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April 11, 2011

Ms. Susan Bunsick
1315 East-West Highway
SSM C#3-13th Floor Rm 13152
Silver Spring, MD 20910

Re: Sierra Club Comments on NOAA and Department of Commerce Draft Aquaculture Policies

Dear Ms. Bunsick,

The Sierra Club appreciates the opportunity to provide comments and supporting documentation on the NOAA and Department of Commerce (DOC) Draft Aquaculture policies. Please accept these comments to be on record for both. We also fully support the comments and recommendations provided in the letter dated April 10, 2011 from the following organizations: Monterey Bay Aquarium, Pacific Coast Federation of Fishermen's Associations, National Coalition for Marine Conservation, Ocean Conservancy, Oceana, Institute for Fisheries Resources, Marine Fish Conservation Network and San Diego Coastkeeper.

Section 1--Our Major Concerns in addition to those listed in the April 10, 2011 letter referenced above

1. Lack of Adequate Environmental Assessments on Existing Aquaculture Sites and Operations

Up to this point, there have not been adequate environmental assessments of individual site impacts or cumulative impacts of aquaculture activities conducted as pilot projects, or small scale grants projects. To the frustration of citizens concerned about the environmental impacts of past aquaculture activities, categorical exclusions were used to avoid the necessary comprehensive analyses. All future aquaculture activities should have adequate environmental reviews and special classifications should not be allowed as means for avoiding regulatory oversight.

2. Lack of Adequate Science and Disclosure of Impacts Provided to Decision Makers

In order to make informed decisions on policies and programs of the magnitude encompassed within a national aquaculture policy, decision makers must have access to independent peer reviewed science on which to base such decisions. While we were participating in the recent NOAA listening sessions, we were directed to visit the NOAA website to review the applicable science. We found no information on the website regarding documented environmental impacts associated with finfish aquaculture. The studies included for shellfish aquaculture provided a positive perspective, but failed to disclose the serious impacts that are also well documented.

We do not see how such a far reaching policy can be implemented to protect our public resources when adverse impacts of industrial aquaculture are ignored. NOAA continues to state that they recognize the importance of science, yet it is apparent that substantial scientific assessment of impacts and risks has not been conducted.

We are also concerned that there is tremendous pressure on National Marine Fisheries Service scientists simultaneously seeking to objectively evaluate the impacts and documented harms of aquaculture projects, while also reporting organizationally to the same entity that is actively promoting such projects. It is essential to preserve public trust in the environmental assessment and regulatory processes. Scientists working on NOAA aquaculture expansion must be free from internal pressure, to insure decisions that are in the best interest of our marine environment, wild species and all stakeholders

The lack of environmental assessments and the lack of adequate science is especially a concern when the NOAA Draft Aquaculture announcement featured on the NOAA webpage as of April 9, 2011 states as follows:

- "The intent of the policies is to guide Commerce and NOAA's actions and decisions on aquaculture and to provide a national approach for supporting sustainable aquaculture."

- "NOAA will begin to implement this policy immediately upon release of the final document."

Section 2—The Need for Compliance with Federal Regulations and National Environmental Policy Act (NEPA)

Should NOAA receive from Congress the authority needed to properly regulate aquaculture in federal waters, NOAA is obligated under NEPA to require both regional programmatic Environmental Impact Statements, as well as site-specific environmental reviews. NEPA regulations apply to both the NOAA policy and the program activities. A review of the program actions under this policy is definitely within the guidelines of the NEPA Act.

It is clear from reviewing information from our Chapters in Sierra Club around the country, that there are unique regional habitat and native species requirements in the Northeast, the Pacific Northwest (Puget Sound and the Straits of Juan de Fuca), The Gulf of Mexico and Hawaii. It is critical that there is meaningful public input from each region, that the smaller projects are reviewed for cumulative impacts, and that the scientists who are working on these projects are fully informed of the documented and potential impacts related to the projects. The documentation we are providing in later sections of this comment letter clearly demonstrates that there are significant impacts from both finfish and shellfish aquaculture. Much of the science we have provided is peer reviewed. It is also very important that all of the steps taken by NOAA be transparent in order to build public confidence.

To be specific, the relevant NEPA requirements are described in the following excerpts from the CEQ document titled "NEPA's Forty Most Asked Question's:

- Question #24a. **Environmental Impact Statements on Policies, Plans or Programs.** When are EISs required on policies, plans or programs?

A. An EIS must be prepared if an agency proposes to implement a specific policy, to adopt a plan for a group of related actions, or to implement a specific statutory program or executive directive. Section 1508.18. In addition, the adoption of official policy in the form of rules, regulations and interpretations pursuant to the Administrative Procedure Act, treaties, conventions, or other formal documents establishing governmental or agency policy which will substantially alter agency programs, could require an EIS. Section 1508.18. In all cases, the policy, plan, or program must have the potential for significantly affecting the quality of the human environment in order to require an EIS. It should be noted that a proposal "may exist in fact as well as by agency declaration that one exists." Section 1508.23.

- Question #24b. When is an **area-wide or overview EIS** appropriate?

A. The preparation of an area-wide or overview EIS may be particularly useful when similar actions, viewed with other reasonably foreseeable or proposed agency actions, share common timing or geography. For example, when a variety of energy projects may be located in a single watershed, or when a series of new energy technologies may be developed through federal funding, the overview or area-wide EIS would serve as a valuable and necessary analysis of the affected environment and the potential cumulative impacts of the reasonably foreseeable actions under that program or within that geographical area.

- Question #24c. What is the function of **tiering** in such cases?

A. Tiering is a procedure which allows an agency to avoid duplication of paperwork through the incorporation by reference of the general discussions and relevant specific discussions from an environmental impact statement of broader scope into one of lesser scope or vice versa. In the example given in Question 24b, this would mean that an overview EIS would be prepared for all of the energy activities reasonably foreseeable in a particular geographic area or resulting from a particular development program. This impact statement would be followed by site-specific or project-specific EISs. The tiering process would make each EIS of greater use and meaning to the public as the plan or program develops, without duplication of the analysis prepared for the previous impact statement.

> (b) NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. Most important,

NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail.

(c) Ultimately, of course, it is not better documents but better decisions that count. NEPA's purpose is not to generate paperwork--even excellent paperwork--but to foster excellent action. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment. These regulations provide the direction to achieve this purpose. (Source: NEPA Section 1500.1 Purpose)

Section 3—Shellfish Aquaculture Significant Environmental Impacts

Shellfish aquaculture practices and the species that are grown vary significantly between different regions of the county. For this reason, a regional EIS is especially important that identifies the unique habitats and native species and the health of that particular region.

Puget Sound—An Estuary of National Significance with the Most Endangered Species in the Country other than Hawaii

NOAA and the shellfish industry have identified Puget Sound as a major expansion area for aquaculture growth of both shellfish and finfish. A regional EIS is especially important in Puget Sound where there is no doubt that significant adverse environmental impacts are already occurring in the areas where aquaculture expansion has resulted in high density introductions of non-native species like Pacific oysters, Manila clams and Gallo mussels. In the late 1990's, intertidal geoduck operations were also added.

Nowhere else in the United States has shellfish aquaculture expanded like it has in Puget Sound over the last 15 years. While industry can say they have been operating in Washington for over 100 years, this expansion has been outside their historical areas with minimal oversight. The evidence shows that the native species of clams and Olympia oysters were not found in these high densities and the Olympia oyster naturally grew further down in the intertidal areas than cultured oysters. Aquaculture projects characterized by unnaturally high densities of shellfish - grown with the use of plastic grow bags, plastic nets, PVC, plastic net tops, rubber bands, plastic zip ties and anchors - have been allowed to expand into Puget Sound's **limited high-value habitats** for forage fish and Critical Salmon habitat, without independent scientific assessment of the impacts of such expansion. Since South Puget Sound is considered by scientists as the nursery for our native species, the expansion of industrial aquaculture presents a major concern.

While the science that is contained on your NOAA website expresses the virtues of "cleaning the water," the other ecological impacts seem to have been ignored. It is well documented that not one local, state or federal authority has denied industry the use of any area they wanted to use or questioned the clearing, the purging of all marketable native species, the dredging , the tilling, the depletion of zooplankton of our native species in the intertidal areas, the introduction of harmful invasive species, the elimination of native animal and plant species they deemed as pests, the harassment and destruction of migrating birds and the introduction of millions of pieces of marine plastic debris.

We have provided detailed documentation on shellfish impacts in Exhibit A as we do not see where these impacts have been documented in the NOAA literature we have reviewed.

Section 4—Problems with Finfish Farming

Since we did not see any information on the NOAA website that documented these significant impacts, we have provided the following list. Please see Exhibit B for a comprehensive list of relevant science studies that should be made available to the public and provided to those scientists who are reviewing implementation of your policy.

1. Potential amplification and spread of disease and parasites to wild fish populations from open cage, submerged and net pen aquaculture operations.

2. Escape of various levels of farmed native or non-native species and genetically modified fish into the open ocean and near shore environments with potential ecological and genetic impacts

3. Deterioration of water quality and impacts on resident and migrating sea life, resulting from the use of various cage materials, biological pollution from fish feces, flushing of chemotherapeutants, pesticides and other chemicals into the surrounding waters. How will this meet the terms of the relevant state and federal fisheries and environmental laws (e.g. Clean Water Act, ESA, and MMPA)?

4. Alterations of benthic environments beneath the net pens from disturbances from anchoring, concentration of feed and feces, discarded and lost netting, plastic feed bags, etc.

5. Global net loss of protein from the use of fish feeds comprised of small fish harvested from Southern oceans and coastlines of developing nations. The changes in pelagic fish populations result in less feed for various predator fish species, seabirds and mammals.

6. Increased carbon footprint from the use of fossil fuels and other energy resources from long distance air freighting of "fresh" products and industrial harvest and processing of pelagic fish for feed. The Hawaiian finfish aquaculture operations have an especially large carbon footprint. These operations raise omnivorous or carnivorous fish species requiring imports of fish feed from distant sources, and export a large percentage of product long distances by air.

7. Transparent monitoring and reporting systems must be in place, so that the public can be assured for example, that an outbreak of disease among either the captive or the wild fish populations would be easily detected early on and appropriate action taken quickly.

Concerns Regarding Hawaii Finfish Aquaculture

1. Use of Hawaiian waters as a testing ground for open ocean aquaculture ventures. Hawaii is currently the site of two open ocean finfish aquaculture operations operating in state waters, Hukilau Foods, LLC and Kona Blue Water Farms, the latter conducting its operations under Keahole Point Fish LLC. A third operation, Hawaii Ocean Technologies, Inc. (HOTI) project has been granted a state lease and permit, and has a Corps of Engineers

permit currently under review. The State of Hawaii Conservation Use District Permit authorizes HOTI to deploy as many as twelve offshore submerged cages, described in the HOTI EIS as self-powered un-tethered "Oceanspheres" 54 meters in diameter. Since these cages would be untethered, they presumably could be deployed rather easily in the EEZ. We are concerned that NOAA's promotion of offshore aquaculture throughout the EEZ, including Guam, American Samoa, and the Commonwealth of the Marianas, could be based on extrapolation of the limited experiences to date with operations that are either still in the experimental stage, as with HOTI, or operating under production levels that are still relatively low compared to production levels required for economic sustainability.

2. Insufficient study of the potential impacts, including cumulative impacts, of increasing the size and number of open ocean aquaculture operations, including expansions into federal waters. The State of Hawaii has required environmental assessments, and in some cases, full environmental impact statements, on a project by project basis, but has not conducted a programmatic EIS for its aquaculture program as whole. In particular, we are concerned that the potential for spreading diseases and parasites among wild fish populations as the captive fish populations increase in number and location has not been adequately addressed.

3. Potential cumulative impacts of increased nutrient loads into coastal waters and the potential for spread of invasive algae species. The Hawaiian archipelago is one of the most isolated regions on Earth, and as a result has a very high level of endemism. It has also proven to be very vulnerable to impacts from alien species, some of which include alien algae species intentionally introduced for purposes of aquaculture. The spread of alien algae species has been linked to nutritional levels in the ocean, and the transport of algae fragments from one location to another by barges or by the action of currents. Large scale open ocean aquaculture operations, or increased numbers of small operations, could contribute to the total nutrient loads in coastal waters increasing the risks of promoting growth of invasive algae species. Also, since net pens provide a substrate for accumulation of growths from all sources, including invasive species, cleaning of net pens could promote spread of such species, as could the movement of untethered net pens from location to location, or the transportation of net pens from open ocean waters into coastal areas for maintenance or replacement. An evaluation, by independent scientists, should be made of these risks prior to expansion of open ocean aquaculture in state waters or the EEZ.

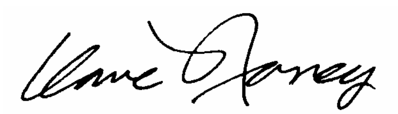
4. Attempts to conduct aquaculture in the Hawaiian EEZ by defining net pens as a "new gear type" for "fishing" in federal waters under a Fishery Management Plan. We support the position taken by Ocean Conservancy, Marine Fish Conservation Network, and others that "aquaculture is not fishing and the nation's fishing laws are an inappropriate vehicle to regulate aquaculture." Further, NOAA will be judged by its actions as well as its words. In this case, during the very time when a NOAA Draft Aquaculture Policy was proclaiming, among other things, that "***Management decisions for aquaculture operations in federal waters should be made in an efficient and transparent manner that produces timely, unbiased, and scientifically based decisions," including "providing public notice and opportunities for state, tribal, local government and stakeholder input on agency management decisions."*** (Appendix I, Item 6), its Pacific Islands Regional Office failed to provide either transparency or sufficient public notice to stakeholders on a decision with potentially far-ranging ramifications regarding NOAA's approach to managing open ocean aquaculture projects within the EEZ. The public notice was not advertised adequately, and

only ten days were allowed for comments by stakeholders who did become aware of the public comment period.

Conclusion

Thank you for the opportunity to submit these comments. We look forward to seeing the Draft Policy revised to address the concerns we have raised, and we will appreciate full compliance by the Department of Commerce and NOAA with NEPA requirements related to adoption of their draft aquaculture policies. Please feel free to contact us if you have questions or comments.

Sincerely,



Dave Raney
Sierra Club
Chair--National Marine Action Team

Cc: Horst Greczmiel

Exhibit A
Shellfish Aquaculture Impact Documentation

Sierra Club Shellfish Aquaculture Power Point

http://washington.sierraclub.org/tatoosh/Aquaculture/SierraClub-Aquaculture-2010-Jul-R08-final.pdf

http://washington.sierraclub.org/tatoosh/Aquaculture/index.asp

A. Changing from a Conservation Estuary to an Aquaculture Production Estuary
The concept of changing the ecology from conservation estuaries to production estuaries is described in the science report named “"The Ecological Role of Bivalve Shellfish Aquaculture in the Estuarine Environment": (Dumbauld, Ruesink, Rumrill, 2009)—page 215: http://washington.sierraclub.org/tatoosh/Aquaculture/Aquaculture--dumbauld%20et%20al.pdf

“From a manager or land use planner’s perspective, the first consideration in evaluating shellfish aquaculture in a given estuary should be an answer to the question: What are we and/or should we be managing for? Estuaries have a wide range of potential functions, have been and will continue to be influenced by many human activities, and similarly are influenced by many natural disturbances in addition to shellfish aquaculture. While the current paradigm for most managers is whole “ecosystem based” management (Grumbine, 1997), in reality managers have only progressed to varying degrees down this path, especially for marine systems. Thus the answer to “what are we managing for?” is driven by a wide variety of stakeholders and societal values (social historical, political, moral and aesthetic as well as economic; Leslie and McLeod, 2007;Weinstein, 2007; Ruckelshaus et al, 2008). Although these values are outside the purview of our intended review, we found it instructive to at least classify West Coast estuaries by the current level of aquaculture and other anthropogenic disturbance as Weinstein (2007) propose. Willapa Bay and Humboldt Bay might therefore be considered “production” estuaries with greater than 10% of the area occupied by shellfish aquaculture, while numerous other smaller estuaries with little aquaculture could be classified as other types.”

It is important to note that this report discusses disturbances and recovery times as follows: “While bivalve aquaculture might be viewed as a press disturbance over the long term in a given area, the individual activities act as pulse disturbances and Z. marina in U.S. West Coast estuaries can recover to pre-disturbance levels relatively rapidly (within a period of 2 years in some systems).” Page 215.

Puget Sound is not just a bay, but an estuary of national significance. It is in trouble as evidenced by the most endangered species listed in the country and a $50 million restoration budget. Since the majority of aquaculture areas are continually turned over with a new season of clearing, planting, maintaining and harvesting, there is virtually little “recovery “ time where these areas will provide the same ecological functions to those species who rely on these critical Nearshore mid intertidal areas for feeding, rearing or migration. The comparison to periodic disturbances, boat wakes and earthquakes is not a realistic comparison to a permanent conversion to a “crop” operation. Our dwindling native species clearly do not have the luxury of waiting for their habitat and food resources to recover for minimal periods between clearing, planting, maintenance and harvesting.

B. SeaGrant Preliminary Science
The preliminary research results published by Washington SeaGrant can be reviewed on the following link:

SeaGrant Interim Progress Report—Geoduck Aquaculture Research--2009
http://www.wsg.washington.edu/research/pdfs/reports/GeoduckIntProReport.pdf

"Among the tentative observations at this early stage in the six-year program: Preliminary data from one site suggest declines in some abundant worms and small crustaceans within the geoduck harvest zone and in adjacent areas immediately following harvest activity. There is evidence of recovery of these populations within six months."

"Diver surveys conducted at planted sites suggest that the addition of structures associated with geoduck aquaculture may change the community of mobile organisms visiting the site during high tides. Populations of structure-associated rock crabs, sea stars and other animals may increase, while populations of flatfish and other sandy-bottom species may decrease when nets and tubes are added to intertidal beaches."

"Initial results suggest that the release of nutrients due to prevalent harvest techniques is not significant."

"Preliminary screening of wild geoduck populations in three locations in Puget Sound and the Strait of Juan de Fuca identified a microscopic parasite that has not been recorded in geoduck previously. Further analysis is required to determine the full extent and severity of the infection."

"Initial results indicate that eelgrass beds neighboring a geoduck farm are affected by aquaculture practices, although additional surveys are necessary to determine whether effects are short-lived or persistent." Page 4

It should be pointed out that the 2010 SeaGrant report is to be publicly issued next week. These preliminary reports should be reviewed for updates and insight into a few of the many potential impacts of intertidal geoduck aquaculture.

C. The Eleven Most Important Impacts From Industrial Shellfish Aquaculture on Habitat and Native Species

1. Bivalve Ingestion of Fish Eggs and Larvae
The studies listed in this section acknowledge that farmed bivalves routinely ingest zooplankton and larvae from other bivalves and other species. It is clear that farmed bivalves filter routinely clear the water column, including eggs and larvae of important aquatic species.

Dan Penttila has been the recognized forage fish expert in Washington writing numerous reports for the Washington Department of Fish and Wildlife for over 38 years. In addition to his numerous reports, Mr. Penttila wrote the following guidance document for the Nearshore Partnership for forage fish as well as many other reports are shown at the end of Exhibit A. http://www.pugetsoundnearshore.org/technical_papers/marine_fish.pdf

Anecdotal evidence as mentioned by Dan Penttila in the March 2011 Pierce County EIS hearing suggests that forage fish may be declining or may be disappearing from Totten Inlet. Egg and larvae ingestion from artificially large densities of farmed bivalves in the intertidal area of Totten Inlet could very easily be the reason why. If so, then bivalve aquaculture violates the Endangered Species Act (ESA), the Magnuson Stevens Act (MSA), and the Washington Shoreline Management Act (SMA), because forage fish are such a large percentage of the diets of listed Puget Sound Chinook juveniles.

This anecdotal evidence makes sense from the chronology of events. The forage fish appear to be declining at the same time and in the same areas that shellfish aquaculture is expanding. For instance, over 90% of Totten Inlet shorelines have been converted to high density aquaculture. Given the scientific acknowledgement that farmed bivalves essentially filter everything in the water column, it should not be a surprise that these farmed bivalves are ingesting and destroying public fisheries resources. Mr. Penttila has recommended that specific science studies by conducted to learn more about this important issue.

Details of Mr. Penttila's scientific concerns regarding significant impacts on forage fish from geoduck aquaculture can be found in the following link. This March 2011 Pierce County DNS appeal hearing requesting an EIS was appealed by the Case Inlet Shoreline Association and endorsed by the Sierra Club:
http://www.caseinlet.org/uploads/Dan_Penttila_testimony_020111_1_.pdf

Sediment transport issues also affect the distribution of forage fish larvae in the water column as well as other considerations. The following report from Jim Johannessen who is noted for his 27 years as a geomorphologist specializing in Puget Sound restoration should be reviewed. This report was presented at the March 14, Pierce County EIS hearing and is applicable to the one site as well as cumulative impact issues:
http://www.caseinlet.org/uploads/Jim_Johannesen_testimony_020111_1_.pdf

Independent Studies on the Impact of Bivalves Ingesting Fish Eggs, Crab Zoes, Copepods, Amphipods and Larvae

A. The CSAS (Canadian Science Advisory), review of the effects of shellfish aquaculture on fish habitat, 2006, pages 33-34 (25-26)

http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2006/RES2006_011_e.pdf

"Field studies reported in the same study found that mussels consumed (based on stomach content analysis) copepods (<1.5 mm), crab zoeas (2mm), fish eggs (1-2mm), and even amphipods (5-6mm). Subsequent to this, Lehane and Davenport (Lehane and Davenport 2002) showed that mussels consumed organisms up to 3mm in length and that cockles (Cerastoderma edule) and scallops (Aequipecten opercularis) are also capable of consuming considerable quantities of zooplankton, both when suspended in the water column and when on the bottom. The size classes of organisms consumed in these studies suggest that the larvae of most commercial species may be at risk from this type of predation."

B. Ingestion of mesozooplankton by three species of bivalve
Lehane/Davenport, 2002-2006, Journal of Marine Biology Association of the United Kingdom.
http://www.caseinlet.org/uploads/Lehane_davenport.pdf

"All species examined had zooplankters in their stomachs." p617

"Numbers of organisms ingested by suspended and field (scallops) were not significantly different." p617

"Clearly bivalves, in particular (mussels), are not strict herbivores and non-algal food sources are readily ingested by them. As expected, the numbers of individual zooplankters or 'prey' ingested increased with mussel size." p618

"It is likely that extensive beds of bivalves can also control zooplankton densities and sizes. From the results presented here, and from interpretation of other studies, it is clear that a wide variety of bivalves do routinely ingest zooplankton."
"Phytoplankton is not an all year round source of food (Landry, 1981), so zooplankton may be relatively more important in the bivalve diet when the seston is phytoplankton-poor." p619

C. The Trophic Linkage between zooplankton and benthic suspension feeders: direct evidence from analyses of bivalve faecal pellets—Wai Hing Wong, Jeffrey S. Levinton, 2006, Marine Biology Research Article.
http://www.caseinlet.org/uploads/Wong_Levinton_zooplankon.pdf

"Large zooplankton have been found in the digestive tracts of bivalve mollusks, e.g. American oysters (Virginica)." P 799

"Individuals (mussels) supplied with the mixture of phytoplankton and zooplankton demonstrated the best growth performance…"

"The classic model of bivalve filtering of phytoplankton may be inadequate to describe the trophic effects of bivalves on planktonic ecosystems."

D. Larviphagy in native bivalves and an introduced oyster—
Karen Troost, Pauline Kamermans, Winn J. Wolff, 2008, Journal of Sea Research.
http://www.caseinlet.org/uploads/larviphagy_in_bivalves_Troost.pdf

"Once filtered, bivalve larvae are either ingested or rejected in pseudofeces. If ingested, almost all larvae die in the digestion process or in the feces."

"Rejection in pseudofeces generally also leads to death."

2. Loss of habitat for sand lance to burrow in sediments in forage fish habitat areas where 43,560 geoduck tubes are inserted and loss of sand lance buried in the sediments as industry harvests and liquefies those sediments

According to the documented life history, sand lance burrow in the lower intertidal sediments. Loss of this forage fish habitat and prey resource for ESA listed species violates the Endangered Species Act (ESA), the Magnuson Stevens Act (MSA), and the Shoreline Management Act (SMA).

3. Shellfish industry introduction of plastic tubes, nets, bands, zipties and oyster bags that are becoming marine plastic debris when leaving the operations

The shellfish industry is placing over 120,000 pieces of plastic into **each acre** of geoduck farms as well as using thousands of plastic oyster bags and plastic canopy nets over manila clam beds in Puget Sound intertidal areas. According to the Department of Ecology, there are 247 intertidal geoduck sites in over 360 acres throughout our South Sound inlets in addition to the thousands of acres of oyster and clam production as shown on the following link: http://www.caseinlet.org/uploads/Aquaculture-South_PugetSound_1_.pdf

Local, state and federal agencies have completely ignored the significant adverse impact of marine plastic pollution that is a result of these shellfish industry practices in Puget Sound. At the March 16, 2011 Pierce County Hearing, the president of the Pacific Coast Shellfish Growers (PCSGA) questioned the 2005 Wayne Palsson WDF&W report that over 80,000 pieces of aquaculture plastic debris was found at the Tacoma Narrows Bridge in 2005. It is important to note that this is well over 10 miles away from the closest aquaculture sites. In addition, large canopy nets are shifting onto other properties and then being abandoned with "no responsible owner" since there is no net identification. It is well documented that plastic nets are killing fish, birds and other marine life.

Charles Moore is the founder of the Argalita Foundation and a world renowned marine plastic debris expert. Sierra Club hosted Mr. Moore's March 16, 2011 Olympia presentation where he spoke about the significant impacts of marine plastic pollution on aquatic organisms, the marine food web and the added burden of plastic pollution introduced by the shellfish aquaculture industry. The following expert report was provided by Charles Moore that provides details on the specific impacts such as ingestion, entanglement, plastic nano particles entering the food web and plastic marine debris absorbing chemicals that are later ingested by aquatic life. The science reports that document these serious impacts were provided by Mr. Moore and are shown at the end of this Exhibit A.
http://www.caseinlet.org/uploads/Charles_Moore_testimony_020211_1_.pdf

The following power point provides pictures of the massive amounts of plastics that are being placed in Puget Sound by the shellfish industry. For years, citizens have reported to state agencies that this plastic marine debris is polluting our shorelines and deeper waters miles away from aquaculture sites.
http://www.caseinlet.org/uploads/Longbranch_DNS.pdf

In addition, our Governor has signed the following West Coast Governors Agreement on Ocean Health that has a task force specifically dedicated to deal with the marine plastic debris issue:
http://www.westcoastoceans.gov/Docs/Marine_Debris_Final_Work_Plan.pdf

"Marine debris was identified as an important component of Priority Area 1: Clean Coastal Waters and Beaches. Action 1.4 asserts that the three states will:
Establish baseline estimates of marine debris and derelict gear off the West Coast and set reduction goals. Support state and federal policies for achieving marine debris reduction goals, including debris prevention through expanded recycling, improved trash maintenance, and enforcement of litter laws."

More information on the amount of PVC used by industry in Puget Sound, can be seen in the following report "The Use of PVC Plastics for Aquaculture in Puget Sound." It should be noted that Dr. Curtis Ebbesmeyer Phd, another well known marine plastic debris expert and Oceanographer, issued the following statement that is included in this report:

"Such plastic poses one of the grave threats to the health of Puget Sound. The particulate plastic from such PVC tubes enters the food web and does untold harm to all the creatures in Puget Sound, including us. It is not healthy to eat geoducks raised in such a fashion."
http://washington.sierraclub.org/tatoosh/Aquaculture/PVC%20Report--June%2028,%202010.pdf

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4. Destruction of macroalgae beds and sand dollar beds that are considered essential fish habitat for both ESA listed species and non-listed species.

The following documentation clearly shows that the shellfish industry destroys marine vegetation, why marine vegetation is critical to both ESA listed and non listed species and why regulators need to be enforcing the laws to protect Washington's marine vegetation.

A. Shellfish Industry Routinely Removes Native Vegetation and Species Essential to Nearshore Ecological Functions
http://washington.sierraclub.org/tatoosh/Aquaculture/Shellfish%20Industry%20Routinely%20Removes%20Native%20Flora%20and%20Faun.pdf

B. Aquaculture—Destruction of Eelgrass by the Shellfish Industry-Page 16
http://www.pugetsoundnearshore.org/technical_papers/marine_fish.pdf

"Standard aquaculture practices may have profound effects on the benthic ecology of Washington state's tidelands and the conservation of forage fish spawning areas, especially for herring. In many areas, herring spawning grounds are now coincident with shellfish culture areas, particularly on tideflats occupied by beds of the native eelgrass. Pacific oyster (Crassostrea gigas) beds intended for the ground-culture and dredge harvest of oysters commonly become devoid of native eelgrass, either due to the cumulative effects of periodic dredging activities over time or by intentional destruction of the eelgrass beds before the start of culture activities (West 1997). Dredging operations routinely take place on or near tideflat areas containing herring spawn (WDFW unpub. data). Currently, the Washington Department of Agriculture (WDA) has regulatory authority over aquaculture activities that occur in intertidal areas of state waters. The Washington Department of Natural Resources (WDNR) has authority over state aquatic bottomlands and marine vegetation management. These agencies together with WDFW should seek a coordinated approach to the management of the growing aquaculture industry, with an eye toward modification of habitat-damaging culture practices and the mitigation of existing habitat degradation for which the industry has been responsible."

C. The Role of Seagrasses and Kelps in Marine Fish Support

Derrick Blackmon, Tina Wyllie-Echeverria and Deborah J Shafer

http://el.erdc.usace.army.mil/elpubs/pdf/tnwrap06-1.pdf

BACKGROUND: The U.S. Army Corps of Engineers (USACE) has been involved in regulating certain activities in the nation's waters since 1890. Until 1968, the primary focus of USACE's regulatory program was the construction and maintenance of navigation infrastructure. Since then, the program has evolved to one that reflects national concerns for both protection and utilization of important resources. Activities that involve construction, excavation, fill, and certain other modifications of the "waters of the U.S." are regulated by USACE under the authority of Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act, and other regulatory policies. In estuarine waters, some of these regulated activities have the potential to impact sensitive aquatic resources such as seagrasses and kelps that provide important habitat for many commercially and recreationally important fish species.

"Many of these estuarine-dependent species are vulnerable to over-fishing, degradation of water quality, and loss of critical habitats. The 1996 Sustainable Fisheries Act amendments to the Magnuson-Stevens Act focus on essential fish habitats. The Act mandates identification and description of estuarine habitats used by managed species for spawning, feeding, breeding or growth, and identification of anthropogenic threats to these habitats (Rader and Davis 1997), and specifically targets managed species."

"This evidence highlights the need for detailed examination of seagrasses at a regional level to determine their role as habitat for ecologically and economically important species. Density, growth, survival, and movement need to be evaluated to determine the importance of a particular area/habitat as a nursery (Beck et al. 2001)."

"Forage fishes. Forages fishes are mentioned in this review due to their ecological role in the life histories of commercially important species such as salmon and rockfish. Surf smelt and sand lance spawn in the upper intertidal on sandy or sand/gravel beaches throughout Puget Sound (Lemberg et al. 1998, Pentilla 2000). Pacific herring spend most of their adult life in offshore waters. However, they spawn inshore, primarily on vegetated habitats, including red and brown algae, eelgrass, and rock kelp (Hay 1985) and feed on pelagic prey (Simenstad et al. 1988)."

D. WDF&W, Preferential Use of Nearshore Kelp Habitats by Juvenile Salmon and Forage Fish, Anne Shaffer

http://www.caseinlet.org/uploads/SalmonKelp_Shaffer__1_.pdf

"In summary, this study indicates that kelp bed habitats are important for, and preferentially used by, both juvenile salmon and surf smelt. Salmon appear to preferentially select the middle kelp bed areas, possibly due to optimal feeding and refuge conditions this area of the kelp bed may offer. Combined, these results indicate habitat partitioning between thee juvenile fish species. Further quantification of fish uses of kelp habitats, including radio tagging of fish, and defining juvenile salmonid and forage fish trophic relationship to kelp habitats, are compelling next steps in defining the relationship between juvenile salmon, forage fish, and their use of nearshore kelp habitats. Such habitat and trophic information is a critical element for the success of future habitat and resource management of nearshore habitat and the salmon and forage fish resources that depend on them (Stephenson 1996).

E. Magnuson-Stevens Act—Essential Fish Habitat—Algae Beds and Sand dollar Beds

These important resources are considered "essential fish habitat" in the EFH technical guidelines as shown below:
"Plan and design mining activities to avoid significant areas (such as consolidated sand ledges, sand dollar beds, or algae beds)."

5. Elimination of Puget Sound and Willapa Bay Aquatic Native Animal and Plant Species by the shellfish industry—"Pest Management Integrated Plan for Bivalves in Oregon and Washington"
http://washington.sierraclub.org/tatoosh/Aquaculture/OR-WAbivalvePMSP.pdf

It is astonishing that local, state and federal agencies continue to allow the shellfish industry to eliminate the long list of native aquatic plant and animal species shown on page 27. It is extremely troubling to Washington citizens to see our aquatic sea life routinely eliminated by the shellfish industry as "unwanted pests" as this industry expands along Washington shorelines.

The shellfish industry expands into habitats rich with native species, then adds “feed” in the form of cultured oysters, clams and geoducks. Growers eliminate the species that were there and species that move in to feed as they are now “predators.” There is no doubt that this is a “net loss” of native species and a significant impact on components of the food web of Puget Sound.

Contrary to industry statements, the following email dated April 6, 2009, documents there are no Washington State protections that prevent the aquaculture industry from eliminating our native species.

Laura:

The primary rule is RCW 77.12.047(3). This exempts private commercial aquaculture from just about everything the WDFW does. The link is below. Let me know if you have any other questions.

Russell

http://apps.leg.wa.gov/RCW/default.aspx?cite=77.12.047

After citizens started reporting industry destroying sand dollar beds, it is ironical that the WDF&W then passed a WAC to “prevent the recreational take” of beach life---just for citizens:

June 6, 2010—Email from Rich Childers, Washington Department of Fish and Wildlife

Laura:

Below is the WAC governing the take of unclassified marine invertebrates and fish for personal use fisheries. WAC 220-56... governs personal use (recreational) fisheries only. The intent of this law is to prevent the recreational take of marine organisms that are not actively managed and/or monitored by the department. I will be out of the office next week but I am available discuss this further when I return. Best way to contact me is cell 360 301-2626.

WAC 220-56-130
Unclassified marine invertebrates and fish.

(1) "Unclassified marine invertebrates" and "unclassified marine fish" mean species existing in Washington state marine waters in a wild state that have not been classified as food fish, shellfish, game fish, protected wildlife, or endangered species.

(2) All Marine Areas are closed to the taking of unclassified marine invertebrates and unclassified marine fish.

(3) It is unlawful to take, fish for or possess Pacific lamprey or river lamprey.

(4) Violation of this section is punishable under RCW 77.15.380 Unlawful recreational fishing in the second degree -- Penalty, unless the fish or shellfish are taken in the amounts or manner to constitute a violation of RCW 77.15.370 Unlawful recreational fishing in the first degree -- Penalty.

[Statutory Authority: RCW 77.12.047. 10-07-105 (Order 10-64), § 220-56-130, filed 3/19/10, effective 5/1/10;

6. Dive harvesting below -18 feet adversely affects salmon--see DNR SEIS wild harvesting restriction and May 8, 1999 letter from Charles Simenstad
The following recommendation was provided by Charles Simenstad, a Nearshore expert scientist with the University of Washington School of Fisheries regarding the DNR subtidal wild geoduck harvesting in 1999.

"You have obviously taken considerable time, effort and thought to evaluate the potential impacts from all aspects of geoduck harvesting, and I believe have incorporated this information into best management practices regulating leasing and harvesting criteria. Most of your considerations encompass mechanisms of impact to juvenile salmon during their initial stages of estuarine residence. Depending upon the methods, practices, and extent of geoduck harvesting, juvenile salmon migrating along Puget Sound and associated shorelines are potentially vulnerable to a variety of effects that could be associated with geoduck harvesting including: (a) direct impact to salmon exposed to sediment plume, (b) alteration of migratory behavior when encountering the sediment plume generated by water jet removal of the clams, (c) sedimentation of intertidal habitat (e.g. eelgrass, Zostera marina) important to juvenile salmon, (d), cumulative loss of primary production due to turbidity shading by sediment plume, and (e) attraction or aggregation of potential predators on juvenile salmon…..I am restricting my evaluation of impacts to juveniles of ocean-type salmon (e.g. chum, Chinook and to some degree pink because during their early marine life history when migrating as fry (30-80mm FL) they are confined to estuarine and nearshore shallow water habitats. As such , they are susceptible to nearshore impacts that alter this behavioral mandate or reduce critical habitat attributes such as the composition and production of their prey resources and refugia from predation (e.g. vegetative structure provided by eelgrass, etc.). **The exclusionary principle of not allowing leasing/harvesting in shallower water than -18ft MLLW or 200 ft distance from shore (MHW), 2 ft vertically from elevation of lower eelgrass margin, and within any region of documented herring or forage fish spawning should under most conditions remove the influences of harvest-induced sediment plumes from migrating salmon. As the available information indicates that sediment plumes do not (or are not allowed to?) enter the nearshore zone, impacts to juvenile salmon habitat and prey resources should also be protected from impact by these policies if effectively regulated."**

The scientific basis for this recommendation and protections required for salmon are clear and this restriction should be enforced for both subtidal and intertidal geoduck harvesting. Regulators should be protecting our Nearshore species and not continue to allow the shellfish industry to ignore this important science based restriction as they dive harvest for intertidal geoduck.

7. Industrial Aquaculture Direct Impacts to Nearshore Habitat That Adversely Affects Wild Salmon and Whale Recovery in Washington

http://washington.sierraclub.org/tatoosh/Aquaculture/Fish_Habitat_Impacts--Overview--Forage_fish,_eelgrass,_salmon-May_31.pdf

Puget Sound now has the unfortunate distinction of having the most listed endangered species in the United States. As shown in the above information, the Nearshore and especially the mid intertidal area is the most critical to species and yet decision makers are allowing it to be converted to high density aquaculture. Many of the following Washington Department of Fish and Wildlife list of species of concern depend on the mid intertidal Nearshore area for survival that is now being converted to aquaculture. The following groundfish management plans are now being developed to help save those dwindling populations that also use this same high value habitat areas that industrial aquaculture is altering for geoducks, oysters and clams.

WDF&W--Species of Concern
http://wdfw.wa.gov/conservation/endangered/lists/search.php?searchby=StateStatus&search=SE&orderby=AnimalType,%20CommonName

DEIS-Puget Sound Rockfish Conservation Plan
http://www.caseinlet.org/uploads/draft_rockfish_plan_19oct09.pdf

Ground Fish--Shore Stewards
http://kitsap.wsu.edu/shore_stewards/bas/v.b.3.htm

Salmon Diet and Prey Studies—Critical Issues for ESA listed species

The following studies document that the main sources of prey for Chinook salmon are insects, epibenthic crustaceans and polychaete annelids with juvenile Chinook salmon diets relying heavily on polychaetes and sand lance.

These sources of prey for both ESA listed and non listed species are being put at risk by shellfish aquaculture operations that have had no limitations on where they site their operations or their practices.

A. Juvenile Chinook Salmon Distribution, Diet and Prey Resources Below the Locks Charles Simenstad, Kurt Fresh
http://www.seattle.gov/util/stellent/groups/public/@spu/@ssw/documents/webcontent/spu01_002667.pdf

"Diet composition of juvenile salmon indicated a strong influence of discharge from the Lake Washington system in the form of freshwater zooplankton (i.e., *Daphnia* spp.), and to a lesser degree pelagic marine/estuarine zooplankton. Insects and epibenthic crustaceans and polychaete annelids were more prominent in the diets of juvenile salmon in the outer Shilshole Bay and adjoining nearshore sites, and slightly more in unmarked than marked chinook salmon. Potential epibenthic prey (harpacticoid copepods, gammarid amphipods) are considerably more abundant at the outer Shilshole Bay sites than at the inner Bay sites." Page 1

"Foraging of most salmon is focused on either pelagic zooplankton, most of which originates from allochthonous freshwater production in the Lake Washington/Ship Canal system, and to a lesser degree drift/neustonic insects; autochthonous littoral production of epibenthic prey, and potentially input of riparian insects, do not appear to play a large role in supporting juvenile salmonids in the inner Bay, although these sources may be more important in the outer Bay and adjoining nearshore." Page 2

B. Juvenile Salmonid Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound in 2001-2002, dated August 2004.
http://your.kingcounty.gov/dnrp/library/2004/kcr1658/nearshore-part1.pdf

Salmonid Diet –page –iii-
Stomach contents of 819 Chinook salmon, 89 coho salmon, and 56 cutthroat trout were analyzed to determine diet composition. Chinook diet samples were analyzed from 410 individual in 2001 and 409 from 2002 at 16 different sites. In both years, terrestrial insects numerically dominated Chinook diets. Gravimetric (weight) composition was similar between years in all ecological categories (benthic/epibenthic, planktonic/neritic, terrestrial/riparian) and varied by size fish and season. For juvenile Chinook salmon in the smallest size classes (90-149 mmFL) had dietary components that were more evenly distributed in the three ecological categories and insects became a more dominant prey item with increasing size, along with benthic and epibenthic prey. The largest size classes of salmonids fed on planktonic and neritic organisms. There were also distinct seasonal patterns in diet composition. Polychaete worms dominated the <90 and 90-149 mm size classes of juvenile Chinook prey early in sampling season (i.e. May), but were replaced by other prey organisms later in the season. For example, in September, insects made up over 50% of the prey weight in Chinook from 90-149 mm size class and over 980% of the >150 mm size classes. Diets were also similar between geographic locations, but some differences were detected. There was also a great deal of similarity between diets of juvenile Chinook classified as hatchery and "wild."

Stomach contents from a total of 56 cutthroat trout from 12 beaches were analyzed for diet composition, including 47 individuals from 2001 and 9 from 2002. Fish ranged in size from 130-441 mm (Fl). Cutthroat trout diets were dominated by fish (mostly non-salmonids) in both years. Other taxa found in significant numbers included insects, crab larvae, amphipods, copepods and isopods.

"The overall results presented here point to three general habitat types—terrestrial/riparian, shallow benthic/epibenthic, and pelagic—as the most important prey production/foraging areas for juvenile Chinook salmon in shallow marine nearshore areas of Puget Sound." Page 4-7

C. Per Washington Department of Ecology Website
http://www.ecy.wa.gov/programs/sea/pugetsound/species/sandlance.html

"The sand lance, also known locally as the "candlefish," is an ecologically important forage fish throughout Puget Sound. Sand lances are important food for young salmon; 35% of juvenile salmon diets are composed of sand lance. Juvenile chinook salmon depend on sand lance for 60% of their diet. Minke whales, other marine mammals, and many species of seabirds also prey on sand lance."

D. Salmon Behavior—Predator Avoidance in the Intertidal Benthic Habitats

Acoustically derived fine-scale behaviors of juvenile Chinook salmon (Oncorhynchus tshawytscha) associated with intertidal benthic habitats in an estuary- Brice Xavier Semmens, Septemer 4, 2008
http://www.caseinlet.org/uploads/semmens_CJFAS_chinook_estuary_habitat.pdf

"Abstract: Given the presumed important of benthic and epibenthic estuarine habitats in Chinook salmon (Oncorhynchus tshawytscha) smolt growth and survival, resource managers would be well served by an improved understanding of how smolts use such habitats…… Model results indicated that smolts had a strong preference for remaining in native eelgrass (Zostera marina). Conversely, no such preference existed for other structured benthic habitats such as oyster (Crassostrea gigas) beds, non-native eelgrass (Zostera japonica), and non-native smooth cordgrass (Spartina alterniflora). There was a positive relationship between individual survivorship in the enclosure and the strength of behavioral preference for native eelgrass, suggesting that predator avoidance may be the evolutionary mechanism driving behavioral responses of smolts to benthic habitats." Page 1

8. Restriction, disturbance and harassment of marine birds by the shellfish aquaculture industry

The shellfish aquaculture industry has expanded into areas which were historically feeding grounds for marine birds. The following statements taken from the "Pest Management Integrated Plan for Bivalves in Oregon and Washington—July 2010" documents how industry is trying to reduce our bird populations:

"Management of Seagulls, Crows, Ravens and Waterfowl

- Passive measures include substrate cover, fencing, and nets on Manila clams, geoducks and mussels (suspended culture)
- Hazing (harassing to disturb the animal's sense of security so it leaves) is used with some degree of success
- Timing farming activities when birds are most likely to be present has proven effective in scaring them away from the sites
- As a last alternative, hunting has been utilized when depradation permits can be obtained. At this time, Scoter populations are depressed, therefore depradation permits are not available."

It is also well documented in South Puget Sound, that large numbers of marine ducks have been massacred as they come into the inlets by hunters whose boats originated from shellfish industry docks. In fact, the massacre of ducks in Eld Inlet (2009) and Henderson Inlet (2010) resulted in citizens requesting that Thurston County Commissioners institute a no shooting zone ordinance. That ordinance is now being drafted after several public meetings.

"Some startling facts according to the Puget Sound Partnership—Marine Birds http://www.psparchives.com/our_work/species/marine_birds.htm:"

- 19 of the 30 most common marine bird species in northern Puget Sound decreased by 20 percent or more between 1978 and 2004.
- Since 1979, the total number of marine birds in the Puget Sound region has dropped 47 percent.
- Western grebe populations have declined by 95 percent over the last 20 years.

"Scientists do not fully know what is driving this decline but some likely factors include decreases in forage fish populations, including herring spawn at Cherry Point and Discovery Bay, changing migration patterns, predation, habitat loss, hunting, by-catch from fishing operations (including derelict fishing gear), and harm to breeding grounds in the Arctic."

Studies of Shellfish Aquaculture Adverse Impacts on Marine Birds

A. Heffernan, et al., A Review of the Ecological Implications of Mariculture and Intertidal Harvesting in Ireland (1999)

http://protectourshoreline.org/studies/Review_Mariculture_Ireland.pdf

Some excerpts from this review:

1.3.4 Competition for space

Areas which would normally be available for birds and other animals may be occupied by shellfish culture. For intertidal culture, loss of habitat can arise from the presence of structures used for growing shellfish on intertidal feeding ground. These structures include frames used for holding small spat, bags held on trestles, and areas under netting. The farming operations are generally quite small in terms of area covered (1-2 ha.). However, the cumulative reduction of feeding grounds arising from the increasing number of operations can be substantial (O'Brian, 1993).

1.3.5 Disturbance to birds

Disturbance can be defined as any situation in which a bird behaves differently from its preferred behaviour. Any overall reduction in birds feeding, as a result of this change in behaviour, may increase energy requirements, and hence adversely affect survival (Davidson and Rothwell, 1993). The main cause of disturbance will be the service and maintenance of the culture structures.

B. Effects of Aquaculture on Habitat Use by Wintering Shorebirds in Tamales Bay, California—John Kelly, Jules Evens, Richard Stallcup and David Wimpfheimer

"Our results suggest a net decrease in total shorebirds in the areas developed for aquaculture."
http://www.caseinlet.org/uploads/0096-Kelly_et_al_1996_aquaculture_1_.pdf

C. Nearshore Birds in Puget Sound

http://www.pugetsoundnearshore.org/technical_papers/shorebirds.pdf
"Is Surf Scoter food availability influenced by exclusion from commercial shellfish operations?" Page 10.

9. Genetics, Disease and Parasites

Potential Impacts of Subtidal Geoduck Aquaculture on the Conservation of Wild Geoduck Populations
http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2004/RES2004_131_e.pdf

Excerpts from this report:
"However, there are several ways in which geoduck aquaculture could negatively impact natural stocks and the commercial fishery although none have been directly assessed. Potential impacts include genetic fitness, transmission of disease, increased number of predators, competition for food, and habitat impacts. Because of these unknowns, and to accommodate the risk and uncertainty related to the stock status of natural geoduck populations, aquaculture development should be controlled and fully integrated in the geoduck stock assessment and management frameworks. Geoduck are long lived animals and negative impacts on populations may be slow to detect." Page 15

"If predator abundance increases after the seeding of an aquaculture tenure, there could be significant impacts on naturally recruited juveniles (geoduck) in the vicinity." Page 11

"The possibility of loss of genetic fitness of wild stocks through interactions with hatchery-produced animals is of considerable concern, and highlights the importance of sound genetic protocols for broodstock collection and the management of the lineage of outplanted geoduck. Studies to investigate the range of larvae drift and therefore the range of potential genetic impacts should be a high priority." Page 10

French May Bid Adieu to Oysters
http://www.dw-world.de/dw/article/0,,6174169,00.html
"Natural oyster producers believe that the main cause of the rampant spread of the virus was the introduction of laboratory manipulated and reproduced triploid oysters."

Until peer reviewed studies are completed and made available for review, it is irresponsible for decision makers to allow expansion and put our wild stocks of geoducks at risk that are a vital part of the ecosystem in Puget Sound. Considering the preliminary findings in the SeaGrant report regarding parasites and now unforseen problems with the non native triploid oyster, a precautionary approach should be required.

10. Ecosystem Effects and Assessment of Non-Native Invasive Species Used in High Density Aquaculture

A. Introduction of Non-Native Oysters: Ecosystem Effects and Restoration Implications
Jennifer Ruesink, Hunter Lenihan, Alan C. Trimble, Kimberly Heiman, Fiorenza Micheli, James E. Byers, and Matthew C. Kay, September 9, 2005
http://www.caseinlet.org/uploads/07-04-EnvironmentalStudyOfIntroduced_Oysters_1_.pdf

"Ecological risk assessments associated with oyster introductions should place greater emphasis on ecosystem-level effects. Oyster introductions require that we advance our understanding of the functions and services provided by different marine species and assemblages. Major gaps in knowledge include how native and introduced species influence nutrient cycling, hydrodynamics, and sediment budgets; whether other native species use them as habitat and food, and the spatial and temporal extent of direct and indirect ecological effects within invaded and adjacent communities and ecosystems. Lack of information on community-level and ecosystem-level consequences of oyster introductions is surprising (but we see Escapa eta al 2004), given that these introductions have occurred worldwide for more than a century. Studies that compare the ecosystem functions and services provided by native and introduced oysters are important research priorities, and they provide the framework for recent research projects, such as that supported by the NOAA-Chesapeake Bay Program to examine C. ariakensis and C. gigas."

B. Assessing the Global threat of invasive species to marine biodiversity
Jennifer L. Molnar, Rebecca L. Gamboa, Carmen Revenga and Mark D. Spalding, 2008

"Our assessment data can also be used by policy makers in specific regions (Table 1). For example, in the two eco-regions that extend along the coastlines of Oregon and Washington State, including the Puget Sound, aquaculture has been the most common pathway for introduction (71% of non-native marine species documented in these eco-regions were introduced by aquaculture). Most of these introductions probably occurred accidentally, through oyster farming (with introduced species hitchhiking on shells or equipment). Of the 33 species known to be associated with oyster farming, 55% are harmful, and most are difficult if not impossible to remove or control (26 of 28 species scored for management difficulty received a
score of 3 or 4). In this region, policy makers, conservation practitioners, and the aquaculture industry should continue to work together to prevent any future invasions, by improving practices and perhaps limiting new operations." Page 491

"Our impact scores offer guidance on the merits of these intentional introductions. For example, oysters have been deliberately introduced into coastal waters worldwide, to be cultured for food.

One species in particular, *Crassostrea gigas*, has been introduced in at least 45 eco-regions (Figure 4). Its high ecological impact score (3) should cause decision makers and regulators toreconsider plans for introduction of this oyster into new areas. While its harvest brings economic gains, the ecological impact of introductions of this species are potentially dramatic. Oysters play a role in many estuarine ecosystem processes; altering their abundance or distribution causes complex changes. Furthermore, when oyster populations are supplemented with alien oysters, other alien species can piggyback on their shells (Ruesink *et al*. 2005). Global information about distribution and impacts could inform risk assessments and decisions about whether, and how, species should be introduced in the future. "Page 491

11. Pesticide and Herbicide Use in Willapa Bay, Washington

A. Carbaryl and Imidacloprid

Up to three tons of Carbaryl (Sevin insecticide) has been sprayed annually by shellfish growers in Washington State (Willapa Bay) on up to 800 acres of tidal flats to exterminate ghost shrimp. Since Carbaryl must be phased out by 2012, the shellfish industry is looking to replace Carbaryl with Imidacloprid. The use of Imidacloprid has raised concerns because of its possible impact on bee populations. The Sierra Club is concerned about the significant impacts on the ecological functions and affected native species of allowing pesticides to be used in our estuaries.

Neurobehavioral Effects of the Carbamate Insecticide, Carbaryl, on Salmonids

Jay Davis, U.S. Fish & Wildlife Service - Western WA Office*
David Baldwin, Jana Labenia, Barbara French, Nathaniel Scholz
NOAA Fisheries - Northwest Fisheries Science Center

Keywords: carbaryl, cutthroat trout, salmonid, carbamate pesticide, acetylcholinesterase inhibition, neurobehavioral effects Willapa Bay is a coastal estuary in Washington State that provides habitat for cutthroat trout (Onchorhynchus clarki clarki) as well as other salmonids. Cutthroat trout forage throughout the estuary in the summer months when carbaryl, a carbamate insecticide, is applied to oyster beds at low tide to control burrowing shrimp populations. On the day of spray, carbaryl has been measured in the estuarine water column at concentrations >1,000 ppb. Carbaryl is a neurotoxicant that inhibits acetylcholinesterase, an enzyme that hydrolyzes the transmitter acetylcholine at neuronal and neuromuscular synapses. Previous studies determined that cutthroat trout do not show an olfactory response to carbaryl, do not avoid carbaryl-containing water, and that short-term (6 hour) carbaryl exposure rapidly (< 2 hrs) depresses brain and muscle acetylcholinesterase activity in a dose-dependent manner (IC50s of 213 ppb and 185 ppb, respectively) for approximately two days. The goals of this study were to determine the impacts of carbaryl exposure on the swimming behavior of cutthroat trout as well as their vulnerability to predation.

Results indicate that salmonids' swimming performance and ability to avoid predation are significantly affected at carbaryl concentrations >=750 ppb and >=500 ppb, respectively.

B. Glyphosate and Imazapyr Use In Washington Estuaries

Glyphosate and Imazapyr are sprayed in Washington State by growers directly in estuaries and on mudfats to kill Spartna, a form of cord grass. If it is necessary to remove spartina, pulling or mowing this grass should be the method used, not the spraying of herbicides in our estuaries.

Dan Penttila—Forage Fish Relevant Research (See Impact #1)

1. Penttila, D., 1978. Studies of the surf smelt (Hypomesus pretiosus) in Puget Sound. WDF Technical Report #42, 47 p.

2. Penttila, D. 1995a. The WDFW's Puget Sound intertidal baitfish spawning beach survey project. Proceedings of the Puget Sound Research-95 Conference, PSWQA, Olympia, WA, vol 1, p. 235-241.
3. Penttila, D. 1995b. Investigations of the spawning habitat of the Pacific sand lance (Ammodytes hexapterus) in Puget Sound. Proceedings of the Puget Sound Research-95 Conference, PSWQA, Olympia, WA, Vol. 2, p. 855-859.
4. Penttila, D., 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Tech. Rep. 2007-03. Seattle District, ACOE, 22 p. potential impacts of aquaculture practices within the text. www. pugetsoundnearshore.org
5. Moulton, L. and D. Penttila. 2001, rev. 2006. Field manual for sampling forage fish spawn in intertidal shore regions. San Juan County Forage Fish Assessement Project. P. 23.
6. WDFW Salmonscape Forage Fish database charts showing the currently documented surf smelt and sand lance spawning habitat polygons in the Longbranch project area.
7. Penttila, D., 1995. Known spawning beaches of the surf smelt (Hypomesus), and the sand lance (Ammodytes) in southern Puget Sound, WA (Pierce, Thurston and Mason Counties), as of March 1995. WDFW unpub. report, 50+ p.
8. Penttila, D. 11/23/92. "S. Carr Inlet-Drayton Pass". WDF Forage Fish Unit field/lab report (13 p.) of first-ever survey through the Longbranch project area, at which time surf smelt spawn was found near the project site.
9. Penttila, D., 1/5/96. "S. Case Inlet-W. Nisqually Reach" WDF Forage Fish Unit field lab report (11 p.) of forage fish spawning habitat survey conducted through the project area at which time sand lance spawn was found on the project site.
10. Penttila, D., 1/19/07. "Drayton Passage, Pierce Co.", WDFW Puget Sound Action Team Forage Fish Project field/lab report (11 p.) documenting a forage fish spawning habitat survey conducted through the project area, in which surf smelt spawn was again documented near the project area.
11. Penttila, D. 2000. Grain-size analyses of spawning substrates of the surf smelt (Hypomesus) and Pacific sand lance (Ammodytes) on Puget Sound spawning beaches. WDFW unpub. report. 12

Charles Moore Marine Plastic Debris Relevant Research (See Impact #3)

1. Fatal ingestion of floating net debris by two sperm whales
Jeff K. Jacobsen, Liam Massey, Frances Gulland

2. Transport and release of chemicals from plastics to the environment and to wildlife
Emma L. Teuten, Jevita M. Saquing, Detlef R. U. Knappe, Morton A Barlaz
http://mc.manuscriptcentral.com/issue-ptrsb
http://www.caseinlet.org/uploads/Moore-PlasticChemTrasportWildlife_1_.pdf

3. Invasion by marine life on plastic debris
Nature/Vol 416/25 April 2002/www.nature.com
http://www.caseinlet.org/uploads/Moore-Invasion_of_Debris-Barnes_article_1_.pdf

4. Plastic Ingestion by planktivorous fishes in the North Pacific Central Gyre
Christiana M. Boerger, Gwendolyn L. Lattin, Shelly L. Moore, Charles J. Moore; Marine Pollution Bulletin
http://www.caseinlet.org/uploads/Plastic_ingestion_by_fish_1_.pdf

5. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment Yukie Mato, Tomohiko Isobe, Hideshige Takada, Haruyuki Kanehiro, Chiyoko Ohtake and Tsuguchika Kaminuma
http://www.caseinlet.org/uploads/Moore-Plastic_Resin_1_.pdf

6. Quantification of persistent organic pollutants absorbed on plastic debris from the Northern Pacific Gyre's "eastern garbage patch," Lorena M.Rios, Patrick R. Jones, Charles Moore and Urja V. Narayan; The Royal Society of Chemistry 2010
http://www.caseinlet.org/uploads/Moore-Rios_et_al__2010_1_.pdf

7. Synthetic polymers in the marine environment: a rapidly increasing long-term threat—Charles James Moore, Fernanda E. Possatto, Mario Barletta, Monica F. Costa, Juliana A. Ivar do Sul, David V. Dantas; Marine Pollution Bulletin
Envir. Res. Plastic Oceans 2008
http://www.caseinlet.org/uploads/Moore--_Env_Res_Plastic_Oceans_2008_1_.pdf

8. The Pollution of the Marine Environment by Plastic Debris: a review
Jose G.B. Derraik; Marine Pollution Bulletin
http://www.caseinlet.org/uploads/Moore--Derraik_1_.pdf

9. Biological Performance Bio Plastic: Mirel
Barry E. DiGregorio; Chemistry and Biology 16, January 30, 2009
http://www.caseinlet.org/uploads/Moore-Biobased_Performance_Bioplastic_-_Mirel_1_.pdf

10. Plastic debris ingestion by marine catfish: An unprecedented fisheries impact
Fernanda E. Possatto, Mario Barletta, Monica F. Costa, Juliana A. Ivar do Sul, David V. Dantas, Marine Pollution Bulletin, 2011
http://www.caseinlet.org/uploads/Plastic_debris_ingestion_by_marine_catfish_An_unexpected_fisheries_impact_1_.pdf

Exhibit B
Finfish Environmental Impact Documentation

Monterey Bay Aquarium Seafood Watch® Farmed Salmon Report **April 27, 2004**
http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_FarmedSalmonReport.pdf

Risk of Escaped Fish to Wild Stocks: Farmed salmon are jeopardizing the health of endangered salmon populations in the Atlantic through interbreeding. By reducing the fitness of wild stocks, farmed salmon may imperil remaining wild Atlantic salmon stocks. In the Pacific, escaped farmed salmon represent a potentially invasive species. The potential for negative effects from interbreeding of farmed and wild salmon in the Atlantic and invasive behavior of escaped farmed Atlantic salmon in the Pacific poses a **Critical Conservation Concern.**

Risk of Disease Transfer to Wild Stocks: Salmon farming operations can serve as a vector for diseases and ectoparasites, notably sea lice, which can negatively affect wild salmon. While biosafety controls reduce the risks of translocating disease, evidence that sea lice from salmon farms are harming wild salmonid populations is substantial. The threat of disease to already stressed wild salmon populations also presents a substantial risk. The threat of disease to wild fish populations and ecosystems is thus of **High Conservation Concern.**

Use of Marine Resources: Salmon reared in captivity are carnivorous fish and farmed salmon are fed diets largely comprised of processed wild fish. The implicit demand salmon aquafeeds place on marine ecosystems off of South America and the Gulf of Mexico is both a practical and ethical issue that affects the sustainability of farming practices, and thus is of **High Conservation Concern**.

Risk of Pollution and Habitat Effects: Because salmon are raised in open marine net-pens, wastes, organic and chemical, are not collected or treated. Organic wastes from uneaten feed and feces can accumulate on sediments and affect the species distribution within the immediate vicinity of net pens. Infaunal species diversity is typically lower beneath and down current from net pens with low to moderate flushing rates. Overall, pollution from organic and chemical wastes is of **High Conservation Concern**.

Effectiveness of the Management Regime: Management practices vary significantly between nations. Management has increased in recent years but concerns remain regarding the density of net-pen sites in specific regions, the approval of pesticide and antibiotic use, and the use of acoustic predator deterrent devices which may affect non-target marine mammals. The current management climate is of **Moderate Conservation Concern**.

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Hawaii

Temporal changes in the polychaete infaunal community surrounding a Hawaiian mariculture operation

Han W. Lee1, Julie H. Bailey-Brock1, 2,*, Michelle M. McGurr2.

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Monterey Bay Aquarium Seriola Issues.pdf Introduction to Seriola Aquaculture Issues. George Leonard probably already knows about this one. It is relevant to Hawaii because it deals with Seriola species.

LD09-OceanLeasingRpt.pdf - This is a State of Hawaii report on ocean leasing/OOA prepared in 2008 for the 2009 legislature that mentions: "The researchers share the general findings that "the bottoms under the fish cage show a partial, but not full recovery with fallowing of the bottom space after experimentation." Page 5. This is an official state report that acknowledges that some benthic impacts have occurred from OOA operations in Hawaii.

Organic_loading under aquaculture cage.pdf Measurement of organic loading , etc. Documents benthic impacts from cobia farming off Puerto Rico. Also mentions findings from a study by Lee, et al of an OOA project in Hawaii , finding that "the sediment directly under the cage to be 'grossly affected' after 11 months. Another area 80m downstream was found to be 'heavily impacted' after 23 months." I have not been able to obtain the Lee study itself, however.

MundyEtAl2003. **Diseases of Tunas.** Relevant since a tuna OOA project has been approved in Hawaiian waters.

MAINE

In 2000, a series of poor wild salmon returns led the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) to officially list Atlantic salmon populations in Maine as endangered. The status assessment noted interactions with farmed Atlantic salmon as one of several credible threats to the remaining wild fish population (FWS 1999; NRC 2004).

In 2001, the state of Maine ordered over 900,000 diseased farmed salmon killed in Cobscook Bay in an attempt to prevent further spread of the disease to nearby farmed or wild salmon. In addition to ISA, farmed and hatchery salmon are affected by numerous diseases and parasites such as sea lice (Gryodactylus salaries; Bakke and Harris 1998)

US Fish and wildlife report on farming of Atlantic salmon in Maine: Diseases, interbreeding with wild salmon, disruption of wild salmon reddshttp://library.fws.gov/salmon/asalmon75.html
Available genetic data and visual observations indicate that aquaculture escapees may have successfully interbred with wild Atlantic salmon. Under current aquaculture practices, this problem will persist because the escapement of aquaculture salmon, and their interactions with wild stocks, is expected to increase with the continued operation and growth of the industry in the State of Maine.

There is a significant potential for escaped aquaculture salmon to disrupt redds of wild salmon, compete with wild salmon for food and habitat, interbreed with wild salmon, and transfer disease or parasites to wild salmon. Comprehensive protective solutions to minimize the threat of interactions between wild and aquaculture salmon have not been implemented. The threat of these interactions is considered critical, given the fact that wild salmon stocks within the DPS are at low abundance levels, and are particularly vulnerable to genetic intrusion or other disturbances caused by escaped aquaculture salmon.

Sea lice from salmon farms were listed by the U.S. Fish and Wildlife Service as one of the threats to Maine’s wild salmon populations (FWS 1999).

The Pew letter also challenges the exception for Maine salmon farming companies to use emamectin benzoate, currently allowed under an Investigational New Animal Drug permit from the FDA.

Washington

Escaped fish: On the Western Coast of North America, escapes have not been accurately recorded but are believed to be substantial (Volpe, Taylor et al. 2000). In July 1997, for example, over 350,000 Atlantic salmon escaped in Puget Sound from a single farm (Gross 1998). U.S. records indicate that 600,000 farmed salmon escaped in the Pacific Northwest between 1996 and 1999, and over a million fish escaped between 1990 and 2000 (Nash, Brooks et al. 2001).

Official policy: The Washington State departments of Agriculture, Ecology, and Natural Resources, along with individual counties, help to regulate the eight salmon farms in the state. Washington issues discharge permits for salmon net pens, and requires the development of pollution prevention plans in compliance with best management practices (BMPs). Periodic assessments review carbon levels in sediments and other indicators; observable impacts from effluents are only allowed to extend 100 feet from salmon net pens. In addition, in 2003, Washington added new rules to existing salmon farming regulation. These included: A requirement for the prior approval of the species, stock and race of marine fish to be grown; A prohibition on growing transgenicfish; Required escape prevention, escape reporting, and escape recapture plans. (WDFW 2003)

American Gold Seafoods operates two hatcheries near Rochester Washington and has 120 pens off Bainbridge Island, Port Angeles, Cypress Island and Hope Island all within the waters of Washington states Puget Sound. At our offshore salmon farms, the fish dine on a mixture of anchovy, herring, wheat, soybeans and corn. They receive no hormones or steroids and are NOT genetically engineered.
http://www.icicleseafoods.com/locations/ags/default.aspx

Atlantic salmon (*Salmo Salar*) are raised in marine net pens in Washington State and British Columbia. In Oregon, however, they are listed as one of the "100 Most Dangerous Invaders to Keep Out of Oregon in 2005." Alaska currently has a ban on finfish farming. In 2003, California passed a bill (SB 245) which prohibits spawning, incubating, or cultivating anadromous or transgenic fish species, or any exotic species of finfish in waters of the Pacific Ocean that are regulated by the state.

http://www.aquaticnuisance.org/fact-sheets/atlantic-salmon

http://www.aquaticnuisance.org/fact-sheets/atlantic-salmon

Industry reported number of Atlantic salmon escaping from Washington and British Columbia fish farms, 1996 - 2006.

613,000 escaped fish in 4 years in Wa. Ongoing "leakage" likely, industry doesn't report all escapes, farmed salmon caught in commercial and recreational fishing gear.

Year Washington State British Columbia

http://wdfw.wa.gov/ais/species.php?Name=salmo_salar

1996 107,000	13,137
1997 369,000	7,472
1998 22,639	80,975
1999 115,000	35,954
2000 0 31,855	
2001 0 55,414	
2002 0 11,257	
2003 0 30	
2004 24,552	43,969
2005 2,500 21	
2006 0 No Data	

GLOBAL PROBLEMS

NMFS Risk Analysis for Marine Aquaculture.pdf This is a 2005 NMFS document focusing specifically on the risk assessment of marine fish aquaculture. While it mostly deals with methodology, rather than actual findings, and speaks of risks "perceived by the public and public administrators," it does list 10 areas of risk associated with marine fish aquaculture.

plbi-06-02-07.pdf: A Global Assessment of Salmon Aquaculture Impacts on Wild Salmonids, Ford and Myers, Feb 2008.
"Through a meta-analysis of existing data, we show a reduction in survival or abundance of Atlantic salmon; sea trout; and pink, chum, and coho salmon in association with increased production of farmed salmon. In many cases, these reductions in survival or abundance are greater than 50%." The study includes fish populations from Scotland and Ireland, as well as Canada."

Dramatic Declines In Wild Salmon Populations Linked To Exposure To Farmed Salmon

http://www.sciencedaily.com/releases/2008/02/080212085841.htm

ScienceDaily (Feb. 13, 2008) — Comparing the survival of wild salmonid populations in areas near salmon farms with unexposed populations reveals a large reduction in survival in the populations reared near salmon farms. Since the late 1970s, salmon aquaculture has grown into a global industry, producing over 1 million tons of salmon per year. However, this solution to globally declining fish stocks has come under increasing fire. In a new study Jennifer Ford and Ransom Myers provide the first evidence on a global scale illustrating systematic declines in wild salmon populations that come into contact with farmed salmon.

FEED
Atlantic, chinook, and coho salmon are carnivorous fish (Halver and Hardy 2002); in the wild, juvenile salmon feed on a range of animals including crustaceans, insects, mollusks,

and other fish. (Other species of salmon, such as sockeye, chum and humpies eat plankton and small crustaceans and cannot be reared for their lifecycle in cages) A third of global fisheries landings are converted into fish meal and fish oil annually (FAO 2002). Fish meal is produced primarily from pelagic fish that live near the surface waters or at mid-water depths in the ocean (IFFO 2001). The fish species that comprise most fish meal include anchovy, sardine, menhaden, jack mackerel, sandeel, sprat, capelin, and whiting (IFFO 2001).

The extraction of anchovies and other forage fish for feed for confined animals and fish affects the Southeast Pacific marine ecosystem. Intensive fishing currently reduces the quantity of prey available to large fish such as tunas, and the sizable populations of guano birds and pelicans that depend on Peruvian anchovies (Froese and Pauly 2003). Similarly, in U.S. waters menhaden form a key dietary component for several species of carnivorous fish including striped bass, tunas and swordfish, as well as marine birds (Franklin 2001; Froese and Pauly 2003).

Several recent reviews have been critical of aquaculture's use of wild fish for both practical and ethical reasons (Naylor, Goldburg et al. 1998; Naylor, Goldburg et al. 2000; Tidwell and Allan 2001). Concern has centered over the ecosystem consequences of removing wild fish for use as poultry, livestock and aquaculture feeds (Naylor, Goldburg et al. 1998; Naylor, Goldburg et al. 2000; Franklin 2001; Dayton, Thrush et al. 2002). The removal of forage fish leaves less prey available for wild predators such as seabirds, marine mammals, and predatory fish. The removal can also have top-down effects on ecosystems, potentially encouraging the growth of plankton and zooplankton (Franklin 2001; Dayton, Thrush et al. 2002).

Ethically, some have objected to the fact that farming carnivorous animals results in a net loss of protein (Naylor, Goldburg et al. 1998). An additional component to the debate has been the effect of fish meal use on food security. The use of fish meal and fish oil has been criticized for depleting the amount of protein available for human consumption (Naylor, Goldburg et al. 2000), The aquaculture industry could transition away from farming carnivorous animals such as salmon and shrimp, and instead focus on herbivorous and omnivorous fish with lower fish meal and fish oil requirements such as catfish, tilapia, and carp (Naylor, Goldburg et al. 1998; Goldburg, Elliott et al. 2001).

PNAS-2009-Naylor.et.al.**Aquafeeds.pdf Feeding Aquaculture in an era of finite resources.** Naylor is one of the preeminent authorities on the impacts of finfish OOA on forage fish, though she is cautiously optimistic that this problem might be overcome through use of alternative foodstuffs now under development. The fish in/fish out issue is major, though I don't know whether it is classified as an environmental impact issue.

Chemical Pollution

Aquaculture, like terrestrial agricultural and livestock industries, routinely employs a variety of chemicals for multiple purposes, such as promoting growth and preventing disease. The range of chemicals that can be used on a salmon farm includes antibiotics, pesticides, fungicides, vitamin supplements, coloring agents, spawning hormones and anaesthetics. Tacon and Forster (2003)

In net pen systems, chemicals are generally applied in water, where they can disperse and affect non-target species (NRC 1999). However, not all of the chemicals listed by Tacon and Forster are used on salmon farms or in other marine net pen systems and many of the chemicals that are used are not considered hazardous. With respect to salmon farming, concern over chemical use has centered on the effects of specific drugs, most notably antibiotics and pesticides, on human health and the surrounding environment (NRC 1999).

These pesticide and antibiotic residues are of concern due to their potential harm to human health and the environment. For example, the pesticide emamectin benzoate, which is used to treat sea lice, is "very toxic to aquatic organisms" and "may cause long-term adverse effects in the environment," according to the manufacturer's safety data. The non-therapeutic use of antibiotics in farmed fish destined for human consumption also raises concerns about the possibility of antibiotic resistant bacterial infections in humans.

Earlier this year through a Freedom of Information Act request, Pew obtained FDA documents revealing that three Chilean salmon farming companies, including the two largest Chilean producers of farmed salmon, used drugs not approved by the U.S. government. While attention has focused on Chile, the Pew Environment Group now has information showing that drugs unapproved for the U.S. market are also being used on salmon farms in Canada, Norway and Scotland. In 2008, more than half of farmed salmon imported to the U.S. came from those countries.

Use of "unapproved" drugs in aquaculture. One issue is whether the FDA will consistently require all companies exporting salmon to the U.S. to adhere to the FDA/Center for Veterinary Medicine Approved Drugs in Aquaculture list; another is how the FDA reconciles its current requirement that Chilean salmon companies use only "approved" drugs in aquaculture with permitting the Maine salmon farming industry to use one of these unapproved drugs, emamectin benzoate.
http://www.pewtrusts.org/news_room_detail.aspx?id=51366

Environmental and health effects of antibiotics

Depending on the antibiotic used, between 60% and 85% of a drug can be excreted through feces, unchanged (Alderman, Rosenthal et al. 1994; Samuelsen 1994; Weston 1996). Some drugs, such as oxytetracycline, are poorly absorbed through the intestinal tract of salmon, and consequently must be administered at high dosage rates for up to two weeks (Miranda and Zemelman 2002).

With respect to human health, antibiotic use encourages the growth of antibiotic resistant strains of bacteria. Some criticism has been leveled at the aquaculture industry for promoting the development of antibiotic resistant bacteria (Angulo and Griffin 2000; Goldburg, Elliott et al. 2001; Miranda and Zemelman 2002).

Pesticides
Along with antibiotics, salmon farms often use pesticides to control parasites such as sea lice (Roth 2000). A year 2000 review of pesticides used in salmon farming showed that the global industry currently uses at least eleven different chemical compounds, representing five pesticide types, to treat sea lice (Roth 2000). Pesticides included are: two organophosphates (dichlorvos and azamethiphos); three pyrethrin/pyrethroid compounds (pyrethrum, cypermethrin, deltamethrin); one oxidizing agent (hydrogen peroxide); three avermectins (ivermectin, emamectin and doramectin); and two benzoylphenyl ureas (teflubenzuron and diflubenzuron). The number of compounds routinely available in any one country is highly variable, ranging from 9 in Norway, to 6 in Chile and the United Kingdom, to 4 in Ireland, the Faeroe Islands and Canada, to 2 in the United States (formalin and hydrogen peroxide) (Roth 2000). For reference, cypermethrin use is authorized in Norway, Scotland, Ireland, and the Faeroe Islands. Additionally, it is under a trial permit in Chile and Investigational New Animal Drug status in the United States. Azamethiphos is authorized in Norway, Scotland, Canada, the Faeroe Islands, and Chile (Grant 2002).

Once released into the marine environment, pesticides may be toxic to non-target organisms (GESAMP 1997). Though there is very little information on the environmental impacts of pesticides, some have been shown to be harmful to other animals such as shrimp and lobsters, especially during early life stages (Abgrall, Rangeley et al. 2000). Specifically, synthetic pyrethroids and organophospates interfere with the nervous system of crustaceans and insects (Grant 2002).
The effects of pesticides can vary with the specific chemical used, the amount and duration of application, and the local water conditions.
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Health concerns over the concentration of PCBs in farmed salmon, originating from contaminated fish meals and fish oils (Easton, Luszniak et al. 2002; Jacobs, Covaci et al. 2002; Hites, Foran et al. 2004).
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A study published in the journal "**Environmental Science and Technology" concludes that, in spite of the heart healthy benefits of omega-3 fatty acids in all salmon, frequent consumption of farmed salmon is more likely than wild to boost levels of PBDEs**.
Farmed salmon are contaminated with much higher levels of chemical flame retardants than most wild salmon, new research demonstrates. Ronald Hites, distinguished professor at Indiana University and lead researcher on the study, studied polybrominated diphenyl ethers (PBDEs), a group of flame retardant chemicals used in electronics, upholstery, and other consumer products. He determined that the contamination is linked to the high fat diet that farmed salmon are fed. PBDEs are structurally similar to PCBs, which have been linked to cancer and to reproductive, neurological, and developmental effects in humans," said Hites.

PCBs, PCDD/Fs, and Organochlorine Pesticides in Farmed Atlantic Salmon from Maine, Eastern Canada, and Norway, and Wild Salmon from Alaska
S U S A N D . S H A W , * , † D I A N E B R E N N E R , † M I C H E L L E L . B E R G E R , † D A V I D O . C A R P E N T E R , *Environment, University at Albany, Rensselaer, New York*
Total PCB concentrations were significantly higher in the farmed salmon samples (as a group)…. The highest POPconcentrations were found in organically grown salmon

from Norway,… These observations suggest that purchasing higher priced organically farmed salmon, even when monitoring results are provided, does not necessarily protect the consumer from toxic exposure.
http://www.puresalmon.org/pdfs/bravo_present_sealice_WAS.pdf

DISEASES
Research shows that the prevalence of disease in cultured species tends to be significantly higher than in wild species (Stephen and Iwama 1997). This phenomenon presumably occurs in part because farmed salmon experience more physiological stress, in part due to unnaturally high salmon density in net pens.

The spread of infectious salmon anemia (ISA), for example, which attacks the kidneys and circulatory system of fish, led to the intentional destruction of millions of farmed fish throughout Europe, Canada, and the United States.

(Butler 2002; Revie, Gettinby et al. 2002; Heuch, Revie et al. 2003), infectious hematopoietic necrosis (IHN) (Naylor, Eagle et al. 2003), furunculosis, bacterial coldwater disease (Flagg, Berejikian et al. 2000), bacterial kidney disease (BKD) (Olafsen and Roberts 1993), salmon swimbladder sarcoma virus (SSSV), amoebic gill disease (Douglas-Helders, Dawson et al. 2002), and infectious pancreatic necrosis virus (Bowden, Small et al. 2002.).

Certain parasites and pathogens from farmed salmon have a demonstrated potential to infect wild salmon (Brackett 1991; Hjeltnes, Bergh et al. 1995; Bakke and Harris 1998). Several accounts have suspected that outbreaks of the following diseases may have originated at salmon farms and infected wild salmon populations: furunculosis (Bakke and Harris 1998); monogean parasites (Bakke and Harris 1998); sea lice (Birkeland 1996; Johnson, Blaylock et al. 1996); and the virus that causes infectious salmon anemia (Whoriskey 2000).

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Diseases affecting Atlantic salmon reared in captivity include bacterial, parasitic, viral, fungal and nutritional diseases (Roberts 1993). The development of a disease epizootic results from an interaction between the host, environment and the disease agent. In farmed salmon, the occurrence of disease is generally due to the high densities at which fish are reared (Hastein and Lindstad 1991). Bacteria may be released to the environment during and after epizootic diseases and may survive and persist (Olafsen 1993; Egusa 1992). The occurrence and spread of infectious diseases increases due to the high densities at which farmed salmon are raised (Institute of Aquaculture 1988; Lura and Saegrov 1991; Hastein and Lindstad 1991; Mork 1991; NASCO 1993; Olafson 1993).

The disease interaction between wild and farmed salmon will likely occur through the water, fish, and other sources such as nets and fishing or handling gear. The transmission of diseases through water can take place over long distances, and transmission has been documented to occur over at least seven km (Hastein and Lindstad 1991.

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Heart and Skeletal Muscle Inflammation of Farmed Salmon Is Associated with Infection with a Novel Reovirus
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0011487#s5
Atlantic salmon (*Salmo salar L.*) mariculture has been associated with epidemics of infectious diseases that threaten not only local production, but also wild fish coming into close proximity to marine pens and fish escaping from them. Heart and skeletal muscle inflammation (HSMI) is a frequently fatal disease of farmed Atlantic salmon. First recognized in one farm in Norway in 1999[1], HSMI was subsequently implicated in outbreaks in other farms in Norway and the United Kingdom[2].

Unlike terrestrial animal farming, where contact between domestic and free ranging wild animals of the same or closely related species is easily monitored and controlled, ocean based aquaculture is an open system wherein farmed fish may incubate and transmit infectious agents to already diminishing stocks of wild fish.
SeaWeb. "Fish Farms Drive Wild Salmon Populations Toward Extinction." *ScienceDaily* 16 Dec. 2007. Web. 9 Apr. 2011

PARASITES: SEA LICE are among the most easily identifiable, and perhaps most problematic of these wide spread, native parasites (NASCO 2003). Sea lice are parasitic copepods that feed on the mucous, skin, and blood of salmon. Infestations of these ectoparasites reduce the fitness of salmon and, on highly infested individuals, can be fatal (Wagner, McKinley et al. 2003; Glover, Hamre et al. in press). Various species of sea lice are endemic to Europe, North America, and South America; however pre-aquaculture observations of sea lice epizootics on wild fish are virtually non-existent. The development of salmon aquaculture may have increased the incidence of sea lice epizootics, however there is no baseline for comprehensive comparison (Butler 2002; Naylor, Eagle et al. 2003).

PARASITE AND PATHOGEN SPREAD

Professor Neil Frazer of the Department of Geology and Geophysics at the University of Hawaii at Manoa explains how farm fish cause nearby wild fish to decline. The foundation of his paper is that higher density of fish promotes infection, and infection lowers the fitness of the fish. http://www.sciencedaily.com/releases/2008/12/081215091017.htm

Conservation Biology: Sea-Cage Aquaculture, Sea Lice, and Declines of Wild Fish, L. NEIL FRAZER Article first published online: 10 DEC 2008
http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2008.01128.x/abstract;jsessionid=FDEC8EB400FB1EE066A8CAD5DE7FCD55.d03t02

Farm fish share water with wild fish, which enables transmission of parasites, such as sea lice, from wild to farm and farm to wild fishes. Sea cages protect farm fish from the usual pathogen-control mechanisms of nature, such as predators, but not from the pathogens themselves. A sea cage thus becomes an unintended pathogen factory. Basic physical theory explains why sea-cage aquaculture causes sea lice on sympatric wild fish to increase and *why increased lice burdens cause wild fish to decline, with extirpation as a real possibility. Theory is important to this issue because slow declines of wild fish can be difficult to detect amid large fluctuations from other causes. The important theoretical concepts are equilibrium, host-density effect, reservoir-host effect, and critical stocking level of farmed fish (stocking level at which lice proliferate on farm fish even if wild fish are not present to infect them). Declines of wild fish can be avoided only by ensuring that wild fish do not share water with farmed fish, either by locating sea cages very far from wild fish or through the use of closed-containment aquaculture systems. These principles are likely to govern any aquaculture system where cage-protected farm hosts and sympatric wild hosts have a common parasite with a direct life cycle.*

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Impacts of organic wastes

Localized impacts of waste from salmon farms are the most apparent environmental impact of cage-based aquaculture, and as such are relatively well documented (Kelly, Stellwagen et al. 1996; McDonald, Tikkanen et al. 1996; Silvert and Sowles 1996; Burd 1997; Findlay and Watling 1997; Hansen, Ervik et al. 2001). Organic matter often accumulates under and around net pens, increasing carbon levels in the sediments and reducing their oxidation-reduction (redox) potential. Sediments and biota can move into a state of overloading, anoxia, and outgassing of carbon dioxide, methane, and hydrogen sulfide (Chang and Thonney 1992; Black, Kiemer et al. 1996). In documenting these impacts, many studies have noted the ecological impacts in terms of changes in infaunal species biomass and species diversity within the impacted area (Findlay, Watling et al. 1995; Costa-Pierce 1996; Burd 1997; Mazzola, Mirto et al. 2000).

The primary effect of chemical and biological accumulation in nearfield sediments is an increased level of organic carbon and sulfides, and consequently altered patterns of species diversity in the benthos (Brooks, Stierns et al. 2003; Wildish, Hargrave et al. 2003). Species diversity in the benthic environment directly beneath salmon net pens with moderate to poor flushing is usually reduced to two taxa: the polychaete complex; and a few nematode species (Findlay, Watling et al. 1995; Pohle and Frost 1997; Mazzola, Mirto et al. 2000). Researchers have found these two taxa occur without fail at salmon farms worldwide (Burd 1997).

Research in Scotland shows major loss of seabed flora and fauna from salmon farm wastes, even in strongly tidal areas.
*Hall-Spencer, J., N. White, E. Gillespie, K. Gillham and A. Foggo. (2006) Impacts of fish farms on maerl
beds in strongly tidal areas. *Marine Ecology Press Series*. 326:1-9.

The waste from feed and feces has been linked to increased mercury levels in rockfish, a main component in the diets of many coastal people

*DeBruyn, A.M., M. Trudel, N. Eyding, J. Harding, H. McNally, R. Mountain, C. Orr, D. Urban, S.
Verenitch and A. Mazumder. (2006). Ecosystemic effects of salmon farming increase mercury
contamination in wild fish. *Environmental Science and Technology*. 40(11): 3489-3493.
In sites without adequate currents there can be an accumulation of heavy metals on the benthos (seafloor) near the salmon farms, particularly copper and zinc

ESCAPED FISH

The International Convention on Biological Diversity has identified invasive species as one of the fundamental threats to biodiversity. Globally, it has been estimated that invasive species are second only to habitat destruction in causing the loss of biodiversity (Vitousek, Mooney et al. 1997). In marine waters, the introduction of invasive species has resulted in "fundamental impacts on fisheries resources, industrial development and infrastructure, human welfare, and ecosystem resources and services" (Carlton 2001).
Some researchers have argued that the risk of establishment is substantial enough to warrant measures being taken against escapes (Volpe, Taylor et al. 2000; Soto, Jara et al. 2001; Gajard and Laikre 2003).

In the North Atlantic up to two million salmon are believed to escape annually (Schiermeier 2003). In some years 30-40% of Atlantic salmon caught in Norway have originated from fish farms (Hansen, Reddin et al. 1997; Naylor, Williams et al. 2001).

According to the intergovernmental North Atlantic Salmon Conservation Organization, concerns about salmon farming center on the risk of disease and parasite transmission, particularly sea lice, to wild stocks, and **effects on the genetic composition of wild stocks caused by interbreeding with escaped farmed salmon**. Interbreeding can disrupt the transmission of adaptive traits important for the survival and reproduction of wild fish, thereby depressing population fitness. "The latest scientific research suggests that such interbreeding and poorly planned stocking practices could have serious consequences for the wild salmon which are adapted to the conditions in each river" (NASCO 2003).

While a variety of interactions between farmed and wild salmon exist, the scientific consensus is that, "As a general rule, interactions (between introduced and wild Atlantic salmon) are likely to be negative in their effect on the viability of wild populations" (Youngson and Verspoor 1998, through competition and displacement. Researchers have shown that escaped farmed fish can alter the natural stream environment of wild salmon by elevating densities and increasing overall levels of competition for food and habitat (Einum and Fleming 1997; McGinnity, Stone et al. 1997). In addition, **escaped farmed salmon arrive later than wild salmon at spawning grounds. While the timing of spawning varies considerably, if farmed salmon spawn later they can dig up the gravel that contains the nests of wild females and replace the wild-salmon eggs with their own** (Webb, Hay et al. 1991). As a consequence of these various interactions, the survival and reproduction rate of wild Atlantic salmon is likely to be depressed.

More importantly, escaped salmon can **affect wild populations through interbreeding**. As a result of selective breeding programs, domesticated Atlantic salmon strains are now genotypically and phenotypically distinct from wild populations.

Farmed strains grow roughly three times faster than their wild counterparts, and have significantly higher pituitary growth hormone levels (Fleming, Hindar et al. 2000). In recent years there has been mounting evidence that male wild Atlantic salmon are mating with escaped farmed Atlantic female salmon, and a shift in the gene pool of the species is occurring

Gene flow from farmed to wild fish can harm wild salmon populations in at least two ways. First, **hybrid farmed-wild salmon can outcompete wild fish in the freshwater environment. Hybrid Atlantic salmon grow faster and tend to be larger than their wild counterparts** (Ferguson, McGinnity et al. 1997; Fleming, Hindar et al. 2000). Empirical evidence indicates that the faster-growing farmed and hybrid juveniles subsequently displace wild juveniles in rivers through competition. Second, despite the growth advantages of farmed strains in laboratory and freshwater settings, research shows **farmed genetic strains to be less fit than wild stocks in the wild marine environment (Oekland**, Heggberget et al. 1995; Fleming, Jonsson et al. 1996; Fleming, Hindar et al. 2000). Farmed and hybrid strains appear to be less able to compete successfully for food, territory, and mates by a substantial margin. The poor survival of farmed and hybrid salmon in marine environments can lead to a net reduction in the number of returning adults.

Contaminents

Review by Institute for Health and the Environment: **A Global Assessment of Organic Contaminants in Farmed vs. Wild Salmon: Geographical Differences and Health Risks**
Press release: First Global Study Reveals Health Risks of Widely Eaten Farm Raised Salmon *Science* Study Suggests Sharp Restrictions in Consumption. Significantly higher levels of cancer-causing and other health-related contaminants in farm raised salmon have been found than in their wild counterparts. The study, published in *Science* and by far the largest and most comprehensive to date, concluded that concentrations of several cancer-causing substances in particular are high enough to suggest that consumers should consider severely restricting their consumption of farmed salmon.
http://www.albany.edu/ihe/salmonstudy/summary.html

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Previous small peer reviewed studies: A study by Easton et al. in *Chemosphere* examined four farmed and four wild salmon purchased in British Columbia. It reports higher levels of PCBs, some organochlorine pesticides, and PBDEs (flame retardants) in the farmed salmon. The study found that contaminant levels in farmed salmon could be as much as ten times those in wild salmon. The study also suggested that the commercial salmon feed consumed by the farmed fish was responsible for the elevated contaminant levels. Differences between farmed and wild salmon were not notably different for other contaminants such as toxaphene and methylmercury. (M. D. L. Easton, D. Luszniak and E. Von der Geest, Preliminary examination of contaminant loadings in farmed salmon, wild salmon and commercial salmon feed. *Chemosphere* 46, 1053-1074 (2002).)

A study by Jacobs et al. in *Environmental Science & Technology* found relatively high concentrations of PCBs and moderate concentrations of organochlorine pesticides and

PBDEs in 13 samples of farmed Scottish and European salmon. (M. Jacobs; A. Covaci, and P. Schepens, Investigation of selected persistent organic pollutants in farmed atlantic salmon (Salmo salar), salmon aquaculture feed, and fish oil components of the feed. *Environmental Science and Technology* 36, 2797-2805 (2002).)

Another study by Jacobs et al. in the journal *Chemosphere* found relatively high concentrations of dioxins and PCBs in 10 samples of farmed and wild Scottish salmon. The study concluded that high levels of farmed salmon consumption could lead to intakes of contaminants above tolerable daily and weekly levels when combined with intakes from the typical UK diet. (M. Jacobs, J. Ferrario, and C. Byrne, Investigation of polychlorinated dibenzo-p-dioxins, dibenzo-p-furans (sic) and selected coplanar biphenyls in Scottish farmed Atlantic salmon (Salmo salar). *Chemosphere* 47

plbi-06-02-07.pdf: A Global Assessment of Salmon Aquaculture Impacts on Wild Salmonids, Ford and Myers, Feb 2008.
"Through a meta-analysis of existing data, we show a reduction in survival or abundance of Atlantic salmon; sea trout; and pink, chum, and coho salmon in association with increased production of farmed salmon. In many cases, these reductions in survival or abundance are greater than 50%." The study includes fish populations from Scotland and Ireland, as well as Canada."

BRITISH COLUMBIA
Predator control: Salmon farmers are granted licenses to kill predators such as sea lions and seals to stop them from eating their fish. According to a report by the Department of Fisheries and Oceans Canada, between 1989 and 2000, BC salmon farmers reported killing 6,243 seals and California and Steller sea lions
*Jamieson, G.S. and P.F. Olesiuk, Department of Fisheries and Oceans Canada. (2001).
Salmon Farm
Pinniped Interactions in British Columbia: An Analysis of Predator Control, its Justification and
Alternative Approaches. http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2001/RES2001_142e.pdf

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Wild Salmon Endangered By Failure To Contain Sea Lice From Salmon Farms:
http://www.sciencedaily.com/releases/2007/09/070919225321.htm*ScienceDaily (Sep. 24, 2007)* — Eighteen scientists throughout Canada have written an open letter to the Canadian government urging a response to the issue of sea lice from salmon farms threatening wild Pacific salmon. The scientists are convinced by the published scientific evidence that the debate is over: sea lice breeding on farmed salmon are threatening BC's wild Pacific salmon

http://web.uvic.ca/~serg/publications/peerreviewed.html

A new study recently published in the journal Public Library of Science ONE by researchers from Raincoast Conservation Foundation, Watershed Watch Salmon Society, and the Universities of Victoria and Simon Fraser provides the first link between salmon farms and elevated levels of sea lice on juvenile Fraser River sockeye salmon in British Columbia.

The article, "Sea Louse Infection of Juvenile Sockeye Salmon in Relation to Marine Salmon Farms on Canada's West Coast," genetically identified 30 distinct stocks of infected Fraser sockeye that pass by open net-pen salmon farms in the Strait of Georgia, including the endangered Cultus Lake population. The study found that parasitism of Fraser sockeye increased significantly after the juvenile fish passed by fish farms. These same species of lice were found in substantial numbers on the salmon farms.

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0016851

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Company	**Headquarters**	**Licences**	**% of BC Industry**
Marine Harvest	Norway	75	55%
Mainstream (Cermaq)	Norway	33	24%
Grieg Seafood	Norway	17	4%
Creative Salmon	Canada	6	4%

total farms in BC 131
http://www.farmedanddangerous.org/solutions/industry-reform/about-the-industry/

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A recent study in a peer-reviewed scientific journal, the *Proceedings of the National Academy of Sciences of The United States of America*, found that **sea lice originating from fish farms can kill up to 95% of juvenile wild pink and chum salmon.** Preliminary studies indicate that the disease transfer from the farms is just as prolific and harmful. Salmon farms can increase the exposure of wild juvenile Pacific salmon to sea lice during early marine life when sea lice are normally rare.

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SEA LICE

Fish Farms Drive Wild Salmon Populations Toward Extinction *ScienceDaily (Dec. 16, 2007*
http://www.sciencedaily.com/releases/2007/12/071213152606.htm
"The impact is so severe that the viability of the wild salmon populations is threatened," says lead author of a new article in Science (December 14) Martin Krkosek, a fisheries ecologist from the University of Alberta. Krkosek and his co-authors calculate that sea lice have killed more than 80% of the annual pink salmon returns to British Columbia's Broughton Archipelago. "If nothing changes, we are going to lose these fish." Previous peer-reviewed papers by Krkosek and others showed that sea lice from fish farms can infect and kill

juvenile wild salmon. This, however, is the first study to examine the population-level effects on the wild salmon stocks.
Sea lice (Lepeophtheirus salmonis) are naturally occurring parasites of wild salmon that latch onto the fishes' skin in the open ocean. The lice are transmitted by a tiny free-swimming larval stage. Open-net salmon farms are a haven for these parasites, which feed on the fishes' skin and muscle tissue. Adult salmon can survive a small number of lice, but juveniles headed from the river to the sea are very small, thin-skinned, and vulnerable.

Sea lice Salmon Canada 2010, etc. pdf: "**Evidence of farm-induced parasite infestations on wild juvenile salmon in multiple regions of coastal British Columbia, Canada; M.H.H. Price, A. Morton, and J.D. Reynolds**

Conclusions: "Sea lice from salmon farms threaten vulnerable wild salmon populations in British Columbia, heightening the urgency required for Canada to develop an effective conservation-based salmon aquaculture policy."

*Krkosek, M.K., A. Morton, J.P. Volpe, M.A. Lewis. 2009. Sea lice and salmon population dynamics: Effects of exposure for migratory fish. **Proceedings of the Royal Society of London, Series B**. *276:2819-2828* (PDF | 586KB)

Krkošek, M., M.A. Lewis, A. Morton, L.N. Frazer and J.P. Volpe, 2006. Epizootics of wild fish induced by farm fish. **Proceedings of the National Academy of Sciences USA** 103: 15506-15510. (PDF | 1.4MB)

Krkošek, M., M.A. Lewis, J.P. Volpe and A. Morton. 2006. Fish farms and sea lice infestations in wild juvenile salmon in the Broughton Archipelago – A rebuttal to Brooks (2005). **Reviews in Fisheries Science.** 14: 1-11. (PDF | 414KB)

Krkošek, M., A. Morton, J.P. Volpe. 2005. Non-lethal assessment of juvenile Pacific salmon for parasitic sea lice infections. **Transactions of the American Fisheries Society** 134: 711-716. (PDF | 53KB)

Krkošek, M., M.A. Lewis and J.P. Volpe. 2005. Transmission dynamics of parasitic sea lice from farm to wild salmon. **Proceedings of the Royal Society of London, Series B**. 272:689-696. (PDF | 311KB)

Morton, A. and J.P. Volpe. 2002. A description of Atlantic salmon *Salmo salar* in the Pacific salmon fishery in British Columbia, Canada, in 2000. **Alaska Fishery Research Bulletin** 9: 102-110. (PDF | 143KB)

Escaped fish BC

Juvenile Atlantic salmon of two year-classes have been captured in BC rivers (Volpe, Taylor et al. 2000). These juveniles were the natural offspring of escaped farmed salmon, indicating that escaped adults have spawned in Pacific rivers on multiple occasions...If Atlantic salmon are able to become fully established, populations of Atlantic salmon could conceivably compete with Pacific salmon populations (some of which are in poor health), prey on native fish species, increase predator densities, or otherwise change the marine ecosystem in ways we cannot currently predict.

DFO's own estimates show that Atlantic salmon have been found in over 81 BC rivers and streams that were surveyed6.
*Naylor, R. L., K. Hindar, I. Fleming, R. Goldburg, S. Williams, J. Volpe, F. Whorikey, J. Eagle, D. Kelso
and M. Mangel. (2005). Fugitive Salmon: Assessing the Risks of Escaped Fish from Net-Pen Aquaculture. *Bioscience.* 55(5):427-437.

There is consistent "leakage" where salmon escape though holes in nets. Industry states this can be anywhere from 1-5% of annual production which would translate into 350,000 fish per year in British Columbia
*Morton, A.B. and J. Volpe. (2002). A Description of Escaped Farmed Atlantic Salmon *Salmo salar*
Captures and Their Characteristics in One Pacific Salmon Fishery Area in British Columbia, Canada, in
2000. *Alaska Fisheries Research Bulletin.* 9(2):102–110.

Volpe, J.P., B.W. Glickman and B.R. Anholt. 2001. Reproduction of Atlantic salmon (*Salmo salar*) in a controlled stream channel on Vancouver Island, British Columbia. **Transactions of the American Fisheries Society** 130: 489-494. (PDF | 61KB)

Volpe, J.P., B.R. Anholt and B.W. Glickman. 2001. Competition among juvenile Atlantic salmon (*Salmo salar*) and steelhead trout (*Oncorhynchus mykiss*): Relevance to invasion potential in British Columbia. **Canadian Journal of Fisheries and Aquatic Sciences** 58: 197-207. (PDF | 193KB)

Volpe, J.P. and B.R. Anholt. 2001. Atlantic salmon (*Salmo salar*) in British Columbia. *In* **Marine Bioinvasions: Proceedings of the First National Conference** (January 24-27 1999; edited by J. Pederson). Massachusetts Institute of Technology, Cambridge, MA. pp. 256-259.

Volpe, J.P., E.B. Taylor, D.W. Rimmer, B.W. Glickman. 2000. Natural reproduction of aquaculture escaped Atlantic salmon (*Salmo salar*) in a coastal British Columbia river. **Conservation Biology** 14: 899-903. (PDF | 319KB)

CHILE

Chile's production of Atlantic salmon has since fallen dramatically due to problems with ISA disease, decreasing by 59%, 40%, and 10% in 2009, 2010, and 2011, respectively.
http://salmonfarmers.khamiahosting.com/sites/default/files/SalmonFarmingOverview2009.pdf

Escaped nonnative salmon are capable of affecting ecosystems prior to or without actually becoming established. In effect, the continual escape of salmon is the equivalent of a small reproducing population. This population can alter existing food webs in freshwater and marine environments. For example, concern has been raised that through their feeding habits, Atlantic salmon released into Chilean lakes may be affecting native fish species. One review of salmon farming speculates that “Chile could be approaching this critical period of decline for several native species without realizing it or taking measures to stop it because of the lack of baseline data and a strategy to monitor the effects of introduced exotic species” (Gajard and Laikre 2003).

In Chilean marine environments, escaped salmon are the top predator in many areas. As a result, the density of escaped salmon found in the wild is negatively correlated with the abundance of native fish, most likely due to predation of salmon on native fish (Soto, Jara et al. 2001).

Cermaq management underestimated the virus outbreak that led to the collapse of the Chilean farmed salmon industry. Instead of responding quickly to the massive outbreaks of infectious salmon anemia in Chile, Cermaq continued to release juvenile salmon into its open-net cages, where many fish became infected by the highly contagious virus. The resulting fish losses translated into a plummeting stock price.

NORWAY

> Norwegian production increased 2% to 741,000 m.t. from 723,000 m.t. in 2008. Norwegian production is expected to rise 12% in 2009 whileUK and Canadian production is expected to relatively stable.
> http://salmonfarmers.khamiahosting.com/sites/default/files/SalmonFarmingOverview2009.pdf

AQUACULTURE ENVIRONMENT INTERACTIONS:
http://preventescape.eu/?page_id=53

Escapes of fishes from Norwegian sea-cage aquaculture: causes, consequences and prevention

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ABSTRACT: The escape of fish from aquaculture is perceived as a threat to wild fish populations. The escapes problem is largely caused by technical and operational failures of fish farming equipment. In Norway, 3.93 million Atlantic salmon *Salmo salar*, 0.98 million rainbow trout *Oncorhynchus mykiss* and 1.05 million Atlantic cod *Gadus morhua* escaped from 2001 to 2009… there is also a so-called ‘escape through spawning’

(Jørstad et al. 2008). This phenomenon has forced a redefinition of the term ‘escapes from aquaculture’ to include the escapement of fertilised eggs into the wider marine environment.

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A news article in Norway's version of the Financial Times (Dagens Naringsliv) has a hard-hitting article on waste emissions from salmon farming based on a new report from the Norwegian Institute of Water Research:

Article in full (in Norwegian) online via: http://tomcat-pm.intermedium.com/pdf/Dagens_Neringsliv/2011/03/09/Dagens_Neringsliv.2011-03-09.0-0-1-0.0-0-1-0.16-17.pdf
Partial English Translation below:

The Climate and Pollution Agency fear that emissions from fishfarms will lead to lifeless fjords. The agency is now asking for help. In a recent report produced by the research foundation IRIS and NIVA (The Norwegian Institute for Water Research) on behalf of the Climate and Pollution Agency (KLIF), it is stated that emissions from fish farming are at a record high. Despite the fact that emissions per fish have been reduced, the total amount increased in line with the total amount of farmed fish has increased. The report also shows that even though there has been a considerable development within the aquaculture industry in recent years, technology has not followed to a large enough degree. Farming of approximately one million salmon still occurs for all practical purposes in open cages in the sea, without waste feed and excrement being collected. Environmental challenges are primarily handled by moving the plants to areas with better current conditions, according to the researchers behind the report - Asbjørn Bergheim from IRIS and Bjorn Braaten and Guttorm Long, both from NIVA.

Straight out

It's not like on land where one has a discharge pipe. Everything goes straight into the water. We are concerned that the emissions together with increasing sea temperature will lead to a reduction in the biological diversity in our fjords, that the sea bed will become lifeless and that the ecological conditions necessary for wild fish disappears, says KLIF director Ellen Hambro. Director of Communications Are Kvistad in the fishfarmer organization FHL does not share Hambro’s fears: - We don’t yet know the contents of the report, but note that the Norwegian Institute of Marine Research, in its recent risk report has concluded that emissions of nutrients does not pose any threat along the Norwegian coast. This is our standpoint, says Kvistad, and stresses that farmers follow all the laws and regulations related to emissions and pollution. The scientists are clear that they believe that efforts to find solutions to collect excrement and waste feed should be prioritised. They also recommend that surveillance cameras should be installed on the cages.

Will monitor

The report also proposes that the industry focuses on moving away from impregnated nets and instead concentrate on developing more environmentally friendly methods to prevent fouling. The scientists reckon that farming on land would be too costly to be sustainable, but points out that in such plants it would be possible to introduce good cleaning solutions. In the hope of attracting more proposals for solutions KLIF are now asking for help concerning how emissions from aquaculture can be reduced. - Aquaculture is the largest anthropogenic source of nutrient discharge from Rogaland and northwards. It isn’t certain that all the solutions as to how to reduce emissions can be found in this report, and we would therefore like more ideas, says KLIF Manager Ellen Hambro.

http://tomcat-pm.intermedium.com/pdf/Dagens_Neringsliv/2011/03/09/Dagens_Neringsliv.2011-03-09.0-0-1-0.0-0-1-0.16-17.pdf

CLOSED CONTAINMENT MAY NOT BE A SOLUTION

Assessing alternative aquaculture technologies: life cycle assessment of salmonid culture systems in Canada
Nathan W. Ayer a,*, Peter H. Tyedmers
http://sres.management.dal.ca/Files/Tyedmers/LC_Impacts.pdf

This study employed life cycle assessment (LCA) to quantify and compare the potential environmental impacts of culturing salmonids in a conventional marine net-pen system with those of three reportedly environmentally-friendly alternatives; a marine floating bag system; a land-based saltwater flowthrough system; and a land-based freshwater recirculating system. Results of the study indicate that while the use of these closed-containment systems may reduce the local ecological impacts typically associated with net-pen salmon farming, the increase in material and energy demands associated with their use may result in significantly increased contributions to several environmental impacts of global concern, including global warming, non-renewable resource depletion, and acidification.

Although closed-containment systems are currently being described and promoted as environmentally-friendly alternatives to net-pen farming, results of this study suggest that there is an environmental cost associated with employing this technology which should be considered in any further evaluation of their
environmental performance.

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