the proposed 2006 MSGP):

1. Timber products (e.g., log storage & handling, mills);
2. Paper and allied products manufacturing(e.g., pulp & paper mills);
3. Chemical and allied products manufacturing (e.g., manufacturing of soap, paints, industrial organic chemicals, fertilizers);
4. Asphalt paving and roofing materials and lubricant manufacturing (e.g., manufacturing asphalt materials & lubricants);
5. Glass, clay, cement, concrete, and gypsum products;
6. Primary metals (e.g., blasting & finishing mills, and foundries);
7. Metal mining;
8. Coal mines & coal mining-related facilities;

9. Oil & gas extraction and refining (e.g., exploration, production, processing, treatment & transmission operations);
10. Mineral mining & dressing;
11. Hazardous waste treatment, storage, or disposal facilities;
12. Landfills, land application sites, & open dumps;
13. Automobile salvage yards;
14. Scrap recycling & waste recycling facilities;
15. Steam electric generating facilities;
16. Land transportation and warehousing;
17. Water transportation (e.g., marine cargo handling operations, ferry operations);
18. Ship & boat building, & repair yards;
19. Air transportation (e.g., deicing/anti-icing operations, equipment repair & cleaning);
20. Treatment works (e.g., domestic sewage, sludge, wastewater treatment systems);
21. Food & kindred products (e.g., meat, dairy, bakery products);
22. Textile mills, apparel, & other fabric products;
23. Furniture & fixtures (e.g., manufacturing of wood cabinets, household & office furniture);
24. Printing & publishing;
25. Rubber, miscellaneous plastic products, & miscellaneous manufacturing industries;
26. Leather tanning & finishing;
27. Fabricated metal products;
28. Transportation equipment, industrial & commercial machinery;
29. Electronic & electrical equipment & components, photographic & optical goods;
30. And non-classified facilities (i.e., any industrial activity that does not meet the description of an industrial activity covered by the above mentioned sectors and designated by the Director of EPA as needing a permit).

Also eligible for coverage are discharges:

- Designated by EPA as needing a stormwater permit to implement an approved TMDL or to address exceedances of water quality standards
- Discharges that are not required to obtain NPDES permit authorization, but are commingled with discharges that are authorized under the permit
- Discharges subject to any of the stormwater-specific effluent limitation guidelines: runoff from material storage piles at cement manufacturing facilities; runoff from phosphate fertilizer manufacturing facilities; coal pile runoff at steam electric generating facilities; discharges resulting from spray down or intentional wetting of

logs at wet deck storage areas; mine dewatering discharges at crushed stone mines; mine dewater discharges at construction sand and gravel mines; mine dewatering discharges at industrial sand mines; runoff from asphalt emulsion facilities; and runoff from landfills.

The permit provides coverage for classes of discharges that are outside of the scope of a state's NPDES program authorization, and does not include facilities located in Regions 4 and 8 (See Table 1 for specific areas of geographic coverage and the overlap with NOAA's trust resources. For more on NOAA's trust resources see Appendix 1). Facilities in these areas are authorized to discharge under this permit provided they: (1) meet the basic eligibility requirements as outlined in the permit; (2) develop and implement a Storm Water Pollution Prevention Plan (SWPPP) for the facility; (3) and submit a Notice of Intent (NOI) to discharge in accordance with the requirements of the permit. Various other aspects of eligibility are addressed in detail in the proposed 2006 MSGP.

Stormwater Pollution Prevention Plans and Monitoring

The focus of the general permit is the development of the SWPP. An SWPP must identify:

- All potential sources of pollution that may affect the quality of stormwater discharges from the facility,
- Describe and ensure implementation of practices used to eliminate or reduce all pollutants in stormwater discharges,
- Ensure compliance with the terms and conditions of the MSGP
- And ensure that discharges do not cause or contribute to exceedances of water quality standards in the applicable receiving waters.

A copy of the SWPPP must be kept on site at the facility, be available for review, and must be maintained as a living document (i.e., change over time with construction or changes in design, operation or maintenance at the facility such that these situations would have a significant impact on the discharge, or potential for discharge, of pollutants; when routine inspection or compliance evaluation determines deficiencies in best management practices (BMPs); inspections indicate modifications are necessary; whenever a spill or leak occurs; or any time there is an unauthorized discharge from the facility).

For the most part, the general permit establishes a self-regulated monitoring and reporting procedure for industry by establishing permit limits for the discharge of sector specific pollutants to waters of the United States. EPA does not expect to evaluate individual discharges covered under a general permit on a regular basis. While a few sectors are subject to effluent limitations, all sectors are required to conduct limited monitoring of stormwater quality for comparison against EPA's designated benchmark concentration thresholds for certain pollutants. An exceedance of a numeric effluent limit is a permit violation, and requires corrective action. The benchmark thresholds, however, serve as indicators of whether or not an operator's stormwater controls are adequate. EPA expects facilities will take corrective action (i.e. review and possibly modify SWPPPs and BMPs) to reduce pollutants of concern in their discharges, if necessary.

The permit requires benchmark monitoring during the first year only. Operators must collect four samples (one each quarter for a year) of the discharge. If the average of the four monitoring values does not exceed EPA's designated benchmark, the operator has fulfilled the benchmark-monitoring requirement for the duration of the permit (up to 5 years). If the average of the four

Table 1. Geographic area of MSGP Coverage (see Appendix C, Proposed 2006 MSGP) relative to the distribution of NMFS' trust resources.

State [1,2]	EPA Administers NPDES Program (✓)			NMFS Trust Resources
	State-Wide	Indian Lands	Federal Facilities	
Alaska	✓	✓	✓	✓
American Samoa	✓			✓
Arizona	✓	✓		✓
California		✓		✓
Connecticut		✓		✓
Delaware			✓	✓
District of Columbia	✓			✓
Guam	✓			✓
Idaho	✓	✓		✓
Johnston Atoll	✓			✓
Louisiana		✓		✓
Maine		✓		✓
Massachusetts	✓	✓		✓
Michigan		✓		
Midway Island	✓			✓
Minnesota		✓		
Nevada		✓		
New Hampshire	✓			✓
New Mexico	✓	✓		
Northern Mariana Islands	✓			✓
Oklahoma	✓ (limited jurisdiction)	✓		
Oregon		✓		✓
Puerto Rico	✓			✓
Rhode Island		✓		✓
Texas	✓ (limited jurisdiction)	✓		✓
Trust Territories				✓
Vermont			✓	✓
Wake Island	✓			✓
Washington		✓	✓	✓
Wisconsin		✓		

[1] Coverage not available in: Alabama, Colorado, Florida, Georgia, Iowa, Kansas, Kentucky, Mississippi Missouri, Montana, Nebraska, New York, Ohio, Pennsylvania, Virgin Islands, Virginia, and West Virginia.

[2] No component of the NPDES Program is administered by EPA in the following states: Arkansas, Hawaii, Illinois, Indiana, Maryland, New Jersey, North Carolina, North Dakota, South Carolina, South Dakota Tennessee, Utah, and Wyoming.

quarterly benchmarks monitoring values exceeds the benchmark the operator must review the SWPPP to determine if it includes all appropriate BMPs. If the SWPPP does not contain all appropriate BMPs the operator has up to 60 days to implement changes in their BMPs and SWPPP. According to the permit, there may be instances where no changes to the BMPs may be necessary despite benchmark exceedances. In this instance the operator must document the basis for this determination in the SWPPP, after which the operator may reduce benchmark monitoring to once per year for the remainder of the permit term. Where a State or Tribe requires monitoring the permit establishes a minimum monitoring frequency of once per year, unless the State or Tribe indicates a different monitoring frequency.

The total suspended solids (TSS) benchmark applies to all discharges under the MSGP 2006. TSS is a relatively inexpensive parameter to measure, and EPA believes it is a reasonable indicator of stormwater discharge quality and whether BMPs need attention. Quarterly visual monitoring (using grab samples) is required four times a year to assess the effectiveness of the BMPs by checking for color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen or other obvious indicators of stormwater pollution. If BMPs are performing ineffectively, corrective action must be taken.

EPA based the Benchmark monitoring criteria primarily on aquatic life water quality criterion (Table 2; *see also* Fact Sheet - Table 1). In total, the MSGP contains 25 benchmark criteria, which vary by industrial sector. Many of the benchmark criteria are based on existing acute aquatic life criteria. The implicit assumption of the MSGP is that when industrial dischargers (operators) conform to applicable water quality standards of a particular receiving waterbody, the chemical, physical and biological integrity of the waters are protected from harm.

EPA established the majority of numeric aquatic life criteria in accordance with the 1985 *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (Stephan *et al.* 1985). The guidelines set forth a process for deriving acute criterion or "criterion maximum concentration (CMC)" from a set of LC50 values for a variety of aquatic species (i.e., LC50 is the concentrations of a chemical which causes 50% mortality, immobilization, or loss of equilibrium in 48- to 96-hour laboratory tests). To provide aquatic organisms a level of protection greater than 50% mortality, the CMC is set to one-half of the fifth percentile of the genus mean acute value for the various species tested. To make exceeding this level of toxicity a relatively rare event, EPA's Technical Support Document (EPA 1991) recommends that the one-hour average exposure concentrations should not exceed the CMC more than once every three years on the average.

Table 2. Proposed Benchmarks (Fact Sheet Table 1).

Pollutant	Proposed Benchmark
Ammonia	19 mg/L †
Biochemical Oxygen Demand (5 day)	30 mg/L
Chemical Oxygen Demand	120 mg/L
Total Suspended Solids	100 mg/L (coal pile 50mg/L)
Turbidity	50 NTU
Nitrate + Nitrate Nitrogen	0.68 mg/L
Total Phosphorus	2.0 mg/L
pH	6.0-9.0 s.u.
Aluminum, Total (pH 6.5-9.0)	0.75 mg/L †
Antimony, Total	0.64 mg/L
Arsenic, Total	0.15 mg/L
Beryllium, Total	0.13 mg/L
Cadmium, Total	0.0021 mg/L †
Chromium, Total*	1.8 mg/L †
Copper, Total*	0.014 mg/L †
Cyanide	0.022 mg/L †
Iron, Total	1.0 mg/L
Lead, Total	0.082 mg/L †
Magnesium, Total	0.064 mg/L
Mercury, Total	0.0014 mg/L †
Nickel, Total	0.47 mg/L †
Phenols, Total	0.016 mg/L
Selenium, Total	0.005 mg/L
Silver Total	0.0038 mg/L †
Zinc, Total*	0.12 mg/L †

*Benchmark value is a function of water hardness (in units of mg/L) in the water column. The benchmark value corresponds to a water hardness of 100 mg/L and should be used if water hardness was not analyzed, water hardness is less than 100 mg/L, or data are not available. If water hardness is greater than 100 mg/L then the corresponding equation may be used to determine the adjusted benchmark value (See the proposed 2006 MSGP for details).

†Based on existing acute aquatic life criteria for fresh water (EPA-822-R-02-047, Nov. 2002-CMC).

The 1985 Guidelines establish a risk-based methodology, supported by quantitative information that requires considerable judgment by EPA to derive water quality criteria. The assessments conducted by EPA are not full risk assessments; rather, they provide an effects benchmark for decision-making and do not incorporate measures of exposure in the environment as an assessment endpoint. There are a number of assumptions about significance and exposure imbedded within these benchmarks including:

- Achieving a benchmark criterion derived from an individual species' toxicological responses to a single chemical will protect aquatic communities.
- Tested species are representative of the composition and sensitivities of species in a natural community.
- 1-hour and 4-day average exposure averages are appropriate test criteria for deriving protection
- If the criterion is satisfied where concentrations are highest, then lower concentrations will occur elsewhere resulting from spatial and environmental variability
- Even where criteria limits are occasionally reached or exceeded, exposure concentrations typically will be below criterion values at most places and times. Accordingly, there should be relatively few places and times at which criteria concentrations are reached or exceeded

Generally, the threshold criteria derived by this method are expected to provide a "reasonable and adequate amount of protection with only a small possibility of considerable overprotection or underprotection (Stephan *et al.* 1985)." The method does not purport to derive criterion that are not exceeded any time or any place. Rather, EPA has defined a methodology that intends to establish a criterion that "can bridge the gap between the nearly constant concentrations used in most toxicity and bioconcentration tests and the fluctuating concentrations that usually exist in the real world (Stephan *et al.* 1985)." Exposure of some species to the threshold identified by the criterion, and possibly even below the threshold, probably will result in "some adverse effect" that may result in "a small reduction in survival, growth, or reproduction (Stephan *et al.* 1985)". Conversely, the concentration of a pollutant can reach or exceed the CMC, although this would generally occur very infrequently and may occur without causing an unacceptable effect, if the magnitude and duration of the exceedance are limited and interspersed with periods where the concentration is below the identified threshold. The guiding decision rule for deriving the numeric criteria is to protect 99% of individuals in 95% of the species in aquatic communities from acute and chronic effects of exposure to a chemical stressor (EPA 1998).

Endangered Species

When an industrial facility submits a NOI to discharge stormwater to EPA, the MSGP requires that they certify their eligibility for coverage by documenting their assessment of how their discharge may affect listed species. By virtue of submitting a NOI each operator is designated as EPA's non-federal representative to conduct informal consultation on their action. Section 402.08 of the regulations implementing section 7 of the ESA provides for this designation (50 CFR 402.08).

According to the process described in the MSGP for eligibility and screening procedures related to listed species and critical habitat, applicants must meet one or more of the six criteria (A-F) to be eligible for permit coverage (summarized in Table 3; the full text is found in Appendix E of the 2006 MSGP). Criteria B and C, rely on previous ESA Section 7 consultation or Section 10 authorization and require documentation of consultation. Criterion A is equivalent to a determination of "no effect," and criterion E is a determination of "may affect, not likely to adversely affect" without the requirement to complete informal consultation (i.e., written concurrence of the Service that the determination is appropriate). Criterion D is similar to standard informal consultation (with concurrence from the Services that a determination of "not likely to adversely affect" listed species and their designated critical habitat is appropriate), although by virtue of the word choice "written statement" as opposed to "concurrence letter" this option contains additional flexibility in the type of required documentation. Lastly, criterion F provides coverage under another operator's certification of eligibility provided the other operator meets any of criteria A-E.

Table 3. MSGP 2006 ESA criteria for certifying eligibility for coverage

Criterion	Abbreviated Description (see Fact Sheet p.47 or Appendix E of the permit for details).
A	There are no endangered or threatened species or critical habitat present in proximity to the facility. A species is in proximity if it is located in the area of discharge activities.
B	Consultation with the Services under section 7 of the ESA was concluded under a separate federal action.
C	The industrial activities and associated stormwater discharges are authorized under a conservation plan issued pursuant to section 10 of the ESA.
D	The applicant has a written statement from the Services that there are not likely to be any adverse effects to listed species or their designated critical habitat.
E	Stormwater discharges from your facility are "not likely to adversely affect" listed species or their designated critical habitat.
F	Your facilities stormwater discharges were addressed in another operators' valid certification of eligibility under criteria A-E, and there is no reason to believe that federally listed species or critical habitat may be present in proximity to the facility.

The MSGP includes a 30-day waiting period for permit authorization once an operator submits their NOI. One purpose of the 30-day waiting period is to give the Services an opportunity to review the proposed discharge to assure that listed species and critical habitat are protected in accordance with the ESA. Within the 30-day period the Services may request that EPA delay authorization beyond the typical waiting period to resolve outstanding questions. An operator is authorized to discharge under the terms and conditions of the permit, unless notified otherwise by EPA. EPA will review the basis of the denial with the operator, and in the event an operator is denied on the basis of an incomplete NOI, then a new 30-day wait period commences upon EPA's receipt of a complete NOI.

DESCRIPTION OF THE ACTION'S EFFECTS ON FISH AND WILDLIFE RESOURCES

The 30 sectors proposed for coverage under the MSGP encompass a wide range of industrial activity across a wide geographic area. The types and concentrations of stormwater pollutants, material used and stored by and operator, variability in regional precipitation characteristics and antecedent dry periods, and hydrologic transport efficiency of a site are a few of the factors that influence the fate, transport, persistence of pollutants in the discharge. The wide variability in these characteristics across industrial sectors and geographic regions makes this an inherently complex risk assessment. Fish and wildlife exposure to stormwater discharged by an industrial activity also depends upon the presence of the chemical in the environment, and the spatial and temporal overlap or use of a water body by the species of concern.

Once the aquatic environment is exposed to a pollutant, a species may uptake the pollutant directly through the dermis, gills, or olfactory system, or they may be exposed indirectly by contact with contaminated sediments or other biota (e.g., aquatic insect prey). Depending upon the pollutant relative toxicity may also be altered by water temperature, pH, and the chemical mixture. In general, a species response to it's exposure to a stressor may range from no observable response to persistent effects such as reduced immunity, reproductive success, or survival. The range of responses will vary widely by species, the antecedent health conditions of the individual, the timing, duration, frequency and magnitude of the exposure, and the environmental conditions under which exposure occurs, to name a few.

In this document, we have examined the consequences of several general assumptions of the proposed MSGP and the whether these assumptions are true for Pacific salmon and shortnose sturgeon. We chose Pacific salmon (*Oncorhynchus* spp.) because they are indicators of the quality of freshwater and estuarine ecosystems in states along the Pacific coast, from California to Alaska. We chose shortnose sturgeon (*Acipenser brevirostrum*) because they are indicators of freshwater and estuarine ecosystems along the Atlantic coast, from Florida to Maine. These species also co-occur (occupy the same general geographic area) with the discharge of industrial pollutants authorized by the MSGP in freshwater areas and marine or estuarine waters, a significant amount of literature is available on the effects of toxic pollutants on these species, and these species represent the probable consequences of the proposed general permit for threatened and endangered species.

Our analysis begins by examining EPA's implicit assertion that when industrial dischargers conform to applicable water quality standards for a receiving waterbody, waters of the United States, important to the ecology of aquatic life and specifically, NOAA's trust resources, are protected from harm. In this step, we review evidence of typical constituents in industrial discharges from a few specific sectors, and then examine how a few select pollutants routinely discharged by these industries affect aquatic resources. Although the precise volume of a pollutant in an industrial discharge will vary among dischargers, in our analysis we use the benchmark threshold as the expected volume of a pollutant discharged, and the level at which aquatic resources are exposed. While our review of selected industrial discharges indicates this may underrepresent the actual volume of a pollutant discharged from some industries, we believe this conservative threshold is sufficient for this examination because: 1) the benchmark level signifies the level at which EPA expects operators to monitor for problems with their BMPS and possible adverse effects to receiving waters, and 2) in many cases the benchmark threshold is equivalent to the water quality standard, representing the acute freshwater criterion or criterion maximum concentration of a pollutant allowed by water quality standards (recall, EPA recommends that the one-hour average exposure concentrations should not exceed this level more than once every three years on the average). Our analysis continues with an examination of the scientific and commercial data available to determine whether and how aquatic resources, specifically four species identified in Attachment B (three species of Pacific salmon and shortnose sturgeon) are likely to respond given their exposure. In particular, we examine the scientific and commercial data available to determine if individual's probable response would include behavioral or physiological changes with consequences for its "fitness" or the individual's growth, survival, and annual or lifetime reproductive success.

Review of Selected Chemicals in Industrial Discharges

A number of studies have examined the chemical constituents that comprise point-source discharges like those authorized under the MSGP. Among other things, industrial storm water discharges are a significant contributor of heavy metals to receiving waters. Line *et al.* (1996) monitored the stormwater runoff from 10 industrial sites in North Carolina, two of each of the following general sectors: auto salvage, metal fabrication, scrap and recycling, vehicle maintenance, and wood preserving. The most prevalent pollutants were zinc and copper, which they found in the runoff from every site for every monitored storm. Line *et al.* (1996) found greater concentrations of zinc than any other metal for all industrial sectors, except from the wood preserving sector where chromium concentrations were greatest. Line *et al.* (1996) detected mean copper concentrations from one site as high as 2,223 ppb (the benchmark standard for copper is 0.014 mg/L or 14 ppb), mean zinc concentrations as high as 10,083 ppb (the benchmark standard for zinc is 0.012 mg/L or 12 ppb), and lead as high as 3,223 ppb (the benchmark standard for lead is 0.082 mg/L or 82 ppb). The values reported by Line reflect the quality of runoff directly from the pollutant sources (i.e., before treatment). However, in their study on industrial stormwater discharges in Los Angeles, California, Lee and Stenstrom (2005) found the concentrations of metals exceeded the EPA's stormwater benchmark values more frequently than other measured water quality parameters. Grab samples for copper were as high 49,500 μg/L (the benchmark standard for copper is 0.014 mg/L or 14 μg/L) at the transportation equipment facilities category, while primary metal industries were highest for concentrations of lead, zinc, and nickel. Lee and Stenstrom (2005) found, based on a set of over 3,500 samples, samples exceeded benchmark values for zinc about 90% of the time. About 2,500 samples were analyzed for copper, and about 57% of these exceeded EPA's benchmark values. Similarly, stormwater monitoring from more than 110 facilities in the textile and food sectors found zinc and copper concentrations greater than the detection limit in about one-third of the samples (Amick 1994).

The Fraser River Water Quality Work Group undertook a one year study of industrial stormwater dischargers entering the Fraser River estuary in Vancouver BC. The study involved monitoring discharges in both wet and dry periods. Lawson *et al.* (1985) found that concentrations of several parameters were higher in dry weather discharges than wet weather. However, loadings were higher with wet weather discharges due to high discharge volume (exhibiting a "first flush" effect). Suspended solids generally increased with flow as did insoluble forms of several pollutants, particularly metals. Dissolved metals were often high in dry weather discharges, and became diluted with increasing in stormwater volume. Lawson *et al.* (1985) found substantial amounts of total aluminum, dissolved calcium, total iron, total magnesium, dissolved potassium, and dissolved sodium in dry and wet weather discharges, with dissolved forms considerably higher in dry weather discharges. Concentration of copper and zinc were relatively constant during both dry and wet flows.

Our review of these few studies on the constituents in industrial stormwater indicates that metals are a prevalent class of toxins that we can expect to occur in discharges authorized by the MSGP. What follows is a limited review of effects of exposing selected species to the volumes of metals we may expect in industrial discharges.

Selected Metals

An implicit assumption of the benchmark approach to trigger review of SWPPPs and BMPs appears to be that the dilution ratios between ambient flows and stormwater runoff will be sufficient to dilute benchmark concentrations in stormwater to concentrations below chronic water quality standards. In situations where stormwater is localized and runs off into large water bodies, beyond a possibly toxic mixing zone, that assumption will likely hold for some of the benchmark values. However, in some urban areas much of a watershed could be influenced by stormwater runoff, and this implicit assumption may not be supportable. For example, in the Puget Sound area, salmon spawn in small urban streams. Following stormwater runoff, the flows may increase several times above baseline values, indicating stormwater dominated flows with little dilution. Recurrent die offs of returning coho salmon have been observed under these circumstances (Spromberg and Scholz 2005).

The benchmark for copper is proposed as 0.014 mg/L (14 µg/L), whereas appreciable adverse effects to salmonids may be expected around 5 µg/L or less (discussed later). Thus a dilution factor of at least 2.8 would be needed to avoid an appreciable risk to salmonids. As illustrated above, assumptions that dilution factors will be at least this large are not supported for small streams that have much of their catchment area influenced by stormwater. The most severe dilution assumption is for mercury. The proposed benchmark is 0.0014 mg/L (equivalent to 1.4 µg/L and 1400 ng/L). The chronic water quality standard for mercury in many jurisdictions of the United States is 12 ng/L. In the biological opinion on the California Toxics Rule, using bioaccumulation factors, reproductive impairment in a salmon was predicted at 5 ng/L (USFWS and NMFS 2000). Thus a stormwater runoff to ambient dilution ratio of about 280 would be needed to dilute stormwater below a concentration predicted to cause adverse effects in fish.

As an example, we compared the selected metals listed in Table 4 with the water quality standards established in the state of Washington and found that the concentration levels observed in selected metals in Table 4 documented to elicit a response were lower than acute and chronic levels specified by the applicable Washington water quality standards (Eisler 1988, 1993 and 1998, Hansen *et al.* 1999, 2002a, 2002b and 2002c, EPA 1980a, 1985a, and 1996, Stevens and Chapmen 1984, Baldwin *et al.* 2003, and Demayo *et al.* 1982). This is consistent with a study by Karr *et al.* (2003) who compared the water quality and biological conditions of a number of Puget Sound streams and concluded that approximately one-third of the streams comply with state water quality standards, but nonetheless are degraded such that they are unlikely to protect and sustain native salmon. Karr *et al.* (2003) found that compliance with Washington State water quality standards are often insufficient to ensure protection of salmon spawning, rearing, and migration. Furthermore, in a review of the BMPs required under the states' stormwater manual, the Washington Department of Ecology (2002) concluded that implementation of the required BMPs would result in regular exceedances of chronic and acute water quality standards in urban and urbanizing areas.

Among metals, copper is one of the more acutely toxic to fish at low concentrations. In general, mortality of tested aquatic species is greatest under conditions of low water hardness, starvation, elevated water temperatures, and among early developmental stages (Eisler 1987). Effects include: (1) impaired disease resistance; (2) disrupted migration (via avoidance behavior of copper-contaminated areas); (3) hyperactivity; (4) impaired respiration; (5) disrupted osmoregulation; (6) pathology of kidneys, liver, and gills; (7) impaired function of olfactory organs and brain; (8) altered blood chemistry, and; (9) enzyme activity that have been documented in fish exposed to copper (Eisler 1997). At high concentrations, copper interferes with osmoregulation.

Table 4. Summary of salmon responses to exposure of selected regulated metals[1]

Constituent	Effects Associated with Exposure
Cadmium	Spinal deformities, inhibited respiration, reduced immune response, temporary immobility, reduced growth, inhibited reproduction, reduced survival [2]
Chromium-3	Reduced growth, reduced disease resistance, behavior modifications, disrupted feeding, cell damage in the gills, osmoregulatory disruption in outmigrating smolts, reduced reproduction and survival [3]
Copper	Impaired disease resistance, disrupted migration (via avoidance behavior), hyperactivity, impaired respiration, disrupted osmosregulation, pathology of kidneys, liver, and gills; impaired function of olfactory organs, and brain; altered blood chemistry, reduced survival [4]
Lead	Reduced growth, spinal curvature, anemia, caudal fin degeneration, destruction of spinal neurons, enzyme inhibition, reduces swimming ability, increased mucus formation and coagulation of body and gills; destruction of respiratory epithelium, scale loss, muscular atrophy, paralysis, impaired reproduction, reduced survival [5]
Zinc	Destruction of gill epithelium, tissue hypoxia, altered behavior, blood and serum chemistry and liver enzyme activity; altered muscle glycogen, total lipids, phosolipids, cholesterol, ribonucleic acid and proteins; interference with gall bladder and gill metabolism, altered immune response, impaired reproduction, reduced growth, increased jaw and branchial abromalities[6]

[1] Note: Effects are related to concentration levels of constituents as well as other chemical and physical parameters. References: [2] Sorensen 1991, Brent and Herricks 1998, Sanchez-Dardon *et al.* 1999; [3] Anestis and Neufeld 1986, Eisler 1986; [4]Eisler 1998; [5]Hodson *et al.* 1982, Eisler 1988, Sorenson 1991, Farag *et al.* 1994; [6]Eisler 1993, Himly *et al.* 1987a and 1987b, Ghanmi *et al.* 1989, Buckler *et al.* 1981

Dwyer *et al.* (2005a) evaluated the 96-hour acute toxicity of copper for rainbow trout, and Atlantic, shortnose, and shovelnose sturgeons, among other species and ranked the species' sensitivity. The LC50 for rainbow trout and shortnose sturgeon was 80 µg/L, 60 µg/L for Atlantic sturgeon, and 160 µg/L for shovelnose sturgeon. As an indicator or commonly used test species in lab tests, rainbow trout was the more sensitive species but relative to other species tested by Dwyer *et al.* (2005a) rainbow trout was not the most sensitive species. Of all the chemicals tested, the Atlantic and shortnose sturgeons were two of the most sensitive species tested. Based on Dwyer *et al.* (2005a) the acute criterion for copper appears protective of the species we chose for comparison in this document (steelhead, Chinook salmon, and coho salmon, of which rainbow trout is assumed a suitable surrogate; and shortnose sturgeon).

Acute lethality endpoints, however, ignore "ecological death (Scott and Sloman 2004)." That is the acute criteria (several of the benchmark values in the MSGP) do not protect species from sublethal adverse effects or significant harm (or "take[1]" of listed species) associated with exposure to toxic chemicals. In many cases even the chronic water quality criterion will not sufficiently protect fish species from adverse sublethal effects of exposure to pollutants. Besser *et al.* (2005) found the effect concentrations for the endangered fountain darter (*Etheostoma fonticola*) were significantly lower than current chronic water quality criteria, even though the acute criterion were protective of lethality. The manner in which chronic values are currently derived and a scarcity of chronic toxicity data for a wide range of sensitive species limit the utility of current chronic values as a benchmark threshold (Dwyer *et al.* 2005b).

Fish exposed to sublethal doses of a toxin may exhibit changes in behaviors essential for survival such as the behaviors associated with foraging, schooling, reproduction, predator avoidance, and the formation of social hierarchies (*see* Scott and Sloman 2004 *for a review*). External stimuli (e.g., pheremones, temperatures, flows, etc) trigger specific physiological sequences via neural networks like the olfactory system and lateral line. Some direct sublethal effects observed in salmonids at concentrations at or below the aquatic life criteria for copper and cadmium, include neuroreceptor death, olfactory inhibition, inability to detect chemical predator cues, changes in avoidance responses, and increased cough rates (Baldwin *et al.* 2003; Drummond *et al.* 1973; Folmar 1976; Scott *et al.* 2003; Sprague 1964). Salmon and other fish rely on their olfactory receptor neurons to detect and respond to chemical signals in aquatic environments. This sense of smell underlies their ability to find food, avoid predators, navigate migratory routes, and participate in reproduction. Using electro-olfactogram measurements in combination with a predator avoidance assay, Sandahl *et al.*, (submitted) present the first evidence that impaired olfaction (smell) resulted in a direct suppression of predator avoidance behavior at environmentally realistic dissolved copper exposures (>2.0 µg/L; 3 hr exposure). Baldwin *et al.* (2003) also demonstrated that short pulses of dissolved copper at concentrations as low as 2 µg/L reduced olfactory sensory responsiveness within 10 minutes such that the response evoked by odorants was reduced by approximately 10%. Similarly, Scott *et al.* (2003) found exposure to 2 µg/L of cadmium for 7 days resulted in significant accumulation of cadmium in the olfactory system, and inhibited olfactory function and normal predatory response behaviors in rainbow trout. Exposure of rainbow trout to 3 µg/L of cadmium significantly reduced agonistic acts during the initial formation of dominance among pairs (Sloman *et al.* 2003).

Baldwin *et al.* (2003) calculated copper concentration neurotoxic thresholds sufficient to cause olfactory inhibition and antipredator behavior in juvenile coho salmon as low as 5.0 µg/L. At 10 µg/L responsiveness was reduced by 67% within 30 minutes, an exposure time that is less than typical discharge times for stormwater outfalls. Baldwin *et al.* (2003) also referenced three studies that reported copper exposures over four hours cause cell death of olfactory receptor neurons within rainbow trout, Atlantic salmon, and Chinook salmon. When they compared their results to the acute EPA water quality criteria for dissolved copper (13 µg/L for 100 mg/L hardness), Baldwin *et al.* (2003) determined that a one-hour exposure at the acute EPA water quality criteria concentration resulted in more than 50% loss of sensory capacity among coho salmon in freshwater habitats.

[1] The term 'take" is defined in the ESA and means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

Physiological recovery of olfactory neuron function is dose-dependent and occurs within hours at low copper concentrations (i.e., <25 μg/L); but in the case of olfactory neuron cell death (i.e. ≥25 μg/l copper [Hansen *et al.* 1999]) recovery is on the order of days or weeks. Recent research demonstrated that copper toxicity to the olfactory system is not ameliorated by alkalinity or hardness (Baldwin *et al.*, 2003; J. McIntyre and N. Scholz unpublished results), however dissolved organic carbon (DOC) appeared to reduce copper bioavailability in a dose dependent manner (J. McIntyre and N. Scholz unpublished results). In Pacific NW basins the United States Geological Survey has monitored DOC for more than 10 years (NAWQA data). In Puget Sound basin streams mean DOC was fairly low and ranged from 0.6 (SD ± 0.1) to 5.2 mg/L (SD ± 2.9). Accordingly, streams with low mean DOC may not confer adequate protection against copper olfactory toxicity.

Another salmon sensory function likely affected by dissolved copper is the lateral line system. Several important fish behaviors are mediated by the lateral line system including shoaling, predator avoidance, and rheotaxis (flow orientation). This teleost (membership includes salmonids and zebra fish) system detects and translates vibrational cues and other forms of water movement from the aquatic environment. Mechanosensory neurons, so called haircells, extend from neuromasts on the fish's surface collecting data from the aquatic environment. In a recent study, dissolved copper (i.e., ≥20 μg/L; 3 hr exposures) killed 20% of zebra fish's mechanosensory neurons (Linbo *et al.* 2006). Coincidently, 25 μg/L dissolved copper (4 hour exposures) killed juvenile chinook olfactory epithelial cells (Hansen *et al.* 1999).

The benchmark threshold proposed by the MSGP for total copper in industrial stormwater is 0.014 mg/L. The proportion of copper in the dissolved phase may be quite high relative to total copper concentrations, although actual values will likely vary among discharges and storm events (Kim *et al.* 2003). Kim *et al.* (2003) noted as an example, one storm where the dissolved copper concentration was 10 times greater than copper in particulate form. In a study of urban runoff in Curitiba, Brazil, Prestes *et al.* (2003) found that lead and cadmium had a high affinity for suspended solids, whereas copper more frequently occurred in dissolved phase. Evidence from the above studies indicate that dissolved copper is a potent neurotoxin that directly affects the sensory capabilities of juvenile salmon and significant adverse effects are likely when stormwater discharges reach the proposed benchmark for copper concentrations. The proposed benchmark is a crude threshold at which to measure adverse effects on aquatic species of national importance. Chronic exposure to toxicants can result in significant sublethal effects that can interfere with complex behaviors necessary to protect the viability of a fish population, and ensure its survival (Scott and Sloman 2004).

In summary, we anticipate that some metal concentrations in both new and existing stormwater outfalls are likely to have more than minor detrimental effects (lethal and sublethal) on all age classes and life history forms of salmon and their prey base in the permit area. Similar effects may occur on sturgeon, although more studies are necessary to ascertain sublethal responses to exposure.

Mixtures

Industrial stormwater discharges contain a mixture of regulated toxicants, including metals, pesticides, polycyclic aromatic hydrocarbons, and other unregulated compounds, like plasticizers and some solvents. Most published literature addresses acute toxicity of single toxicants on an organism under laboratory conditions, although most pollutants exist in mixtures in the environment. Some mixtures are known to interact with each other (Niyogi *et al.* 2004). These mixtures interact at gills and olfactory receptors, likely resulting in adverse effects, although the physiological and toxicological consequences of metal mixtures are an area where more study is necessary. Exposure to two or more pollutants simultaneously may produce a response that is additive, or one that is synergistic or antagonistic compared that which is expected in and individual exposure (Denton *et al.* 2002). An example of altered toxicity with mixtures is provided by chromium and zinc. When present in water, chromium and zinc, may alter toxicity of cadmimum to freshwater fish. The presence of chromium resulted in increased cadmium uptake in fish (Rai *et al.* 1995). Data also exist on the effects of zinc toxicity. Cadmium, copper, iron, and molybdenum can interact antagonistically with zinc (Hammond and Beliles 1980), while calcium and magnesium can reduce zinc toxicity (EPA 1999b).

Mixtures of zinc and copper are generally acknowledged to have greater than additive toxicity to a wide variety of aquatic organisms including freshwater fish (Eisler 1993). In general, mercury toxicity was higher at elevated temperatures and in the presence of other metals such as lead and zinc (Eisler 1987). Playle (2004) reported that metal mixtures yield greater than strict additivity (of toxic effects) at low aqueous metal concentrations, strict additivity at intermediate metal concentrations, and less than strict additivity at high metal concentrations. Individual exposure to cadmium chloride, mercuric chloride and zinc chloride resulted in significant immune system suppression within rainbow trout, conversely, the toxicity of mercury or cadmium is reduced in fish simultaneously exposed to zinc (Sanchez-Dardon *et al.* 1999).

Clearly mixtures of chemical have a range of effects. The entire suite of compounds in industrial stormwater is unknown, but would likely vary even within a subsector of industries. We expect that in some cases the effects of the mixtures may be greater than the effects from exposure to individual toxicants, and may have more than minor detrimental adverse effects on aquatic species of national importance.

Other Selected Toxicants and the Benchmark Thresholds

Turbidity and Total Suspended Solids

Sediment in stormwater discharges authorized under the MSGP is measured using turbidity, total suspended solids, and water clarity. The three measures are often correlated to each other, although the size, shape, and refractive index of particles can affect correlation (Sorenson *et al.* 1977). As a practical matter, we agree with EPA's use of TSS as an inexpensive parameter to measure in activities authorized under the MSGP. However, discharges that reach MSGP TSS benchmark value (100 mg/L) may result in adverse effects as severe as death of exposed individuals to temporary changes in behavior and physiological responses. The duration of the exposure, among other factors will influence the severity of the responses of aquatic species of national importance.

According to Newcombe and Jensen's (1996) meta analysis of 80 reports of the effects of sediment on fish, including Pacific and Atlantic salmon, acute mortality is likely after about a few days of exposure at the benchmark criteria, while sublethal (behavioral and physiological) responses are likely after only a few hours of exposure at this threshold. Sigler *et al.* (1984) observed turbidity levels at only 25 NTU reduced growth in juvenile coho salmon.

Elevated sediment levels have been reported to cause physiological stress, reduce growth, adversely affect fish survival, and modify fish habitat. Fish response to elevated sediment levels is generally a factor of the frequency and duration of the exposure, time of occurrence, temperature, natural background levels, concentration of exposure, the size and angularity of particles, the lifestage of the species exposed and their antecedent health condition, to name a few. Behavioral avoidance of turbid waters may be one of the most important effects of suspended sediments (DeVore *et al.* 1980; Birtwell *et al.* 1984; Scannell 1988). Salmonids have been observed to move laterally and downstream to avoid turbid plumes (Sigler *et al.* 1984; Lloyd 1987; Scannell 1988; Servizi and Martens 1991). Juvenile salmonids tend to avoid streams that are chronically turbid, such as glacial streams or those disturbed by human activities, except when the fish need to traverse these streams along migration routes (Lloyd 1987).

Exposure duration is a critical determinant of the occurrence and magnitude of physical or behavioral effects. Anadromous fish have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are adapted to such high pulse exposures. Adult and larger juvenile salmon appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjorn and Reiser 1991). However, research indicates that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Lloyd 1987; Servizi and Martens 1991).

Deposition of solids from a discharge may be more detrimental to benthic organisms than suspended sediment plumes, as the potential exists for smothering, which leads to a decrease in the amount of available dissolved oxygen. Also, large quantities of sediment deposited on the bottom can result in entrapment of benthic organisms, diminish prey success and availability, and smother submerged aquatic vegetation (e.g., sea grasses). Embedded gravel and cobble reduce access to microhabitats (Brusven and Prather 1974), entombing and suffocating benthic organisms. When fine sediment is deposited on gravel and cobble, benthic species diversity and densities have been documented to drop significantly (Cordone and Pennoyer 1960; Herbert *et al.* 1961; Bullard 1965; Reed and Elliot 1972; Nuttall and Bilby 1973; Bjorn *et al.* 1974; Cederholm *et al.* 1978).

Suspended sediments and nutrient increases are two of the most important factors that have contributed to severe losses in submerged aquatic vegetation within Chesapeake Bay since 1965 (Gimon *et al.* 1998). By 1980 the area within the Bay suffering from hypoxic (<2.0 mg/L dissolved oyxgen) and anoxic conditions (<1.0 mg/L) was about fifteen times more extensive than in 1950 (Gimon *et al.* 1998). Not only is foraging area significantly reduced where submerged aquatic vegetation is smothered by deposited sediments, but dissolved oxygen levels decrease which can lead to hypoxic or even anoxic conditions. Where demand exceeds the available oxygen supply, shortnose sturgeon respond by reducing activity, feeding and growth rates, and eventually, depending upon the duration and concentration of the exposure, death may result.

Fine sediment deposition on redds (fish nests) can act as a physical barrier to fry emergence (Cooper 1959, 1965; Wickett 1958; McNeil and Ahnell 1964), and McHenry *et al.* (1994) found that fine sediment (greater than 13 percent of sediments less than 0.85mm) resulted in intragravel mortality of salmon embryos due to oxygen stress and metabolic waste build-up. This effect may be even more pronounced at lower levels of sediment deposition for a fish like shortnose sturgeon. The shortnose sturgeon is demersal fish that broadcast spawns adhesive eggs that are about half the size of coho salmon eggs (egg diameter is about 3.0-3.2 mm compared to the coho salmon eggs that are about 4.5-6.0 mm diameter). Morgan *et al.* (1973) determined that blanketing of the eggs of white perch (adhesive eggs of about 0.90 mm diameter) by sediment greater than 2 mm in thickness (a covering of 1.2 mm over the top of the egg) resulted in 100 percent mortality; and 50 percent of the eggs died when the sediment thickness was between 0.5 and 1.0 mm (Morgan *et al.* 1973). Deposited sediment can also cover intragravel crevices that juvenile salmon use for shelter, in turn decreasing the carrying capacity of streams for juvenile salmon (Cordone and Kelley 1961; Bjorn *et al.* 1974).

Particulate materials physically abrade and mechanically disrupt respiratory structures (fish gills) and respiratory epithelia of benthic macroinvertebrates (Rand and Petrocelli 1985). Suspended sediments have been shown to produce gill trauma, gill flaring, and coughing (Berg 1982; Berg and Northcote 1985; Severizi and Martens 1987, 1992). The stress response, evidenced by elevated cortisol levels, blood plasma, plasma glucose, and osmoregulatory ability, can compromise the organism's normal functions (Redding *et al.* 1987; Severizi and Martens 1987).

These are a few examples of the adverse effects we expect under the MSGP. Of particular concern are benchmark standards that provide point estimates of degradation, up to known harmful levels of exposure, without assurances for modifying BMPs in such instances. Clearly, given our limited examination of relevant scientific information, EPA cannot ensure adverse effects to aquatic resources of national importance are not likely from the MSGP and its associated stormwater discharges. Our abbreviated analysis indicates that a comprehensive analysis of the effects of the MSGP on aquatic resources of national importance is warranted.

Cyanide

The MSGP benchmark threshold for cyanide is 0.022 mg/L (equivalent to the aquatic life CMC is 22.4 µg/L). Available data suggest that this acute criterion may be harmful to listed salmon and sturgeon, particularly when dissolved oxygen concentrations are below 5 mg/L or water temperatures are equal to or below 6° C. Leduc (1984) found that cyanide concentrations at the chronic criterion in water colder than 6° C may be associated with chronic toxicity effects. Other data indicate salmon sperm can be killed when exposed to cyanide concentrations as slow as 1 µg/L.

Cyanide toxicity increases with decreasing pH (when below 6.8) and dissolved oxygen. The influence of water temperature on toxicity varies depending on whether the concentration is "slowly lethal" (chronic), in which case toxicity is inversely related to temperature, or "rapidly lethal" (acute), in which case there is a direct relation (Eisler 1991). Eisler (1991) defines concentrations less than 10 µg/L as being slowly lethal. In rapid toxicity, cyanide is a potent and rapid asphyxiant that acts through the inhibition of adenosine triphosphate synthesis in cells. Acute cyanide toxicity therefore increases with water temperature in large part because of increased metabolic and respiration demands and lower dissolved oxygen content of the water. The effect of pH occurs when it falls below about 6.8. Effects of cyanide on aquatic organisms also vary with chemical speciation, exposure time, aquatic species and life stage, level of fish activity, and the influence of flow rate on respiration. Chronic effects of cyanide on fish include: reduction in egg fecundity and viability; alevin deformities; delayed mortality; reduced biomass, fat content, and weight gain; liver and other cellular damage; and impaired swimming performance, respiration, osmoregulation, and growth.

Once exposed to cyanide, it is carried throughout the body by the blood stream. Fish appear to be the most sensitive aquatic organisms to cyanide toxicity (EPA 1980b, 1985b; Heming and

Blumhagen 1989; Eisler 1991; Kevan and Dixon 1991). The toxicity of cyanide to fish may act through the direct action of the cyanide compound itself or through the metabolism of cyanide compounds to the thiocyanate anion (SCN-) and the subsequent action of SCN- (Lanno and Dixon 1996).

The acute criteria may not be protective of listed salmon and sturgeon under specific water quality conditions. Two studies in particular determined LC_{50} values that were close to the acute criterion, from which it follows that the respective incipient lethal levels were also likely to have been less than or equal to the criterion: Alabaster et al (1983) determined that Atlantic salmon smolts exhibited a 24 hour LC_{50} equal to 24 μg/L when the dissolved oxygen concentration to which they had been previously acclimated was at the stressful level of 3.5 mg/L. An LC_{50} of 73 μg/L was determined when dissolved oxygen concentration was at the non-stressful level of 10 mg/L. The difference in concentrations reflects the asphyxiating nature of cyanide. The importance of Alabaster et al's (1983) results to this evaluation is tempered by the observation that a dissolved oxygen concentration of 5 mg/L is the minimum level for salmon and trout prior to respiratory distress, and 3 mg/L is the lethal point at summer water temperatures (Lietritz and Lewis 1980). However, the possibility exists for dissolved oxygen sags to occur during low flow summer season, particularly at night. For instance in some streams where listed salmon reside dissolved oxygen has been observed as low as 3.5 mg/L and the dissolved oxygen content in portions of Cheseapeake Bay, where the demersal shortnose sturgeon resides, dips below 2.0 mg/L during summer. Coupled with cyanide concentrations at the proposed acute concentration criterion, the result could be lethal. Under these circumstances the impaired respiration and metabolism of listed salmon, steelhead, and shortnose sturgeon makes them more susceptible to the acute respiratory effects of cyanide.

Leduc (1984) reported a 96 hour HCN LC_{50} for juvenile rainbow trout equal to 28 μg/L when the test water temperature was 6°C. LC_{50} concentrations rose with increasing temperature. This result suggests that the lethality described by Eisler (1991) is for listed juvenile salmon and steelhead when cyanide concentrations are equal to the acute criterion during the period that extends between late fall and early spring, when water temperatures are less than or equal to 6°C.

The proposed chronic cyanide criterion is 5.2 μg/L. Kovacs and Leduc (1982) observed chronic toxicity effects on growth in terms of average fat gain and dry weight, but not wet weight when juvenile rainbow trout were exposed to 5 μg/L at 6°C. At 12°C, toxicity effects were determined at concentrations greater than or equal to 10 μg/L. As with acute toxicity, chronic effects were inversely related to water temperature in the study. All measures of growth were affected significantly at an exposure concentration of 15 μg/L at the temperatures tested (6°C to 18°C). The results of Kovacs and Leduc (1982) suggest some chronic toxicity to occur at the proposed chronic criterion when temperatures are 6°C or lower. Billard and Roubaud (1985) suggest that the potential exists for reproductive failure when ambient water concentrations are below the chronic criterion for cyanide. Billard and Roubaud (1985) determined that sperm (but not the ova) of rainbow trout were adversely affected when they were exposed directly to a cyanide concentration equal to 1 μg/L, which is below the proposed chronic criterion. It is unknown whether sperm *in situ* would be exposed to a similar level inside the male when it is exposed to water concentrations below the proposed chronic criterion. Nonetheless, the implication is that the reproductive effectiveness of listed salmonids may be reduced when water concentrations are at and below the proposed chronic criterion during spawning.

Water Quantity

Existing stormwater discharges and new industrial stormwater discharges that will be added in the 5-year permit term will likely contribute to altered hydrological and geomorphological changes in areas covered under the MSGP. New stormwater discharges usually accompany new development, and result in the concomitant conversion of upland forest and meadow, wetlands, and floodplain habitat. Such conversions and the addition of new impervious surfaces lead to increases in surface runoff and reduced subsurface flows and groundwater recharge altering the hydrologic regime of aquatic species. Such changes may have more than a minor effect on aquatic ecosystems that support salmon and other aquatic species of national importance. While the number and distribution of new industrial development and the associated discharges that would be covered by the 2006 MSGP is unclear, a reasonable predictive analysis should be conducted to ascertain the effects of altered hydrological regimes combined with the persistent effects from existing discharges in receiving waters. These effects must be considered in developing appropriate BMPs as well. While BMPs are designed to minimize effects to "beneficial uses," including aquatic species of national importance and federally-listed species, there is considerable variability in the performance of most BMPs, and little supporting evidence (and some counterevidence) that implementation of a BMPs will be effective to meet water quality standards or ameliorate changes in natural hydrology of a system.

For Pacific salmon and other fish and aquatic organisms flow regimes in streams and rivers determine the amount and availability of habitat. In general, high flows shape channel pattern, cross section, and profile, redistribute sediment, and recruit materials (e.g., gravel and wood) to downstream reaches. Naturally occurring peak flow events are essential to the development and maintenance of healthy floodplain systems. These events define channel boundaries through the movement and deposition of coarse sediment, maintain floodplain soils through the movement and deposition of fine sediment, recharge groundwater aquifers, and disperse vegetation (Spence *et al.* 1996). Flow regimes that maintain adequate low flow conditions are needed to maintain adequate amounts of refugia habitat, water temperatures and prey availability (Gregory and Bisson 1997).

The new impervious surface, and associated stormwater, related to the permits is likely to result in loss of groundwater recharge, and a subsequent increase in surface runoff and peak flow frequency, volume, and duration, in the streams and tributaries affected by the permit (Beyerlein 1999). BMPs will moderate some of these effects, but cannot eliminate changes to hydrological cycles. In particular, structural stormwater management facilities (e.g., detention ponds) generally do not promote infiltration.

Hydrogeology is complex and varies with surface soils, deep soil strata, precipitation patterns, vegetation, and slope, to name a few. Land use patterns can significantly change the manner in which water flows across the landscape, and enters surface and groundwater sources. In some metro areas like Washington DC and Boston the loss of infiltration may be significant (Otto *et al.* 2002). To illustrate how changes in land use influences water routing in a region, we examined data from the Pacific Northwest (Table 5). In this region and others, there is a strong relationship between the amount of forest cover and levels of impervious and compacted surfaces in a basin, and the degradation of aquatic systems (Klein 1979; Booth 2000; Booth *et al.* 2001). Although an "imperfect measure of human influence," basin imperviousness is commonly used as an indicator of basin degradation (Booth 2000). A reduction in forest cover and conversion to impervious surfaces can change the hydrological regime of a basin by altering the duration and frequency of runoff, and by decreasing evapotranspiration and groundwater infiltration (May *et al.* 1998; Booth *et al.* 2001). Such changes can be detected when the total percentage of impervious surface in the watershed is as low as 5 to 10% (Booth and Reinelt 1993). In the Pacific Northwest, these changes have resulted in obvious increases in the duration, occurrence and volume of high flows resulting in streambed scour and channel incision (Klein 1979; Schueler 1994). Invertebrate diversity also declines as a result of changes in hydrology associated with increased impervious surfaces (Lucchetti and Fuerstenberg 1993; May *et al.* 1998; Schueler 1994). In some areas degradation likely occurs with incremental increases in impervious surfaces below 5% imperviousness, and is exacerbated by other factors such as reduced riparian cover and pollution (Booth 2000; Karr and Chu 2000). Watershed degradation from these changes would vary by geographic region, and the soil and precipitation characteristics of a region.

The effect of impervious surfaces on channel morphology will vary, depending on the conditions of the stream (e.g., armored vs. forested riparian streams), and its typical flow patterns. For ditched and heavily altered sections of affected streams, the impacts are likely to be insignificant. However, for sections of the affected streams that are currently functioning, the results are likely to be more severe. Increases in frequency and magnitude of peak flows will degrade suitable spawning and rearing habitat for Pacific salmon (Spence *et al.* 1996). The increased velocity and scour can limit high flow refuge habitat and potentially flush fish downstream, increasing their exposure to predation and environmentally stressful conditions (Spence *et al.* 1996). Larger and more frequent discharges cause downstream channels to enlarge (by downcutting and/or widening), and become destabilized which can affect fish and prey distribution. The flushing associated with high flows also interferes with smolt timing by accelerating their seaward migration.

Table 5. Division of average annual precipitation in inches based on Seatac Airport precipitation records (1945-1996 [Beyerlein 1999]).

Land Use	Surface Runoff	Interflow (subsurface flow)	Groundwater Recharge	Evapo-transpiration
Forest	0.09	8.46	13.4	18.79
Pasture	0.29	13.26	10.15	17.02
Lawn	0.61	16.72	8.89	14.48
Rural residential	1.64	12.73	9.75	16.6
Suburban residential	9.3	12.37	6.58	12.44
Multi-family housing	16.66	8.69	4.62	10.72
Commercial	29.37	2.34	1.24	7.74
Impervious	34.05	0	0	6.64

Alteration of hydrological regimes, specifically reductions in baseflow, loss of cool groundwater inputs, and removal of forest cover can increase the stream temperatures (Frissell 1999). Pluhowki and Cantrowitz (1963 *in* Frissell 1999) measured a more than 3°C increase in summer groundwater temperatures as a function of the loss of forest cover during urbanization. Soil temperatures on both upland and floodplain sites increase dramatically when forest cover is removed (*see* Frissell 1999) and such heating is associated with warming of the shallow groundwater associated with those soils. Groundwater warming reduces its capacity to act as thermal buffer when it emerges in surface waters, including streams (Frissell 1999).

Changes in instream temperatures can have detrimental adverse affects on cold-water fishes, like Pacific salmon. Effects to the thermal regimes in streams can impact fish growth and survival rates, adult migration and reproduction, and fry emergence (Spence *et al.* 1996). EPA (2001a) reports that adult fish holding in warm stream reaches are subject to bioenergetic stress and may consume so much of their stored energy that spawning success is impaired. Prolonged holding in water temperatures that are higher than optimal can result in death due to multiple stresses, such as concurrent thermal stress, disease and energy depletion. Additionally, thermal effects on gametes in holding fish can decrease gamete viability. Temperatures above 13 °C have also been associated with significant losses in eggs even while they are retained unfertilized in the body cavity of female fish (EPA 2001b). In salmonids that feed in fresh water, as well as for all juveniles, warm temperatures can alter rates of growth and development. In addition, high water temperatures can present thermal barriers to adult and juvenile migrations (EPA 2001a).

In summary, structural BMPs in the MSGP may minimize the effects of impervious surface (i.e., those BMPS that provide "flow control") by reducing erosive forces through capturing, detaining and slowly releasing the stormwater on some sites, but may not maintain the hydrology needed for aquatic resources of national importance. In many cases, infiltration and dispersion BMPs would more effectively minimize the effects of changes to altered hydrological regimes resulting from impervious surfaces. However, the characteristics of soils and other technical considerations may limit the use of infiltration and dispersion BMPs in many areas. Pollutant removal efficiencies and flow control efficiencies of BMPs are unlikely to eliminate adverse changes to receiving waters. We expect that stormwater discharged from existing development and new development (even with the use of structural stormwater BMPs) will over time impact the hydrology, biotic integrity, habitat elements, riparian corridors, channel morphology and connectivity, and basin condition of the streams containing aquatic resources of national importance.

<u>Endangered Species</u>

When EPA designates a non-federal representative to conduct informal consultation, the ultimate responsibility for compliance with section 7 remains with EPA ("the Federal agency", 50 CFR Part 402.08). To this end, the implementing regulations state that the Federal agency (EPA) must independently review and evaluate the scope and contents of the non-federal representative's biological assessment. In accordance with section 7(a)(2) of the ESA, it is EPA's responsibility to ensure that any action it undertakes is not likely to jeopardize the continued existence of any endangered and threatened species or result in the destruction of adverse modification of habitat, and under section 7(a)(1) is to use their authorities in furtherance of the purpose of the ESA, promoting the conservation of listed species and their designated critical habitat. The substantive duty imposed by statute is that each Federal agency ***shall insure*** their actions will not jeopardize listed species or result in the destruction or adverse modification of habitat. To accomplish this, the Act imposes a procedural duty to use the "best scientific and commercial data available" in evaluating their action and to do so in consultation with the Services.

Ultimately, EPA bears the burden of ensuring the totality of effects authorized under the MSGP will not jeopardize listed species or result in the destruction or adverse modification of critical habitat. Because EPA intends to request informal consultation on the MSGP, it is apparent EPA believes the individual discharges and the sum total of effects from all discharges authorized under the 2006 MSGP "may affect, but are not likely to adversely affect" listed species and their designated critical habitat.

NOAA Fisheries Service respectfully disagrees with this conclusion for a variety of reasons, not the least of which is the evidence presented previously that stormwater discharged under the MSGP will likely result in sublethal behavioral and physiological effects to listed species. The consequences of such exposure will affect the fitness of individuals, and may result in long term consequences for population viability and persistence (see previous discussion – example: heavy metals). Such effects, at a minimum, warrant examination under formal consultation pursuant to section 7 of the ESA.

According to the MSGP, coverage under the permit is only available if an operator's stormwater discharges are not likely to jeopardize the continued existence of any listed species or result in the adverse modification of critical habitat (Part 1.2.4.6). It appears that EPA has abrogated what is the responsibility of the Federal Action agency, by establishing a process that recognizes only individual discharges, requires individual operators to "certify" they are not jeopardizing by using one of 6 possible criteria, and does not evaluate the sum total of effects on listed species from MSGP as a whole (that is, the total effect of more than 3,000 industrial discharges). As stated previously, EPA established the 30-day waiting period following submission of an NOI to give the Services an opportunity to review the proposed discharge to assure that listed species and critical habitat are protected in accordance with the ESA. It remains unclear what if any role EPA will take in this review period, specifically whether EPA will review the effects of the discharge on listed species and their critical habitat, or if it is the intent of EPA to place the burden of meeting the substantive duty of the ESA on the Services and EPA's applicants.

While NOAA Fisheries Service appreciates that EPA is willing to further delay authorization of an NOI if necessary, it is not clear if EPA expects the Services to make this decision based on the limited information provided in the NOI. At a minimum, NOAA Fisheries will require a copy of a facility's SWPPP submitted with an NOI to review the operator's effect analysis and BMPs designed to minimize adverse effects to listed species and their designated critical habitat. While the Services are happy to assist EPA in meeting their substantive duty under the ESA, as a reminder the obligation to review NOIs (dischargers certifications, and associated activities) and thereby ensure the totality of effects authorized under the MSGP will not jeopardize listed species or result in the destruction or adverse modification of critical habitat is EPA's burden.

Based on a limited review of the electronic Notice of Intent (eNOI) database for the construction general permit, operators frequently select criteria A and E for certifying their eligibility to discharge. Criterion A is equivalent to what the Services commonly refer to as a "no effect" determination Under Criterion A there is a high likelihood that operators will falsely conclude that species are not present in proximity to their facility when in fact they are present. One flaw in the permit language for criterion A is reference to "in proximity" of discharge activities. Stormwater discharges influence downstream water quality and quantity characteristics. The full extent of any direct and indirect effects from discharges must be considered to ascertain the full geographical area in which listed species and their critical habitat must be considered. As described, operators may be inclined to truncate the area in which they need to assess exposure of listed species and their critical habitat (termed the "action area" under section 7). Lastly, as a practical matter, criterion E does not meet the procedural duty to consult until the Services concur in writing with the assessment that the project is not likely to adversely affect listed species and their critical habitat. Such step-down consultations are necessary to assess the site-specific effects of individual actions.

Where an operator determines that a listed species could be present near their facility the guidance provides further instruction that the operator must do one or more of the following: conduct (1) visual inspections of their facility, (2) formal biological surveys, or (3) an environmental assessment under the National Environmental Policy Act (NEPA). Generally, the latter tool, the NEPA analysis, relies upon a combination of survey methods such as the visual inspection, the formal field survey, and can rely upon a wide array of other sources. While NEPA should be referenced if conducted, more useful and comprehensive sources of information are available on species presence and EPA should encourage their staff and "non-federal" representatives to be using the best scientific and commercial data available (section 7(a)(2) of the ESA). Generally, the best information involves a combination of sources such a state agency data sets, visual inspections, and formal surveys. Reliance on only one method for detecting a species presence increases the risk of falsely concluding the listed species is not using the action area. In particular, visual inspections are one of the least reliable methods for detecting species and although the power of visual inspections can increase with repeated sampling, visual inspections often have high error rates. Many factors influence the accuracy of visual inspections including: some species have cryptic life stages or are cryptic throughout their life cycle making visual detection (without sampling impossible or nearly so); habitat attributes can decrease visibility and detection (e.g., vegetative and geologic structure, water clarity, and velocity to name a few); species behaviors also strongly influence detectability – species are mobile, their ranges shift over time, and individual animals move within their range on a variety of scales, not to mention many species will hide if disturbed by the individual conducting visual observations.

Conclusion

Based on the evidence present above and without greater assurances that harm to listed species is unlikely as a result of the 2006 MSGP, we cannot concur with EPA's determination that the permit may affect, but would be unlikely to adversely affect listed species. At least some of the recommended benchmark thresholds, and water quality criteria will harm aquatic resources, including listed species. We anticipate the MSGP and the stormwater discharges it authorizes is likely to adversely affect the fitness of individual fish.

Because we fully support development of an effective MSGP we have provided some preliminary suggestions for minimizing the effects of the MSGP on aquatic species. Since our analysis does not comprehensively address all listed species potentially affected by the MSGP, we look forward to further working with EPA to minimize the effects of the permit and the discharges in waters of the United States that contain listed species and their designated critical habitat. That is, we look forward to further assisting you in ensuring the proposed action is not likely to jeopardize listed species or destroy or adversely modify critical habitat.

Selected Recommendations

NMFS supports issuance of MSGP 2006 and provides the following suggestions for minimizing the effects to aquatic resources of national importance, which includes threatened and endangered species and their critical habitat.

1. Conduct a comprehensive analysis of adverse effects, which would include a review of applicable water quality standards and revising applicable benchmark standards to establish monitoring protocol that can be used to indicate potentials for adverse effects before such effects occur.
2. Evaluate the use of biological indicators such as the index of biological integrity (IBI) in water quality criteria to detect degradation of streams (e.g., altered watershed hydrologic regime) and their designated uses.
3. Establish areas and interim water quality standards that minimize sublethal adverse effects of exposing listed species and critical habitat to toxicants.
4. Analyze the 2000 permit benchmark exceedances to determine if exceedances are useful indicators of SWPPP inadequacies or potential water quality problems.
5. Inspect a subset of facilities to examine BMP effectiveness, stormwater constituents, whether benchmark thresholds are informative indicators of problems, and whether water quality standards are exceeded. Conduct routine and comprehensive inspections to build long-term case studies, upon which to determine informative changes to the program..
6. Revise MSGP procedures for compliance with Endangered Species Act. Specifically, reduce the likelihood that operators are falsely concluding species are not present, or effects do not exist in proximity to their facility (that is, the action area), when in fact species are present and effects do exist. Modify the MSGP to provide that operators must obtain a concurrence letter from the Services before assuming they are eligible to discharge.
7. Modify the MSGP so that SWPPPs are submitted with each NOI.
8. Modify the MSGP to require a statistically rigorous monitoring protocol by which EPA can make informed changes to the program that will promote the protection of the chemical, physical, and biological integrity of waters of the United States.

ATTACHMENT B. NOAA TRUST RESOURCES AND AUTHORITY FOR COMMENT

The conservation and management of living marine resources in the United States is entrusted to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries Service), which is responsible for stewardship of the nation's living marine resources and their habitats within the United States Exclusive Economic Zone. NOAA Fisheries Service protects and restores aquatic organisms and their habitat on behalf of current and future generations of Americans. NOAA Fisheries Service is a trustee for coastal and marine resources, including:

- Commercial and recreational fishery resources;
- Anadromous species (fish, like salmon, that spawn in fresh water and then migrate to the sea);
- Catadromous species (species, like the American eel, that spawn in sea water and then migrate to fresh water);
- Marine mammals, including whales, dolphins, and seals;
- Endangered and threatened marine species and their habitats (e.g., Pacific and Atlantic salmon, Steller sea lions, and sea turtles);
- Marshes, mangroves, seagrass beds, coral reefs, and other coastal habitats; and
- Resources associated with National Marine Sanctuaries and National Estuarine Research Reserves

NOAA Fisheries Service carries out its charge under many laws, treaties, and legislative mandates from the United States Congress. Most of the agency's stewardship responsibilities come from five statutes:

- The Endangered Species Act (ESA) protects species that are in danger of extinction or likely to become endangered
- The Fish and Wildlife Coordination Act (FWCA) authorizes collection of fisheries data and coordination with other agencies for environmental decisions affecting living marine resources
- The Magnuson-Stevens Fishery Conservation and Management Act regulates fisheries within the United States Exclusive Economic Zone.
- The Marine Mammal Protection Act regulates the taking of marine mammals,
- The Federal Power Act provides for concurrent responsibilities with the United States Fish and Wildlife Service in protecting aquatic habitat.

Overall, NOAA is guided by three goals in carrying out its responsibilities as a trustee:

- Reducing threats to coastal resources and human health through planning and prevention;
- Protecting coastal resources and human health by recommending and implementing appropriate response actions; and
- Restoring injured trust resources.

Aquatic Resources of National Importance

The coastal zone is one of the most sensitive and biologically productive areas of the marine environment. Coastal waters in the United States include estuaries, coastal wetlands, coral reefs, mangrove and kelp forests, seagrass meadows and upwelling areas. These coastal waters provide critical habitat for fish, birds, shellfish, marine mammals, and other wildlife. The MSGP and its associated stormwater discharges will affect fresh water streams and downstream coastal zones. Species under NOAA Fisheries Service's jurisdiction, potentially affected by the MSGP include anadromous salmon, sturgeon, groundfish, shellfish, and many others, including a number of species represented in commercial fisheries and species listed pursuant to the Endangered Species Act (ESA). In many cases stormwater collected and conveyed by the industries covered under the proposed MSGP will discharge to streams and other waters that support these aquatic resources of national importance.

For the purposes of this review we focused our analysis on four anadromous fishes, three species of west coast Pacific salmon (Chinook salmon, steelhead, and coho salmon), and one sturgeon species located along the East coast (shortnose sturgeon), to illustrate the effects of the MSGP on aquatic resources of national importance. These species, and the subsequent risk analysis, merely demonstrate some of the effects issuance of the EPA's MSGP and the associated industrial activities will have on aquatic resources of national importance. These cases are a sample of a large number of potentially informative examples.

Anadromous Fishes

The generalized life history of anadromous fish involves incubation, hatching, and emergence in fresh water; migration to the ocean or estuary; and the subsequent initiation of maturation and return to fresh water for completion of maturation and spawning. The juvenile rearing period in freshwater can be minimal or extended depending upon the species and the environmental characteristics in which it resides. Some anadromous fish may be more appropriately considered amphidromous because they will undertake migrations from salt waters back into fresh water for reasons other than spawning (as observed in some shortnose sturgeon (*Acipenser brevirostrum*) and coastal cutthroat trout (*Oncorhynchus clarki clarki*). Pacific salmon and sturgeon exhibit seasonal peaks in spawning migrations, which can precede spawning by weeks or months. In a given river basin there may be one or more peaks in migration activity. For Pacific salmon these runs are usually named for the season in which the peak occurs, some rivers may have runs known as winter-, spring-, summer-, or fall-run.

Chinook Salmon

The Chinook salmon (*O. tshawytscha*) is the largest-bodied of the seven Pacific salmon species. Historically Chinook salmon ranged from the Ventura River in California to Point Hope, Alaska, in North America, and in northeastern Asia from Hokkaido, Japan, to the Anadyr River in Russia (Healey 1991). Chinook salmon have also been reported in the Mackenzie River area of northern Canada (McPhail and Lindsey 1970).

Chinook salmon exhibit a diverse and complex life history strategy. Healey (1986) described up to 16 age categories for Chinook salmon, combinations of seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to that seen in sockeye salmon (*O. nerka*), although the latter species has a more extended freshwater residence period and uses different freshwater habitats (Burgner 1991; Miller and Brannon 1982). Gilbert (1912 in Myers *et al.* 1998) initially described two generalized freshwater life-history types: "stream-type" Chinook salmon, which resides in freshwater for a year or more following emergence, and "ocean-type" Chinook salmon, which migrates to the ocean within their first year. Healey (1983, 1991) has promoted the use of broader definitions for ocean-type and stream-type to describe two distinct races of Chinook salmon. Healey's approach incorporates life-history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of Chinook salmon populations.

Of the 17 distinct evolutionarily significant units (ESUs) of Chinook salmon NOAA Fisheries Service identified in Washington, Oregon, Idaho and California, two are listed as endangered pursuant to the ESA, which means they are in danger of extinction throughout all or a significant portion of its range. Seven Chinook salmon ESUs are listed as threatened species, meaning they are likely to become an endangered species within the foreseeable future throughout all or a significant portion of their range. Winter-run Chinook salmon in the Sacramento River and spring-run Chinook salmon Upper Columbia River are endangered, while those ESUs listed as threatened are:

- Snake River Spring/Summer-run
- Snake River Fall-run
- Puget Sound
- Lower Columbia River
- Upper Willamette River
- Central Valley Spring-run
- California Coastal

Steelhead

NOAA Fisheries has identified 15 ESUs for West Coast steelhead (*O. mykiss*) in Washington, California, Oregon, and Idaho. Of these, one (Southern California) ESU is listed as endangered and five are listed as threatened. The ESUs listed as threatened are:

- Upper Columbia River
- Central California Coast
- South Central California Coast
- Snake River Basin
- Lower Columbia River
- California Central Valley
- Upper Willamette River
- Middle Columbia River
- Northern California

Steelhead is the name commonly applied to the anadromous form of the biological species *Oncorhynchus mykiss*, while rainbow trout is the common name for the resident form. The present distribution of steelhead extends from the Kamchatka Peninsula in Asia, east to Alaska, and south to southern California, although the historical range of *O. mykiss* extended at least to the Mexico border (Busby *et al.* 1996). *O. mykiss* exhibit perhaps the most complex suite of life history traits of any species of Pacific salmon. They can be anadromous or freshwater resident (and under some circumstances, apparently yield offspring of the opposite form). Anadromous *O. mykiss* may spend up to 7 years in fresh water before outmigrating as smolts, and then spend up to 3 years in salt water prior to first spawning. The half-pounder life history type in southern Oregon and northern California spends only 2 to 4 months in salt water after smoltification, then returns to fresh water and outmigrates to sea again the following spring without spawning. Steelhead are iteroparous (can spawn more than once), whereas all other species of *Oncorhynchus*, except *O. clarki*, spawn once then die (semelparous).

Depending on water temperature, steelhead eggs may incubate for 1 to 4 months before hatching. Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Some older juveniles move downstream to rear in larger tributaries and mainstem rivers. Juveniles rear in freshwater from 1 to 4 years, then migrate to the ocean as smolts. Winter steelhead populations generally outmigrate as smolts after 2 years in fresh water (Busby et al 1996). Typically steelhead reside in marine waters for 2 or 3 years before returning to their natal stream to spawn at 4 or 5 years of age. Populations in Oregon and California have higher frequencies of age 1 ocean steelhead than populations to the north, but age 2 ocean steelhead generally remain dominant (Busby *et al.* 1996). Age structure appears to be similar to other west coast steelhead, dominated by 4 year old spawners (Busby *et al.* 1996).

Coho Salmon

NOAA Fisheries Service identified 7 ESUs of coho salmon (*O. kisutch*) in Washington, Oregon, Idaho and California. One ESU, Central California coast, is listed as endangered, while two are listed as threatened under the ESA. Threatened coho salmon are in the Southern Oregon/Northern California and Lower Columbia River ESUs.

Coho salmon is a widespread species of Pacific salmon, occurring in most major river basins around the Pacific Rim from Monterey Bay in California north to Point Hope, Alaska; through the Aleutians; and from the Anadyr River in Russia south to Korea and northern Hokkaido, Japan (Laufle *et al.* 1986). From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18months in freshwater and 18 months in salt water (Gilbert 1912 *in* Weitkamp *et al.* 1995; Sandercock 1991). The primary exceptions to this pattern are "jacks," sexually mature males that return to freshwater to spawn after only 5 to 7 months in the ocean. However, in southeast and central Alaska, the majority of coho salmon adults are 4-year-olds, having spent an additional year in fresh water before going to sea (Godfrey *et al.* 1975, and Crone and Bond 1976 *in* Weitkamp *et al.* 1995). The transition zone between predominantly 3- and 4-year-old adults occurs somewhere between central British Columbia and southeast Alaska.

With the exception of spawning habitat, which consists of small streams with stable gravels, summer and winter freshwater habitats most preferred by coho salmon consist of quiet areas with low flow, such as backwater pools, beaver ponds, dam pools, and side channels (Reeves *et al.* 1989). Habitats used during winter generally have greater water depth than those used in summer and also have greater amounts of large woody debris. West Coast coho smolts typically leave freshwater in the spring (April to June) and when sexually mature re-enter freshwater from September to November and spawn from November to December and occasionally into January (Sandercock 1991). Stocks from British Columbia, Washington, and the Columbia River often have very early runs (entering rivers in July or August) or late runs (spawning into March), in addition to normally timed runs.

Shortnose Sturgeon

The shortnose sturgeon is listed as endangered throughout its range. They occur along the Atlantic Coast of North America, from the St. John River in Canada to the St. John's River in Florida. NOAA Fisheries Service's recovery plan, published in 1998, recognized 19 wild populations based on capture data. Since the recovery plan was written, a number of genetic studies were conducted throughout the species range. Results from these studies reveal that shortnose sturgeon exhibit high fidelity to their natal rivers and estuaries resulting in significant population structuring at the basin scale (Kynard 1997; Walsh *et al.* 2001; Grunwald *et al.* 2002; Quattro *et al.* 2002; Waldman *et al.* 2002).

In general, shortnose sturgeon are benthic fish that occupy the deep channel sections of large rivers or estuarine waters of their natal rivers, and will migrate considerable distances. Dadswell (1979 in Dadswell *et al.* 1984) observed shortnose sturgeon traveling up 160 km between tagging and recapture in the St. John estuary, and it is not uncommon for adults to migrate 200 km or more to reach spawning areas (Kynard 1997).

The general migratory strategy of shortnose sturgeon is similar to many freshwater and diadromous fishes, which probably optimizes feeding opportunities, minimizes losses due to unfavorable conditions (winter refuge migrations), and optimizes spawning success (Northcote 1978; Harden-Jones 1968 in Dadswell 1984). Water temperatures, flow regimes, and barriers influence their movement patterns (Kynard 1997; Kynard *et al.* 2000). Adult shortnose sturgeon will migrate upstream to spawning areas in the spring or in the fall. Fish that migrate upstream in the fall generally overwinter in areas just downstream of spawning sites, while others including non-spawners will overwinter in estuarine waters. After spawning in the spring, spent (post-spawned) adults tend to migrate rapidly downstream to feeding areas in the estuary or to tidally influence fresh water (*see* Dadswell *et al.* 1984 for a review).

Young-of-the year shortnose sturgeon are believed to move downstream after hatching, remaining in fresh water for about 1 year (Kynard 1997). Initially, young shortnose sturgeon will reside short distances from spawning areas, and as they grow will tend to move further downstream (Dadswell *et al.* 1984). By age 3 or older juvenile sturgeon will spend a large portion of their year at the salt- and freshwater interface of coastal rivers (NMFS 1998).

Brief Overview of Coastal Water Conditions in the US

A disproportionate percentage of the nations population, and hence municipalities and industry are located in coastal regions of the US. Accounting for only 17% of the Nation's contiguous land area, coastal areas are home to more than 50% of the Nation's population and the rate of growth is faster than that of the nation as a whole (EPA 2005). This places significant pressures on coastal environments for waste disposal, development of shorelines habitats, water use, commerce and other uses. Toxic chemicals are a byproduct of these developmental pressures and are released into the water by a variety of point and non-point sources. Significant progress has been made in cleaning up polluted waters of the United States in the past 30 years, although much room for improvement remains. Recent assessments of the overall condition of United States coastal waters indicate that quality is generally fair to poor. Although many of the impairments are largely attributable to non-point sources of pollution, point sources contribute to overall conditions, in particular industry is frequently associated with elevated levels of heavy metals in sediment including lead, mercury, cadmium, and zinc (USGS 2001).

Water quality information from the 2000 305(b) reports submitted by states to EPA indicate that 51% of the assessed estuaries, 45% of the assessed lakes, and 39% of assessed rivers in the United States (excluding Alaska) are impaired by some form of pollution or habitat degradation. The 305(b) reports are required under the CWA, and are assessments by a state, tribe, or territory of the degree to which state water quality standards are being met, which may include biological, chemical, and physical measurements, the use of predictive models and surveys. While data are not nationally consistent and are often incomplete, EPA reported that the leading stressors resulting in these impairments are metals, siltation, nutrients, bacteria and oxygen-depleting substances (EPA 2000).

NOAA, EPA, and others conducted a national assessment using nationally consistent monitory surveys in an effort to overcome some of the problems inherent in the variable data submitted in 305(b) reports. The result is summarized in the National Coastal Conditions Reports, first published in 2001 using data from 1990 to 1996, and more recently updated in 2005 using data collected between 1997 and 2000. The National Coastal Conditions Reports focus on the quality of United States estuaries. The overall condition of the nation's coastal waters was rated as fair under both studies. The 2005 rating was based on five key indicators of ecological health: 1) water quality, 2) coastal habitat, 3) sediment quality, 4) benthic community condition, and 5) fish tissue contaminants. Indices are given equal weight to derive an overall condition for the nation and each region. Regional conditions are characterized as: poor in the Northeast Coast region; good in the Southeast Coast region; poor in the Gulf Coast region; poor in the West Coast region; poor in the Great Lakes region; and poor in Puerto Rico.

The poorest conditions, according to the indicators, are coastal habitat condition, sediment quality, and benthic conditions. Only one of the five indicators, the coastal habitat index, received a poor overall rating. The sediment and benthic indexes received fair to poor ratings, while the water quality index and the fish tissue contaminants index received fair ratings. The coastal habitat index is evaluated using data on estuarine-emergent and tidal flat acreage, the benthic index is an indicator of the condition of the benthic community. The water quality index includes dissolved oxygen (bottom waters below 2.0 mg/L DO is characterized as poor), chlorophyll *a*, nitrogen, phosphorus, and water clarity, and the sediment quality index is based on sediment toxicity, sediment contaminants, and sediment total organic carbon. The fish tissue contaminants index is a measure of the level of chemical contamination in target fish/shellfish species (EPA 2005).

Coastal monitoring indicate that about 70% of the United States estuaries show evidence of impaired and threatened aquatic life uses (EPA 2005). Sediment quality is poorest in the Northeast Coast, Puerto Rico and the West Coast, although many regions of the United States have significant sediment degradation from polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides and metals that are above EPA guidance levels. Data indicate that 60 % of the nation's estuaries are experiencing a moderate-to-high degree of water quality degradation (characterized by increased chlorophyll *a* concentration or decreased dissolved oxygen concentration; EPA 2005).

LITERATURE CITED

Alabaster, J.S., D.G. Shurben, and M.J. Mallett. 1983. The acute lethal toxicity of mixtures of cyanide and ammonia to smolts of salmon, *Salmo salar* L. at low concentrations of dissolved oxygen. Journal of Fish Biology 22:215-222.

Amick, J.P. 1994. Coping with EPA's Agricultural Industry Storm Water Permit, ASAE Paper No. 942088, American Society of Agricultural Engineers, St. Joseph, MI. *Cited in:* Line, D.E., J.A. Arnold, G.D. Jennings, and J.Wu. 1996. Water Quality of Stormwater Runoff from Ten Industrial Sites. Water Resources Bulletin 32(4):807-816.

Anestis, I., and R.J. Neufeld. 1986. Avoidance-preference reactions of rainbow trout (*Salmo gairdneri*) after prolonged exposure to chromium (VI). Water Resources 20:1233-1241.

Baldwin D.H., J.F. Sandahl J.S. Labenia and N. L. Scholz. 2003. Sublethal effects of copper on coho salmon: impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. Environmental Toxicology and Chemistry 22:2266-2274.

Berg, L. 1982. The effect of exposure to short-term pulses of suspended sediment on the behavior of juvenile salmonids. P. 177-196 in G.F. Hartman *et al.*, editors. Proceedings of the Carnation Creek workshop: a ten-year review. Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, Canada.

Berg, L. and T.G Northcote. 1985. Changes in territorial, gill flaring, and feeding behavior in juvenile coho salmon (Oncorhynchus kisutch) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410-1417.

Besser, J.M., N. Wang, F.J. Dwyer, F.L. Mayer, Jr., C.G. Ingersoll. 2005. Assessing contaminant sensitivity of endangered and threatened aquatic species: Part II. Chronic toxicity of copper and pentachlorophenol to two endangered species and two surrogate species. Archives of Environmental Contamination and Toxicology 48:155-165.

Beyerlein, D. 1999. Why Standard Stormwater Mitigation Doesn't Work Proceedings: Watershed Management to Protect Declining Species. Pages 477-479 *in* American Water Resources Association, Annual Water Resources Conference. Seattle, Washington.

Billard, R., and P. Roubaud. 1985. The Effect of Metals and Cyanide on Fertilization in Rainbow Trout. Water Res. 19:209-214.

Birtwell, I.K., G.F. Hartman, B. Anderson, D.J. McLeay, and J.G. Malick. 1984. A brief investigation of Arctic grayling (Thymallus arcticus) and aquatic invertebrates in the Minto Creek drainage, Mayo, Yukon territory: an area subjected to placer mining. Can. Tech. Rpt. Fish. Aquat. Sci. 1287.

Bjorn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society, Special Publications 19:83-138. Bethesda Maryland.

Bjorn, T. C., M. A. Brusven, M. Molnau, F. J. Watts, R. L. Wallace, D. R. Neilson, M.F. Sandine, and L.C. Stuehrenberg. 1974. Sediment in streams and its effects on aquatic life. Technical Completion Report, Project B-025-IDA. University of Idaho, Water Resource Research Institute, Moscow.

Booth, D. B. 2000. Forest Cover, Impervious-Surface area, and the Mitigation of Urbanization Impacts in King County, Washington. University of Washington, Center for Urban Water Resource Management, Seattle, Washington.

Booth, D.B. and L.E. Reinelt. 1993. Consequences of Urbanization on Aquatic Systems –Measured Effects, Degradation Thresholds, and Corrective Strategies. Pages 545-550 *in* Proceedings of the Watershed 1993: A National Conference on Watershed Management, Alexandria, Virginia.

Booth, D.B., J.R. Karr, S. Schauman, S.P. Konrad, S.A. Morley, M. G. Larson, P.C. Henshaw, E.J. Nelson and S.J. Burges. 2001. Urban Stream Rehabilitation in the Pacific Northwest. Washington Water Resource - Center for Urban Water Resources Management 12:1-11.

Brent, R.N., and E.E. Herricks. 1998. Post exposure effects of brief cadmium, zinc, and phenol exposures on freshwater organisms. Environmental Toxicology and Chemistry 17:2091-2099.

Brusven, M. A., and K. V. Prather. 1974. Influence of stream sediments on distribution of macrobenthos. Journal of the Entological Society of British Columbia 71:25-32.

Buckler, D. R., A. Witt, Jr., F. L. Mayer, and J. N. Huckins. 1981. Acute and chronic effects of kepone and mirex on the Fathead minnow. Transactions American Fisheries Society 110:270-280.

Bullard, W. E., Jr. 1965. Role of watershed management in the maintenance of suitable environments for aquatic life. Pages 265-269 *in* C. M. Tarzwell, editor. Biological problems in water pollution: transactions of the third seminar. United States Department of Health, Education, and Welfare, Public Health Service, Cincinnati Ohio.

Burgner, R.L. 1991. Life history of Sockeye Salmon (*Oncorhynchus nerka*). Pages 1 – 117 *in* Groot, C., and L. Margolis, editors. Pacific salmon life histories. UBC Press. University of British Columbia, Vancouver.

Busby P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California.: U.S. Dept. of Commerce. p 261 p.

Cederholm, C. J., L. C. Lestelle, B. G. Edle, D. J. Martin, J. V. Tagart, and E.O. Salo. 1978. The effects of landslide siltation on the salmon and trout resources of Stequaleho Creek and the main Clearwater River, Jefferson County, Washington, 1972-1975. Final Report FRI-UW-7804. University of Washington, Fisheries Research Institute, Seattle.

Cooper, A. C. 1959. Discussion of the effects of silt on survival of salmon eggs and larvae. Pages 18-22 in proceedings of the fifth symposium-Pacific Northwest on siltation-its source and effects on aquatic environment. U.S. Department of Health, Education and Welfare, Portland, Oregon.

Cooper, A. C. 1965. The effects of transported stream sediments on the survival of sockeye and pink salmon eggs and alevins. Bulletin 18. International Pacific Salmon Fisheries Commission, New Westminster, British Columbia, Canada.

Cordone, A. J., and D. W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game 47:189-228.

Cordone, A. J., and S. Pennoyer. 1960. Notes on silt pollution in the Truckee River Drainage. Inland Fisheries Administrative Report 60-14. State of California, California Fish and Game, Sacramento.

Crone, R.A. and C.E. Bond. 1976. Life history of coho salmon, Oncorhynchus kisutch, in Sashin Creek, southeastern Alaska. Fish. Bull., U.S., 74(4): 897-923. Cited in Weitkamp L.A., T.C. Wainwritght, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U. S. Dept. of Commerce. p 258.

Dadswell, M.J. 1979. Biology and population characteristics of the shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818 (Osteichthyes: Acipenseridae) in the Saint John River Estuary, New Brunswick, Canada. Can. J. Zool. 57:2186-2210. *In* Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818. National Oceanic and Atmospheric Administration Technical Report NMFS 14, Washington D.C.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818. National Oceanic and Atmospheric Administration Technical Report NMFS 14, Washington D.C.

Demayo, A., M.C. Taylor, K.W. Taylor, and P.V. Hodson. 1982. Toxic effects of lead and lead compounds on human health, aquatic life, wildlife plants, and livestock. CRC Crit. Rev. Environ. Control 12:257-305.

Denton D. L., Wheelock C. E., Murray S. A., Deanovic L. A., Hammock B. D., and D. E. Hinton. 2002. Joint Acute Toxicity of Esfenvalerate and Diazinon to Larval Fathead Minnows (Pimephales promelas) Environmental Toxicology and Chemistry. Vol. 22:336-341.

DeVore, P.W., L.T. Brooke, and W.A. Swenson. 1980. The effects of red clay turbidity and sedimentation on aquatic life in the Nemadji River system. Impact of nonpoint pollution control on western Lake Superior. S. C. Andrews, R. G. Christensen, and C. D. Wilson. Washington, D.C., U.S. Environmental Protection Agency. EPA Report 905/9-79-002-B.

Drummond, R.A., W.A. Sppor, and G.F. Olson. 1973. Some short-term indicators of sublethal effects of copper on brook trout, Salvelinus fontinalis. J. Fish. Res. Board Canada 30:698-701.

Dwyer, F.J., F.L. Mayer, L.C. Sappington, D.R. Buckler, C.M. Bridges, I.E. Greer, D.K. Hardesty, C.E. Henke, C.G. Ingersoll, J.L. Kunz, D.W. Whites, T. Augspurger, D.R. Mount, K. Hattala, G.N. Neuderfer. 2005a. Assessing contaminant sensitivity of endangered and threatened aquatic species: Part I. Acute toxicity of five chemicals. Archives of Environmental Contamination and Toxicology 48:143-154.

Dwyer, F.J., D.K. Hardesty, C.E. Henke, C.G. Ingersoll, D.W. Whites, T. Augspurger, T.J. Canfield, D.R. Mount, F.L. Mayer. 2005b. Assessing contaminant sensitivity of endangered and threatened aquatic species: Part III. Effluent toxicity tests. Archives of Environmental Contamination and Toxicology 48:174-183.

Eisler, R. 1986. Chromium hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Department of the Interior, Fish and Wildlife Service. Biological Report 85(1.6). 60 pp.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Department of the Interior, Fish and Wildlife Service. Biological Report 85(1.10). 90 pp.

Eisler, R. 1988. Lead hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Department of the Interior, Fish and Wildlife Service. Biological Report 85(1.14). 134 pp.

Eisler, R. 1993. Zinc hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Department of the Interior, Fish and Wildlife Service. Biological Report 10. 106 pp.

Eisler, R. 1998. Copper hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Department of the Interior, Geological Survey, Biological Resources Division. Biological Science Report USGS/BRD/BSR–1997-00002. 98 pp.

Eisler, R. 1991. Cyanide hazards to fish, wildlife, and invertebrates: A synoptic review. Biological Report 85(1.23). Fish and Wildlife Service Contaminant Hazard Review.

EPA [U.S. Environmental Protection Agency]. 1980a. Ambient water quality criteria for lead. U.S. Environmental Protection Agency Report 440/5-80-057. 151 pp.

EPA [U.S. Environmental Protection Agency]. 1980b. Ambient Water Quality Criteria for Cyanides. EPA Report 440/5-80-037.

EPA [U.S. Environmental Protection Agency]. 1985b. Ambient Water Quality Criteria for Cyanide - 1984. EPA Report 440/5-84-028.

EPA [U.S. Environmental Protection Agency]. 1985a. Ambient water quality criteria for lead - 1984. U.S. Environmental Protection Agency Report 440/5-84-027. 81 pp.

EPA [U.S. Environmental Protection Agency]. 1991. Technical Support Document for Water Quality-base Toxics Control. EPA/505/2-90-001. Washington, DC, USA.

EPA [U.S. Environmental Protection Agency]. 1996. 1995 Updates: Water quality criteria documents for the protection of aquatic life in ambient water. Office of Water. EPA-820-B-96-001.

EPA [U.S. Environmental Protection Agency]. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. April 1998.

EPA [U.S. Environmental Protection Agency]. 1999a. Introduction to water quality standards. EPA-823-F-99-020. Office of Water, October 1999.

EPA [U.S. Environmental Protection Agency]. 1999b. Biological Assessment of the Idaho Water Quality Standards for Numeric Water Quality Criteria for Toxic Pollutants for the U.S. Fish and Wildlife Service and National Marine Fisheries Service. Seattle, WA.

EPA [U.S. Environmental Protection Agency]. 2000. National Water Quality Inventory: 2000 Report. EPA-841-R-02-001. Office of Water, Washington DC 20460. Available at: http://www.epa.gov/305b/2000report

EPA [U.S. Environmental Protection Agency]. 2001a. Technical Synthesis: Scientific

EPA [U.S. Environmental Protection Agency]. 2001b. Summary of Technical EPA-910-D-01-005. May 2001.

EPA [U.S. Environmental Protection Agency]. 2005. National Coastal Condition Report II. United States Environmental Protection Agency, Office of Research and Development, Office of Water, Washington DC 20460.

Farag, A.M., C.J. Boese, D.F. Woodward, and H.L. Bergman. 1994. Physiological changes and tissue metal accumulation in rainbow trout exposed to foodborne and waterborne metals. Environmental Toxicological and Chemistry 12:2021-2030.

Folmar, L.C. 1976. Overt avoidance reaction of rainbow trout fry to nine herbicides. Bulletin of Environmental Contamination and Toxicology 15:509-514.

Frissell, C.A. 1999. An ecosystem approach to habitat conservation for bull trout: groundwater and surface water protection. Open File Report Number 156-99. Flathead lake Biological Station, The University of Montana, Polson, MT.

GAO [United States General Accounting Office]. 1993. Environmental Enforcement: EPA Cannot Ensure the Accuracy of Self-Reported Compliance Monitoring Data. Report to the Chairman, Committee on Government Affairs, U.S. Senate. GAO/RCED-93-21.March 1993.)

GAO [United States General Accounting Office]. 1994. Water Pollution: Poor Quality Assurance and Limited Pollutant Coverage Undermine EPA's Control of Toxic Substances. Report to the Chairman, Subcommittee on Superfund, Ocean, and Water Protection, Committee on Environment and Public Works, U.S. Senate. GAO/PEMD-94-9

Ghanmi, Z., M. Rouabhia, O. Othmane, and P.A. Deschaux. 1989. Effects of metal ions on cyprinid fish immune response: in vitro effects of Zn2+ and Mn2+ on the mitogenetic response of carp pronephros lymphocytes. Ecotoxicology and Environmental Safety 17:183-189.

Gilbert, C.H. 1912. Age at maturity of the Pacific coast salmon of the genus Oncorhynchus. Fish. Bull., U.S. 32:3-22.

Gimon, A., V. Myers, and C. Petry. 1998. The role of pollution prevention in reducing nutrient enrichment of Chesapeake Bay. Pollution prevention in the coastal zone, National Pollution Prevention Center for higher education, Univ. of Michigan.

Godfrey, H., K.A. Henry, and S. Machidori. 1975. Distribution and abundances of coho salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 31, 80 p. *Cited in* Weitkamp L.A., T.C. Wainwritght, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U. S. Dept. of Commerce. p 258.

Gregory, S.V. and P.A. Bisson. 1997. Degradation and loss of anadromous salmonid habitat in the Pacific Northwest. Pages. 277-314 *in* D.J. Stouder, P.A. Bisson and R.J. Naiman, editors. New York Pacific salmon and their ecosystems: status and future options. Chapman and Hall.

Grunwald, C. J. Stabile, J.R. Waldman, R. Gross, and I. Wirgin. 2002. Population genetics of shortnose sturgeon *Acipenser brevirostrum* based on mitochondrial DNA control region sequences. Molecular Ecology 11:1885-1898.

Hammond, P.B., and R.P. Beliles. 1980. Metals. Pages. 409-467 *In* J. Doull, C.D. Klaasen, and M.O. Amdur (Eds.). Toxicology, the basic science of poisons, second edition. Macmillan Publishing Co., Inc., New York, NY. .

Hansen, J.A. , P.G. Welsh, J. Lipton and M.J. Suedkamp. 2002a. The effects of long-term cadmium exposure on the growth and survival of juvenile bull trout (*Salvelinus confluentus*). Aquatic Toxicology 58:165-174.

Hansen, J.A., J.D. Rose, R.A. Jenkins, K.G. Gerow, and H.L. Bergman. 1999. Chinook Salmon (*Oncorhynchus tshawytscha)* and Rainbow Trout (*Oncorhynchus mykiss)* Exposed to Copper: Neurophysical and Histological Effects on the Olfactory System. Environmental Toxicology and Chemistry 18: 1979-1991.

Hansen, J.A., P.G. Welsh, J. Lipton, D. Cacela and A.D. Dailey. 2002b. Relative sensitivity of bull trout (*Salvelinus confluentus*) and rainbow trout (*Oncorhynchus mykiss*) to acute exposures of cadmium and zinc. Environmental Toxicology and Chemistry 21:67-75.

Harden-Jones, F.R. 1968. Fish Migration. Edward Arnold, Long., 325p. *In* M.J. Dadswell, B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818. National Oceanic and Atmospheric Administration Technical Report NMFS 14, Washington D.C.

Healey, M.C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type chinook salmon, Oncorhynchus tshawytscha. Can. Field-nat. 97:427-433.

Healey, M.C. 1986. Optimum size and age maturity in Pacific salmon and effects of size-selective fisheries. Can. Spec. Publ. Fish. Aquati. Sci. 89:39-52.

Healey, M.C. 1991. Life history of Chinook Salmon (*Oncorhynchus tshawytscha*). Pages 311 – 393 *in* Groot, C., and L. Margolis, editors. Pacific salmon life histories. UBC Press. University of British Columbia, Vancouver.

Heming, T. A., and K. A. Blumhagen. 1989. Factors influencing thiocyanate toxicity in rainbow trout *Salmo gairdneri*. Bull. Environ. Contam. Toxicol. 43:363-369.

Herbert, D. W., J. S. Alabaster, M. C. Dart, and R. Lloyd, 1961. The effect of china-clay wastes on trout streams. International Journal of Air and Water Pollution 5:56-74.

Hilmy, A. M., N.A. El-Domiaty, A.Y Daabees, and H.A.A. Latife. 1987a. Some physiological and biochemical indices of zinc toxicity in two freshwater fishes, *Clarias lazera* and *Tilapia zilli*. Comparative Biochemistry and Physiology 87C:297-301.

Hilmy, A.M., N.A. El-Domiaty, A.Y. Dadbees, and H.A.A. Latife. 1987b. Toxicity in *Tilapia zilli* and *Clarias lazera* (Pisces) induced by zinc, seasonally. Comparative Biochemistry and Physiology 86C:263-265.

Issues Relating to Temperature Criteria for Salmon, Trout, and Char Native to the

Karr, J. R. and E.W. Chu. 2000. Sustaining Living Rivers. Excerpts from Hydrobiologia 422/423: 1-14, 2000.

Karr, J.R., Horner, R.R. and Horner, C.R. 2003. EPA's Review of Washington's Water Quality Criteria: An Evaluation of Whether Washington's Criteria Proposal Protects Stream Health and Designated Uses. Paper Commissioned by the National Wildlife Federation.

Kevan, S.D., and D.G. Dixon. 1991. The acute toxicity of pulse-dosed thiocyanate (as KSCN and NaSCN) to rainbow trout (*Oncorhynchus mykiss*) eggs before and after water hardening. Aquat. Toxicol. 19:113-122.

Kim, L-H, M. Kayhanian, S-L Lau, & M.K. Stenstrom. 2003. A new modeling approach for estimating first flush metal mass loading. Diffuse Pollution Conference Dublin 2003.

Klein, R. D. 1979. Urbanization and stream quality impairment. Water Resources Bulletin. 15: 948-963.

Kovacs, T.G., and G. Leduc. 1982. Sublethal toxicity of cyanide to rainbow trout (*Salmo gairdneri*) at different temperatures. Can. J. Fish. Aquat. Sci. 39:1389-1395.

Kynard, B. 1997. Life history, latitudinal patterns, and status of the shortnose sturgeon, *Acipenser brevirostrum*. Environmental Biology of Fishes 48:319-334.

Kynard, B., M. Horgan, M. Kieffer, and D. Seibel. 2000. Habitats used by shortnose sturgeon in two Massachusetts Rivers, with notes on estuarine Atlantic sturgeon: A hierarchical approach. Trans. Am. Fish. Soc. 129:487-503.

Lanno, R.P., and D.G. Dixon. 1996. The comparativc chronic toxicity of thiocyanate and cyanide to rainbow trout. Aquat. Toxicol. 36:177-187.

Laufle, J.C., G.B. Pauley, and M.F. Shepard. 1986. Species profiles: Life histories and environemtnal requirements of coastal fishes and invertebrates (Pacific Northwest): coho salmon. U.S. Fish and Wild. Serv. Biol. Rep. 82 (11.48), 18 p.

Lawson, E.M., G.B. Mitchell, and D.G. Walton. 1985. Stormwater monitoring in an industrial catchment basin located in Burnaby, British Columbia. Waste Management, Lower Mainland Region, Ministry of Environment, Province of British Columbia.

Leduc, G. 1984. Cyanides in water: Toxicological significance. P. 153-224 in: Weber, L.J. [Ed.]. Aquatic toxicology, Volume 2. Raven Press, New York, NY.

Lee, H. and M.K. Stenstrom. 2005. Utility of Stormwater Monitoring. Water Environment Research. 77(3):219-228.

Lictritz, E., and R.C. Lewis. 1980. Trout and salmon culture (hatchery methods). Cal. Fish. Bull. No. 164, Univ. Of California.

Linbo AO, Stehr CM, Incardona JP, Scholz NL. 2006. Dissolved copper triggers cell death in the peripheral mechanosensory system of larval fish. Environmental Toxicology and Chemistry 25:597-603

Line, D.E., J.A. Arnold, G.D. Jennings, and J.Wu. 1996. Water Quality of Stormwater Runoff from Ten Industrial Sites. Water Resources Bulletin 32(4):807-816.

Literature Examining the Physiological Effects of Temperatures on Salmonids.

Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

Lucchetti, G. and R. Fuerstenberg. 1993. Management of coho salmon habitat in urbanizing landscapes of King County, Washington, USA. Pages 308-317 *in* Proceedings of the Coho Salmon Workshop. Canadian Department of Fisheries and Oceans, Habitat Management Sector, Policy and Information Unit, Vancouver, British Columbia.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr and B.W. Mar. 1998. Quality indices for urbanization effects in Puget Sound Lowlands streams. Final Report for Washington Department of Ecology. Publication 98-04.

McHenry, M. L., D. C. Morrill, and E. Currence. 1994. Spawning gravel quality, watershed characteristics and early life history of coho salmon and steelhead in five North Olympic Peninsula watersheds. Prepared by the Lower Elwha S'Kallan tribe and the Makah Tribe, Port Angeles WA.

McNeil, W. J., and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. Special Scientific Report-Fisheries 469. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

McPhail J.D., and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Ottawa: Fish. Res. Board Can. Bull. 173. 381 p.

Miller R.J., and E.L. Brannon. The origin and development of life-history patterns in Pacific salmon. In: Brannon EL, Salo EO, editors; 1982; Seattle, WA. Univ. Wash. Press. p 296-309.

Moffa, P.E. 1996. The control and treatment of industrial and municipal stormwater. Van Nostrand Reinhold, New York, NY. 310 p.

Morgan, R.P., V.J. Rasin and L.A. Noe. 1973. Effects of Suspended Sediments on the Development of Eggs and Larvae of Striped Bass and White Perch. Natural resources Institute, Chesapeake Biological Laboratory, U of Maryland, Center for Environmental and Estuarine Studies. 20 pp.

Myers J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neeley, S.T. Lindley and others. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-35: U.S. Dept. of Commerce. 443 p.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693-727.

Niyogi, S., Couture, P., Pyle, G., McDonald, D.G., and C.M. Wood. 2004. Acute cadmium biotic ligand model characteristics of laboratory-reared and wild yellow perch (*Perca flavescens*) relative to rainbow trout (*Oncorhynchus mykiss*). Canadian Journal of Fish and Aquatic Sciences. 61, 942-953.

NMFS [National Marine Fisheries Service]. 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring MD.

Northcote, T.G. 1978. Migratory strategies and production in freshwater fishes. Pages 326-359 *in* S.D. Gerking, editor. Ecology of freshwater fish production. Blackwell Scientific Publications. Oxford, UK.

Nuttall, P. M., and G. H. Bilby. 1973. The effect of china-clay wastes on stream invertebrates. Environmental Pollution 5:77-86.

Otto B., K.Ransel, J. Todd, D. Lovaas, H. Stutzman, and J. Bailey. 2002. Paving our way to water shortages: How sprawl aggravates the effects of drought. American Rivers, NRDC and Smart Growth America. 32 p.

Pacific Northwest. EPA 910-R-01-007. August 2001, pp 21.

Playle, R.C. 2004. Using multiple metal-Gill binding models and the toxic unit concept to help reconcile multiple-metal toxicity results. Aquatic Toxicology 67 (2004) 359-370.

Prestes, E.C., V.E. dos Anjos, F.F. Sodré, & M.T. Grassi. 2005. Copper, lead, and cadmium loads and behavior in urban stormwater runoff in Curitiba, Brazil. Journal of Brazilian Chemical Society. Available @: http://jbcs.sbq.org.br/online/fpapers/026-05.pdf

Quattro, J.M., T.W. Greig, D.K. Coykendall, B.W. Bowen, and J.D. Baldwin. 2002. Genetic issues in aquatic species management: the shortnose sturgeon (*Acipenser brevirostrum*) in the southeastern United States. Conservation Genetics 3:155-166.

Rai, U.N., R.D. Tripathi, S. Sinha and P. Chandra. 1995. Chromium and cadmium bioaccumulation and toxicity in Hydrilla verticillata (l.f.) Royle and Chara coralline Wildenow. J. Environ. Sci. Health. A30: 537-551.

Rand, G. M. and S. R. Petrocelli, editors. 1985. Fundamentals of aquatic toxicology: methods and applications. Hemisphere Publishing Corporation, Washington D.C.

Redding, J.M., C.B. Schreck, and F.H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions of the American Fisheries Society 116:737-744.

Reed, R. D., and S. T. Elliot. 1972. Effects of logging on Dolly Varden. Project F-9-4, Job R- V-B. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Division of Sport Fisheries, Juneau, Alaska.

Reeves G.H., F.H. Everest, and T.E. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in Western Oregon and Washington. Gen. Tech. Rep. PNW-GTR-245. Portland, OR: United States Department of Agriculture, Forest Service, Pacific Northwest Research Station. p 18 p.

Sanchez-Dardon, J., I. Voccia, A. Hontela, S. Chilmonczyk, M. Dunier, H. Boermans, B. Blakley, and M.Fournier. 1999. Immunomodulation by heavy metals tested individually or in mixtures in rainbow trout (*Oncorhynchus mykiss*) exposed in vivo. Environmental Toxicology Chemistry 18:1492-1497.

Sandahl JF, Baldwin DH, Jenkins JJ, Scholz NL. A sensory system at the interface between stormwater runoff and salmon survival. Submitted to Conservation Biology

Sandercock, F.K. 1991. Life history of Coho Salmon (*Oncorhynchus kisutch*). Pages 395 – 445 *in* Groot, C., and L. Margolis, editors. Pacific salmon life histories. UBC Press. University of British Columbia, Vancouver.

Scannell, P.O. 1988. Effects of elevated sediment levels from placer mining on survival and behavior of immature Arctic Grayling. Alaska Cooperative Fishery Unit, University of Alaska. Unit Contribution 27.

Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques. 1: 100-111.

Scott, G.R., and K.A. Sloman. 2004. The effects of environmental pollutants on complex fish behavior: integrating behavioral and physiological indicators of toxicity. Aquatic Toxicology 68(2004): 369-392.

Scott, G.R., K.A. Sloman, C. Rouleau, C.M. Wood. 2003. Cadmium disrupts behavioral and physiological responses to alarm substances in juvenile rainbow trout (*Oncorhynchus mykiss*). Journal of Experimental Biology 206:1779-1790.

Severizi, J.A. and D.W. Martens. 1987. Some effects of suspended Fraser River sediments on sockeye salmon (*Oncorhynchus nerka*), p. 254-264, in H.D. Smith, L. Margolis, and C.C. Wood, editors. Sockeye salmon (*Oncorhynchus nerka*) population biological and future mangement. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Severizi, J.A. and D.W. Martens. 1992. Sublethal responses of coho salmon (*Oncorhynchus kisutch*) to suspended sediments. Can. J. Fish. Aquat. Sci., Vol. 49: 1389-1395.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transaction of the American Fisheries Society 113: 142-150.

Sloman, K.A., D.W. Baker, C.G., Ho, D.G. McDonald, and C.M. Wood. 2003. Cadmium affects the social behavior of rainbow trout, Oncorhynchus mykiss. Aquat. Toxicol. 65:171-185.

Sorensen, E.M. 1991. Metal poisoning in fish. CRC Press, Boca Raton, FL. Pp. 285-332. Spacie, A. and J.L. Hamelink. 1985. Bioaccumulation. *In:* F.M. Rand, and S.R. Petrocelli (Eds.). Fundamentals of Aquatic Toxicology. Hemisphere, Washington, D.C. pp. 495-525.

Spence, B. C., G. A. Lomnicky, R. M. Hughs, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR. (Available from the National Marine Fisheries Service, Portland, Oregon.).

Sprague, J.B. 1964. Avoidance of copper-zinc solutions by young salmon in the laboratory. J. Water Pollut. Control Fed. 36:990-1004.

Spromberg, J. and N. Scholz. 2005 Recurrent die-offs of coho salmon returning to spawn in restored urban streams: modeling population-scale effects (abstract). Presentation SPR-1117-848608 at 26th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Baltimore, MD.

Stephan, C.E., D.I. Mount, D.J. Hansen, J.H. Gentile, G.A. Chapman, and W.A. Brunge. 1985. Guidelines for Deriving Numerical Criteria for the Protection of Aquatic Organisms and Their Uses. U.S. Environmental Protection Agency, Office of Research and Development, Duluth, Minnesota.

Stevens, D.G. and G.A. Chapman. 1984. Toxicity of trivalent chromium to early life stages of steelhead trout. Environmental Toxicology and Chemistry 3:125-133.

USFWS and NMFS. 2000. [Final biological opinion on California Toxics Rule]: Letter of March 24, 2000 from Michael J. Spear and Mc Innis, Rodney R. to Ms. Felicia Marcus, Administrator EPA Region 9, regarding the "Final Rule for the Promulgation of Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California". U.S. Fish and Wildlife Service, Sacramento CA and National Marine Fisheries Service, Long Beach, CA, Reference 1-1-98-F-21. 236 pp.

USGS [United States Geological Survey]. 2001. Selected findings and current perspectives on urban and agricultural water quality by the National Water-Quality Assessment Program. Fact Sheet. Available at: http://water.usgs.gov/nawqa/.

Waldman, J.R., C. Grunwald, J. Stabile, and I. Wirgin. 2002. Impacts of life history and biogeography on the genetic stock structure of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus,* Gulf sturgeon *A. oxyrinchus desotoi,* and shortnose sturgeon *A. brevirostrum.* J. Appl. Ichthyol. 18(2002):509-518.

Walsh M.G., M.B. Bain, T. Squiers, J.R. Waldman, and I. Wirgin. 2001. Morphological and genetic variation among shortnose sturgeon *Acipenser brevirostrum* from adjacent and distant rivers. Estuaries 24:41-48.

Washington State Department of Ecology. 2002. Background Materials on the Stormwater Management Manual for Western Washington. Washington Dept of Ecology, Olympia, Washington.

Weitkamp L.A., T.C. Wainwritght, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U. S. Dept. of Commerce. p 258.

Wickett, W. P. 1958. Review of certain environmental factors affecting the production of pink and chum salmon. Journal Fisheries Research Board of Canada 15:1103-1126.