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FINAL ENVIRONMENTAL IMPACT STATEMENT

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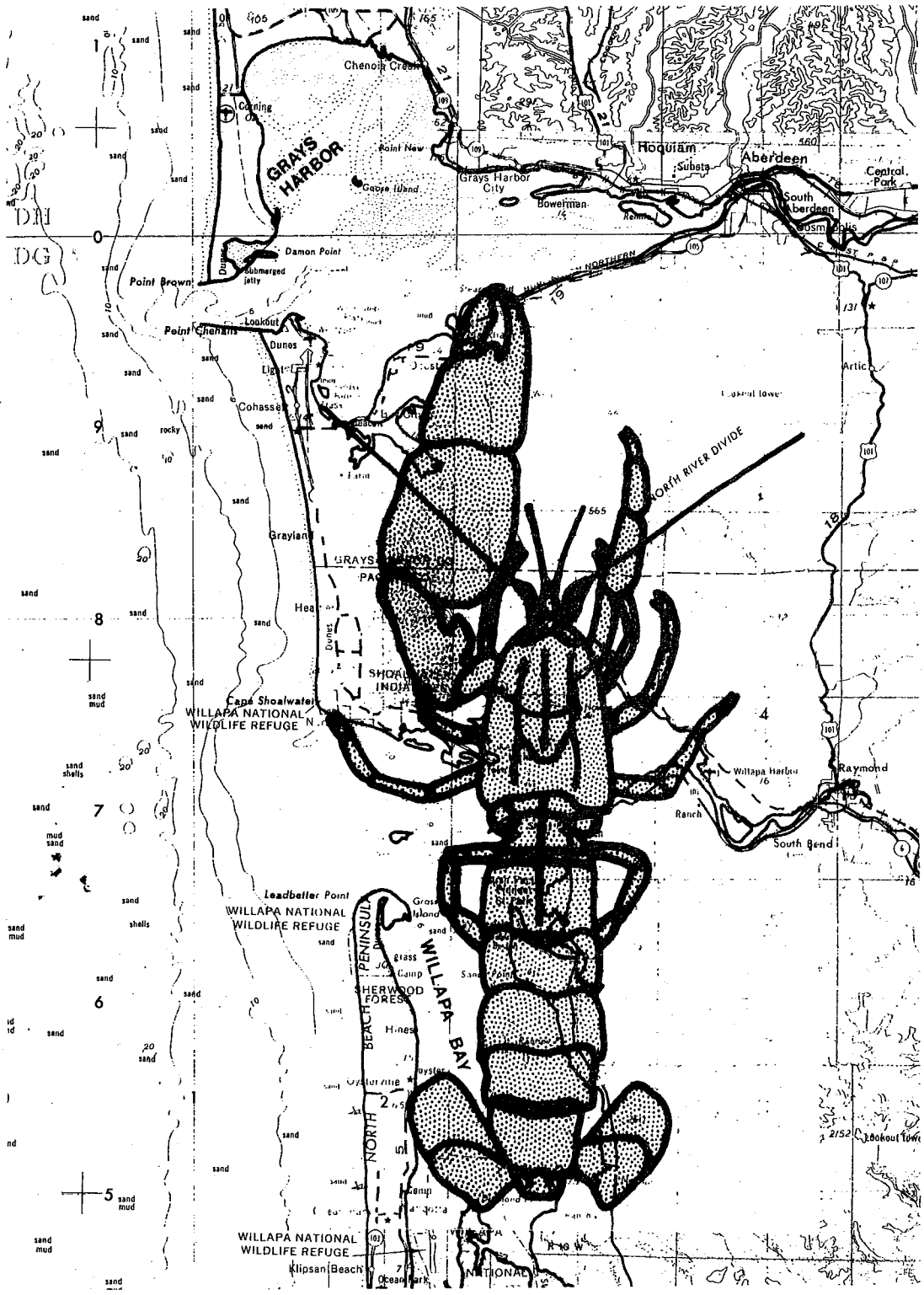

Washington Department of Fisheries
Washington Department of Ecology

June 1985

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FINAL ENVIRONMENTAL IMPACT STATEMENT

USE OF THE INSECTICIDE SEVIN TO CONTROL GHOST AND MUD SHRIMP ON OYSTER BEDS IN WILLAPA BAY AND GRAYS HARBOR

Washington Department of Fisheries
Washington Department of Ecology

June 1985

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DEPARTMENT OF FISHERIES
115 General Administration Building • Olympia, Washington 98504 • (206) 753-6600 • (SCAN) 234-6600

June 17, 1985

Dear Reader:

The attached final environmental impact statement (EIS) is for the continued use of the insecticide Sevin to control ghost and mud shrimp on privately owned oyster beds in Willapa Bay and Grays Harbor. The draft EIS for the proposal was issued in June 1984. During the 1984 treatment, we conducted further studies and reviewed additional literature. We have revised the final EIS to include the results of those efforts and to respond to needs outlined in the comment letters on the draft EIS.

Under the shrimp control program, up to 300 acres in Willapa Bay and 100 acres in Grays Harbor would be treated annually with Sevin to kill ghost and mud shrimp. These animals burrow in oyster beds and make them too soft to support oysters. Without control of the burrowing shrimp populations, oyster production in the two bays would fall.

The major adverse impact from the burrowing shrimp control program is the mortality of young Dungeness crab which are on the beds at the time of treatment or which move onto the beds at high tide to feed on dead shrimp. Other crustacea, such as amphipods (important to the food chain), are killed on the treated beds. In addition, some small fish trapped in tide pools on the beds are killed during treatment. The mortalities to these organisms are not well quantified. Studies are planned to provide a more detailed quantitative evaluation of the extent of impacts and mortalities. A supplemental EIS will be prepared when substantive information is available.

This final EIS will guide decisionmakers in the departments of Fisheries and Ecology as they review applications for permits which would allow oyster growers to spray Sevin on oyster beds in Willapa Bay and Grays Harbor. In addition, it will guide those planning future studies on impacts from the burrowing shrimp control program.

Sincerely,

Duane Phinney

Duane Phinney, Chief
Department of Fisheries
Habitat Management Division

Dennis Lundblad

Dennis Lundblad, Supervisor
Department of Ecology
Operations Management Division

INTRODUCTION

Project Sponsor	Willapa Bay-Grays Harbor Oyster Growers Association c/o Coast Oyster Company P.O. Box 166 South Bend, Washington 98586
Proposed Action	Annual application of the pesticide Sevin to control ghost and mud shrimp on up to 400 acres of oyster growing grounds in Willapa Bay and Grays Harbor. Application is currently authorized by the U.S. Environmental Protection Agency and the Washington Department of Agriculture Special Local Needs restrictions.
Project Location	Various locations in Willapa Bay and Grays Harbor
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Licenses and Permits Required

Department of Fisheries
Shellfish Pest Control Permit
WAC 220-20-010(16)

Department of Ecology
Short-term Modification of Water Quality Standards Permit
WAC 173-201

Date of Issuance of Final EIS — June 14, 1985

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1.0 SUMMARY

1.1. BACKGROUND

After the 1957-58 El Nino, burrowing shrimp infestations in Willapa Bay and Grays Harbor significantly expanded. Ghost and mud shrimp burrow tunnels in oyster beds and generate large amounts of silt. Oysters planted in heavily populated beds sink into the mud or are smothered by the silt. The expanded burrowing shrimp population threatened the multi-million dollar oyster culture industry in the bays with reduced production.

The Washington Department of Fisheries (WDF) considered and experimented with a variety of measures to reduce and control the burrowing shrimp population. The carbamate insecticide Sevin (carbaryl) was selected for use. The WDF also established procedures to regulate the use of Sevin under the authority of the Washington Department of Agriculture (WDA).

Beginning about 1976, WDF prepared declarations of nonsignificance each year for the burrowing shrimp control program. Recently questions and concerns have been expressed about the use of a pesticide in the marine environment. Because of this, WDF and the Washington Department of Ecology (WDOE) determined that an environmental impact statement (EIS) should be prepared on the program.

1.2. DESCRIPTION OF PROPOSAL

Oyster growers propose to continue using Sevin to control burrowing shrimp on oyster beds in Willapa Bay and Grays Harbor. Normally no more than 300 acres per year would be treated in Willapa Bay and not more than 100 acres would be treated in Grays Harbor.

Control of these shrimp is of significant benefit to the oyster industry: as a worst case scenario, oyster growers estimate that production would be reduced by 70 to 80 percent without control of burrowing shrimp. This would represent a $5 million annual loss to the economies of Pacific and Grays Harbor counties.

1.3. ALTERNATIVES

Alternatives to the present control program include:

- Mechanical - use of machines to disrupt the beds
- Surfacing - use of plastic to cover the beds
- Insecticides - use of other insecticides
- Growing methods - use of methods that raise the oysters off the beds
- No action - no control of burrowing shrimp
- Postpone - suspend program until methods with fewer impacts are developed or more definitive information is available

While some of these methods may be effective, they are expected to have greater adverse environmental impacts and cost more to implement than the use of Sevin. Alternative culture methods involving structures to hold the oysters off the bottom may be possible. However, they have unknown impacts when used on the scale needed to meet the current level of oyster production from Willapa Bay and Grays Harbor.

The alternative of using Sevin at reduced concentrations will be evaluated in the summer of 1985. It offers the possibility of less impacts to crab, fish, and other organisms. However, may not kill as many of the burrowing shrimp.

1.4. MITIGATION

Mitigation measures have been implemented to minimize impacts to nontarget organisms, to the extent possible. These have been developed by the WDF in cooperation with the WDA and the EPA. Under these criteria, treatment has been limited to 400 acres total in the state (300 acres in Willapa Bay and 100 in Grays Harbor). This limit was exeeded in 1984 under a special emergency exemption. No more than 50 acres can be treated in one application and no aerial spraying is allowed within 200 feet of sloughs or large bodies of standing water. Oyster growers submit applications for treatment to WDF whose staff inspects the beds and determines if treatment is warranted.

Application is only allowed on dry oyster beds at low tide and may not exceed 10 pounds of Sevin per acre. Treatment is only allowed during the months of July and August when the abundance of crab and most important fish is at its seasonal low. All treatment is under the direct supervision of WDF personnel at the site. WDF may terminate or delay treatment to prevent adverse impacts. In addition to pre-treatment observations, all tracts are re-inspected within 24 hours to determine the effect on crab. The specific criteria for treatment are presented in Section 2.3.

Sevin is applied during the summer months, which probably mitigates impacts because the chemical degrades more rapidly at the higher summer temperatures than it would during other seasons.

Studies are being conducted on the use of bait to attract crab away from the treated oyster tracts. This measure has appeared promising in early tests.

1.5. IMPACTS

The proposed burrowing shrimp control program would result in short-term impacts from immediate acute toxicity and long-term changes from removal of burrowing shrimp and planting with oysters. Based on over 20 years of observation by WDF, adverse impacts from the treatment program have been minimal. Observed impacts are limited to the treated ground and are temporary. Impacts off of the treated plots have not been observed but this lack of effect has not been documented.

The major adverse impact is to young Dungeness crab which are on the beds at the time of treatment or which move onto the beds at high tide to feed on the dead shrimp. On average, about 29 crab are killed per treated acre. This figure provides a relative index of the crab losses on treated tracts from year to year. The crab counts do not provide an estimate of the total crab killed or their relation to the total crab populations of the two bays. Studies are planned which would provide a more quantitative measurement of crabs in the bays and on the treated beds.

Small fish (including juvenile lingcod) trapped in tidepools and exposed to a direct application of Sevin may be killed. Detailed records of these fish losses have not been kept due to the low numbers observed. No dead adult fish have been observed. However, additional study is necessary to identify the effects of possible feeding by fish on dead shrimp, crab, and other organisms.

Other arthropods inhabiting the oyster beds and the sediments may be killed when tracts are treated. The extent of the losses and the time required to re-establish the populations is unknown. Recolonization appears to begin shortly after treatment; but rate of recolonization is not well known. The presence of burrowing shrimp may reduce the abundance and diversity of certain of these organisms and may provide habitat for others. Due to the elimination of burrowing shrimp, overall species abundance and diversity may increase as the result of Sevin treatment; however additional confirmation is necessary.

Birds and fish could be affected if a significant portion of their important food chain organisms are killed. The application of Sevin would not be toxic to birds directly. Currently, the impact of such reductions is minimized by the limited acreage sprayed and by spraying during a period of low bird and fish abundance.

Sevin degrades rapidly in the environment. In water Sevin decomposes to non-lethal concentrations within an hour while in sediment, Sevin persists for several weeks under summer conditions.

Treatment of the burrowing shrimp may have long-term beneficial impacts. Burrowing shrimp have been observed to inhibit other species (Posey 1985) and the presence of oysters on treated beds probably provides enhanced habitat for juvenile crab and small fish. This may or may not mitigate for those animals killed during treatment. In connection with a proposed channel dredging project, the University of Washington is conducting studies of crab habitat in Grays Harbor but additional studies are needed.

No significant, long-term, adverse impacts have been identified. However, additional studies are needed to better identify and quantify the extent and nature of the impacts and to assure that they are minimized as much as possible. Studies are being planned.

1.6. NON-MITIGATABLE IMPACTS

The objective of the Sevin treatment program is to eliminate the burrowing shrimp from the oyster culture beds. This allows the beds to become firm again and to be returned to aquaculture. The effects of this elimination are viewed by many as beneficial, while others view them as adverse because they alter a natural process.

Incidental mortalities to crab, invertebrates, and some fish are unavoidable. Additional efforts are being made to minimize crab mortalities and to better assess the effects of treatment on fish and other organisms. The extent of the impacts from these losses is not well know. However, the area treated each year is less than 0.4% of Willapa Bay and 0.2% of Grays harbor.

FINAL ENVIRONMENTAL IMPACT STATEMENT

USE OF THE INSECTICIDE SEVIN TO CONTROL GHOST AND MUD SHRIMP ON OYSTER BEDS IN WILLAPA BAY AND GRAYS HARBOR

2.0 DESCRIPTION OF THE PROPOSED ACTION

The Draft Environmental Impact Statement (DEIS) on the Sevin program was issued in June 1984. Following this date a large quantity of information on existing conditions and the effects of Sevin in Willapa Bay and Grays Harbor became available. These included observations from the 1984 spraying program, reports of fish use in Willapa Bay and Grays Harbor, descriptions of burrowing shrimp ecology, and information provided by or referenced by reviewers. Consequently, the EIS has been extensively revised.

The Willapa Bay and Grays Harbor oyster growers propose to use the carbamate insecticide Sevin (1-naphthyl-N-methylcarbamate) manufactured by the Union Carbide Corporation to control ghost shrimp (Callianassa californiensis) and mud shrimp (Upogebia pugettensis) on oyster beds in Willapa Bay (Pacific County) and Grays Harbor (Grays Harbor County). The Washington Departments of Ecology (WDOE) and Fisheries (WDF) are co-lead agencies under the State Environmental Policy Act (SEPA) for this Environmental Impact Statement (EIS). The purpose of this EIS is to identify the impacts of the treatment program and assess the probable, significant environmental impacts.

Since 1973, the Willapa Bay and Grays Harbor oyster growers annually treated oyster beds under special pest-control permits issued by WDF. The WDF permits are specifically exempt from provisions of the SEPA Rules (WAC 197-10-175 and 197-11-835). However, since 1976, environmental checklists have been prepared for each treatment and Declarations of Non-Significance (DNS) issued. Recently, WDOE has required that oyster growers obtain a short-term modification to the water quality standards, which requires compliance with SEPA.

Concern and controversy has developed over the use of Sevin, or any pesticide, in the marine and estuarine environments. Consequently, WDF and and WDOE determined that an EIS was an appropriate tool to review and re-evaluate the Sevin treatment program and to provide a public forum for discussion of the issues surrounding the program.

2.1. BACKGROUND OF SEVIN USAGE

Sevin has been used on oyster beds in Washington since 1963 to control ghost and mud shrimp (Appendix A). These shrimp are crustaceans which burrow into intertidal mud flats. Dense infestations of burrowing shrimp inhibit the culture of Pacific oysters (Crassostrea gigas) by

suspending silt which smothers oyster seed. Also, the shrimp activities soften the ground causing adult and seed oysters to sink and die (McCrow 1972). Excessive concentrations of these shrimp threaten the viability of the coastal oyster industry.

After 1958, an unusually warm year, large numbers of burrowing shrimp colonized new areas (Lindsay 1961). Oyster growers and WDF conducted studies to find suitable methods to control these shrimp. The pesticide Sevin was finally chosen based on its special effectiveness on arthropods, short persistence in the environment, and limited toxicity to other animals (Sayce 1970, Sayce and Chambers 1970, Chambers 1970). Figures 1 and 2 show areas of oyster culture and where Sevin has been used annually since 1963 in Willapa and Grays Harbor.

Annual treatment has been limited to 300 acres in Willapa Bay and 100 total acres for the remainder of the state. The only exception was in 1984 when an emergency exemption was allowed for treatment of additional acreage. According to Westley (1984) and Tufts (1984a), the 300 acre limit was established in 1976 when spraying criteria were set. This was the most land, at that time, that the oyster growers could economically leave fallow in any one year.

2.2. CONTROL OF SEVIN USE

Sevin is one of the most widely used pesticides in the United States. It is used extensively to control insects on fruit and vegetables, and in forests. It is also applied to pets and livestock to control insect pests (Appendix B). Sevin is applied to infested oyster beds in a powder form either by hand or by helicopter. Because Sevin is toxic to other marine invertebrates, WDF, in cooperation with the Washington Department of Agriculture (WDA) and the U.S. Environmental Protection Agency (EPA), developed a review and approval policy for its use. This policy resulted in criteria for permit issuance and application of Sevin (see Section 2.3).

Under the Washington Administrative Code (WAC) 220-20- 010(16), WDF authorizes and regulates treatment of pests on oyster beds to protect oyster growing habitat and the fish and shellfish of the area. The use of Sevin for burrowing shrimp control complies with the provisions of Washington State Special Local Needs Pesticide Registration No. WA-760021, issued by the EPA through the WDA under authority of Section 24(c) of the Amended Federal Insecticide, Fungicide, and Rodenticide Act (Westley 1981).

2.3. CRITERIA FOR USE AND APPLICATION OF SEVIN

The use of Sevin for ghost and mud shrimp control is supervised by WDF following the criteria below:

1. The WDF shall inspect all tracts of oyster ground proposed for spraying and assess the need for treatment. Only tracts demonstrating sufficient need, as determined by WDF, will be authorized for spraying. Assessment of the need is based on the density of shrimp burrow entrances and the judgment and experience of the WDF biologist and the oyster grower. Generally, ground having over 10 holes (shrimp burrow entrances) per square yard is usually approved for treatment.

2. Under EPA guidelines (Appendix C and D), no more than 300 total acres will be sprayed in any one year in Willapa Bay. No more than 400 acres, total, will be treated in any one year in the State, and no more than fifty acres will be sprayed in any one treatment. A "treatment" is the sprayed application of Sevin to a given plot of oyster ground.

3. No aerial application is allowed within 200 feet of sloughs or channels or near large areas of standing water, or within 50 feet if applied by hand.

4. Sevin may only be applied at low tide when the beds are dry, and application must be completed by one-half hour after low tide.

5. All tracts must be re-inspected by WDF within 24 hours after spraying.

6. All tracts to be sprayed must be marked and flagged.

7. Sevin application shall not exceed 10 pounds of active ingredient per acre.

8. A tract may be treated over two consecutive years, but then may not be treated for at least three years.

9. Wind velocity over the oyster flat being aerially sprayed shall not exceed 10 miles per hour.

10. Treatment is permitted only in July and August.

11. A representative of the oyster grower responsible for the specific tract shall be present on the tract during spraying.

12. All spraying activities shall be under the control of WDF personnel at the site who shall halt operations if wind velocity exceeds 10 miles per hour or if unforeseen problems should occur.

2.4. RELATION TO EXISTING LAND USE PLANS

All land proposed for treatment has been classified or zoned for shellfish production. According to the planning departments and shoreline programs of both Pacific and Grays Harbor counties, the use of Sevin in commercial oyster growing is a normal aquacultural practice and is not considered a development (Kimura 1984, Mark 1984). Thus, neither county requires any permits for its use.

3.0. EXISTING ENVIRONMENTAL CONDITIONS

Sevin is used to control ghost and mud shrimp in both Grays Harbor and Willapa Bay, where Pacific oysters are commercially grown. Both bays are discussed in this section.

3.1. WILLAPA BAY

3.1.1. **Physical Environment.** Several descriptions of Willapa Bay, its geography, physical processes, and fisheries are available. These are reviewed and summarized by the U.S. Army Corps of Engineers (COE 1976), Hedgpeth and Obrebski (1981), Shotwell (1977), and Sayce (1976). The following physical and biological descriptions are drawn from these reviews and from fishery landings data and studies by WDF.

3.1.1.1. Geography. Willapa Bay encompasses about 100 square miles or 79,000 acres at mean high water. It is separated from the open Pacific Ocean by a long barrier spit to the north of the Columbia River. The connection between bay and ocean is a broad, shallow pass about six miles wide at the bay's northwestern corner separating Cape Shoalwater on the north and Leadbetter Point on the south (Fig. 1). Most of this entrance area contains shifting sand bars with the most consistent channel near Cape Shoalwater.

Willapa Bay is oriented north and south with a length of about 25 miles and a maximum width of about six miles in mid-bay above Long Island. To the north is a short eastward arm containing the mouth of the Willapa River. In addition to the Willapa, several other rivers (the North, Cedar, Nemah, and Palix) drain into the bay forming a complex estuary. The total area draining into the bay encompasses about 720 square miles.

The bay contains extensive areas of tidal flats. More than 50 percent of the total area covered at high tide is exposed at low tide. A large portion of the remainder is only 1 to 6 feet below mean low tide. Bordering these shallow and intertidal areas are a number of deeper channels. Most of these channels are caused primarily by tidal action and secondarily by stream runoff. Maximum depths in these channels reach 75 feet below mean low water. The relationship between channels, shallower

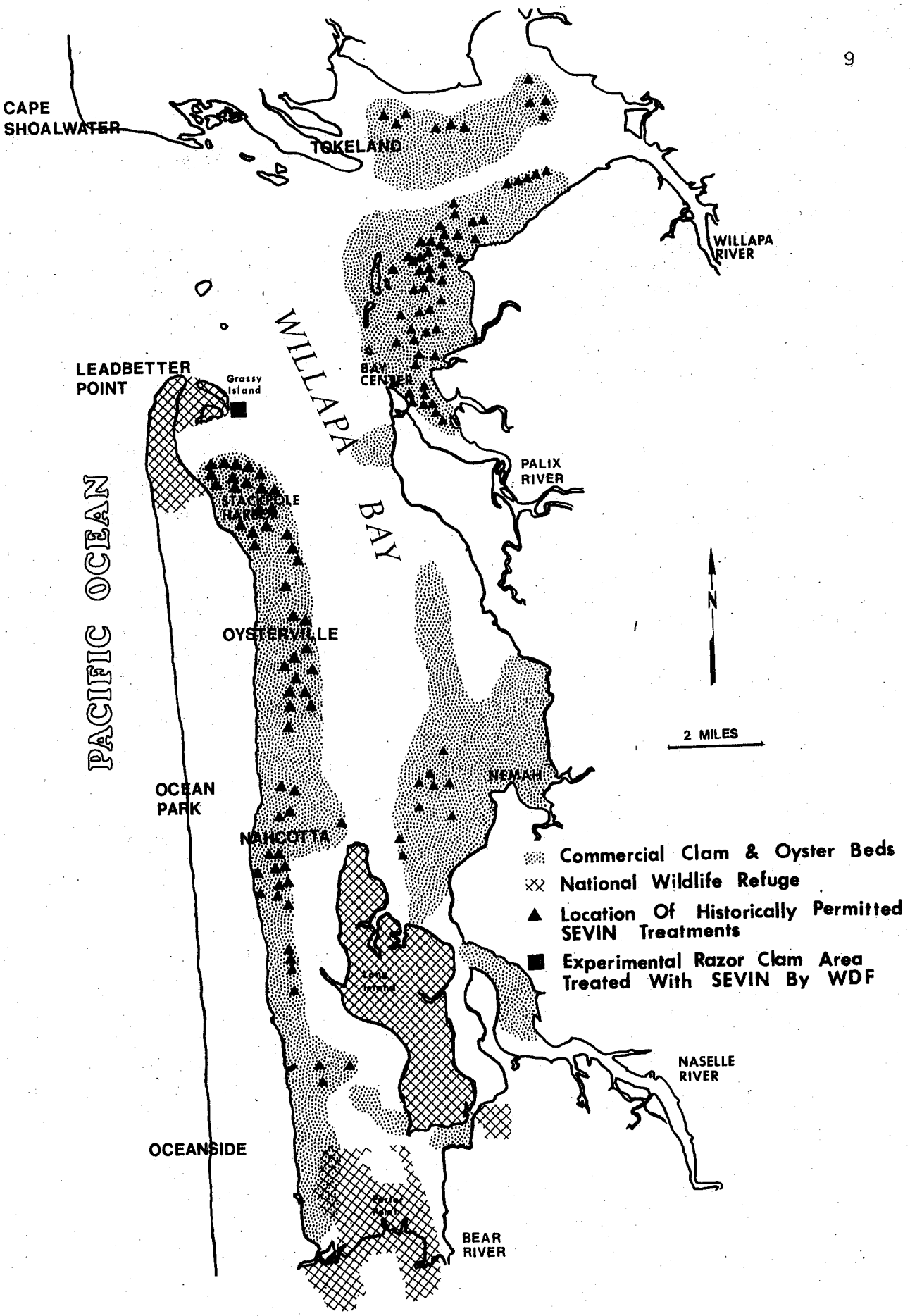


FIGURE 1. Map of Willapa Bay with Areas of Oyster Culture and Locations of Sevin Treatment

connecting sloughs, and the tidal flats is highly dynamic. The best evidence of this situation is the constantly shifting bars at the bay entrance and the ongoing erosion or accretion at Cape Shoalwater and Leadbetter Point (COE 1976).

3.1.1.2. Water Quality. Willapa Bay is generally considered to be among the most biologically productive estuaries of the Pacific Coast of the United States (Hedgpeth and Obrebski 1981). Unpolluted water and good circulation encourage biological productivity and the resulting commercial and recreational benefits. Agriculture, logging, and some industry on the surrounding uplands may influence water quality; but for the most part human activities have much less influence on the quality of Willapa Bay water than do natural factors.

Water conditions are influenced mostly by the large tidal exchange. Most of the bay is shallow, with about 55 percent of the bay area drained at mean lower low water (MLLW). Of the total bay volume of 56,585,900 cubic feet, (the tidal prism) is 25,416,000 cubic feet (COE 1976). Approximately 45 percent of the water in the bay is emptied into the Pacific Ocean on a tidal cycle from mean higher high water to MLLW.

The large tidal prism does not always cause rapid flushing of the bay water (COE 1976). Conditions in the ocean, with which the bay waters mix, determine how much of the water leaving the bay will return on the next incoming tide. In the summer, strong northwesterly winds bring upwelled water from the ocean into the bay, promoting a rapid turnover. Storms and high wave action also promote mixing. At other times, the Columbia River plume, as a discrete water mass, prevents extensive mixing from occurring and reduces complete flushing. The successful setting of oyster larvae, which drift with the water for 2 to 3 weeks, indicates that complete flushing may take more than 20 days (COE 1976).

The annual temperature in the bay exhibits trends that can be expected in a shallow estuarine situation. Water temperatures in the Willapa River ranged from less than 3°C (February 1969), to 20.4°C the following August (COE 1976). Temperatures cover a smaller range closer to the ocean at Toke Point. These ranged from 7.2°C in January to 17.4° in July, due to the moderating effect of the ocean on estuarine waters. At the WDF Shellfish Laboratory in Nahcotta, a high temperature of 21.4°C was recorded during August, 1984. There is little variation in temperature between surface and bottom waters, indicating a high degree of mixing throughout the bay up to the Willapa River. The upper temperature limit for Class A, Excellent, waters in the state water quality standards for Willapa Bay is 18.3°C. However, the shallowness of the bay and the extreme low tides during the daytime in the summer combine to warm the water beyond this limit.

The level of dissolved oxygen in the water is important in determining both the species and the abundance of finfish and invertebrates inhabiting the bay or passing through it. The state water quality standards specify a minimum dissolved oxygen level of 6 milligrams per liter (mg/l) for Class A waters. Generally, waters in Willapa Bay remain well above 6 mg/l. Occasionally levels of 5 mg/l have been recorded in the Willapa River near Raymond (COE 1976).

In Willapa Bay, dissolved oxygen appears to be influenced most strongly by physical factors such as wind and and ocean waves which increase dissolved oxygen concentrations through surface agitation. Water temperature also affects the water's ability to hold dissolved oxygen. Maximum dissolved oxygen levels occurring locally in the bay are 15 mg/l. This extreme is not representative throughout the bay, but shows the influence that low winter temperatures and wind and wave action can have. Representative winter levels of 8 to 11 mg/l continue through May or June. Summer levels are 6 to 9 mg/l. Autumn brings an upturn in the seasonal curve.

Salinity in the Willapa River ranges from 7.5 parts per thousand (o/oo) on the surface to 25 o/oo at the 20-foot depth at the same time and place. Higher salinity occurs near the central bay and entrance where intruding ocean water is diluted less by river water. Oceanic salinities can reach 30 o/oo or more.

Turbidity or suspended sediment result from both natural and human influences. Wind and wave action suspends bay sediments while upland erosion contributes sediments to increase turbidity in Willapa Bay. Turbidity is highest during winter when frequent storms agitate bottom sediments and increase upland erosion. The bay is usually clearer than the Willapa River where turbidity ranges from three JTU (Jackson Turbidity Units) to 100 JTU at South Bend. River turbidity averages 10.1 JTU on the surface and 19.3 JTU at 20 feet. In comparison, turbidity in the open bay ranges from 2 JTU to 30 JTU and averages 6.6 JTU on the surface and 8.0 JTU at 20 feet. Turbidity changes over the seasons with January through March having the highest turbidity on the surface. Surface turbidity is higher than at depth, indicating upland runoff as the source. During the summer, bottom turbidity often exceeds surface turbidity, probably as the result of wave action.

Sevin was not detected in analyses of water, mud, and oyster samples taken from tidal flats before the use of Sevin (Westley 1970). If Sevin persisted in the environment, residual or background concentrations should have been detected because of past use of Sevin in upland forests adjacent to Willapa Bay and the annual application of Sevin by oyster growers.

3.1.1.3. Estuarine Sediments. WDF data from sediment analyses of oyster flats near Leadbetter Point (Fig. 1) show that oyster bed sediments consist of 78 percent medium to fine sands with low percentages of silt, organics, volatile solids, etc. (Tufts 1984b). This is the only available information on sediments of commercial oyster beds.

3.1.2. **Estuarine Biota.** Sevin is sprayed at low tide well away from channels and sloughs, and decomposes rapidly. However, if it persisted and was picked up by the incoming tide, Sevin could affect plankton, benthic (bottom dwelling) organisms, finfish, and marine birds and mammals either through direct contact, ingestion of organisms containing Sevin, or through loss of food resources.

3.1.2.1. Plankton. Other than studies conducted by WDF on declining productivity in Willapa Bay (Westley 1962, Westley and Tarr 1962), little information is available on plankton in the bay. However, information from Grays Harbor and the Columbia River estuary may be applicable. The phytoplankton, planktonic algae, is probably composed of diatoms, dinoflagellates, and microflagellates. Phytoplankton is especially important as the source of food for commercially important oysters and clams and also for the zooplankton which feeds bait fish, juvenile salmonids, and gray whales, etc. Dissolved nutrients largely limit phytoplankton abundance in Willapa Bay, especially nitrates (Westley 1962, Westley and Tarr 1962). The occurrence of higher concentrations of important nutrients may partially control the timing of phytoplankton blooms. When offshore conditions such as an El Nino inhibit nutrient-rich upwellings, phytoplankton populations suffer declines which in turn slow oyster growth (see Section 3.1.3.2.1.).

The zooplankton contains larvae of many benthic organisms, as well as species that are planktonic their entire lives. Dungeness crab (Cancer magister) larvae appear in the zooplankton throughout the spring (Kyte 1981). Oyster larvae may be present when high water temperatures stimulate spawning. Copepods, several species of other small planktonic crustacea, arrow worms, jellyfish, and comb jellies make up the rest of the zooplankton. Haertel and Osterberg (1967) found that the copepod Eurytemora hirundoides dominates the Columbia River estuarine zooplankton. In addition, small planktonic annelid polychaetes, tunicates, and large crustaceans such as mysids and euphausids may be carried into the bay from the open ocean on flood tides.

3.1.2.2. Benthic Biota. The organisms living in the benthic community in the Willapa Bay estuary are strongly influenced by a number of factors. These include salinity changes which progress upstream, the sediment characteristics, and the tide. Intertidal zonation is not readily apparent in much of Willapa Bay, because the extensive areas of tidal flats have little vertical relief. Vertical zonation is only noticeable where steeper slopes occur.

3.1.2.2.1. Plants. In much of the bay, sand and mud substrates support eelgrass (Zostera marina and Z. japonica). The eelgrass forms large, dense beds. There root-like rhizomes stabilize the substrate, while the blades dampen wave action creating a distinct habitat for bay organisms. The eelgrass shelters juveniles of many species including Dungeness crab (Cancer magister), flatfish, perch, and Pacific herring (Clupea harengus). Herring also spawn on the blades and its roots provide habitat for various invertebrates. The blades also are substrate for epiphytic diatoms, other algae, hydroids, bryozoans, and anemones.

WDOE lists the tidal flats east of the North Beach Peninsula, north and west of Long Island, and surrounding the Nemah River channel as "Areas of Major Biological Significance" (AMBS) for the eelgrass Z. marina (Gardner 1981). According to Gardner (1981), an AMBS is an area that supports a major reproducing population of a species that also provides recruitment to the surrounding region. In addition, an AMBS may provide some necessity for a critical life stage of an organisms.

In addition to sea grasses, an unidentified filamentous red macroalgae (Rhodophyta; probably Polysiphonia sp.) is present, attached to oyster shell and other hard objects on the flat. The only other macro-algae that has been observed associated with oyster beds is the sea lettuce Ulva sp. (Tufts 1984b). However, no complete inventory of benthic flora has been conducted in Willapa Bay.

3.1.2.2.2. Invertebrates. Benthic invertebrates living in the tributary river estuaries of Willapa Bay are subjected to widely varying salinities. These range from no measurable salinity during times of low tide and heavy runoff to greater than 30 o/oo at high tide in the summer. This condition limits the fauna to those species tolerant of these changes. A small species of clam (Macoma balthica) inhabits the bottom in these areas, feeding on the abundant supply of detritus washed in from nearby saltmarshes. The eastern soft shell clam (Mya arenaria) is also found in these tributary estuaries. These clams tolerate brackish water but are unable to survive in areas of high wave action. Blue mussels (Mytilus edulis) and barnacles (Balanus spp.) are attached to solid substrates such as rocks, sunken logs, oyster shell, and pilings, while amphipods and burrowing polychaetes feed on bottom detritus.

In the bay, the benthic community is largely determined by sediment distribution (COE 1976). In the limited gravelly areas, littleneck (Protothaca staminea) and butter clams (Saxidomus giganteus) are found. Many polychaete worms also inhabit these areas, while mussels and barnacles attach to stones and pilings. In subtidal channels, horse clams (Tresus capax) are numerous down to 15 or 20 feet below MLLW. Cockles (Clinocardium nuttallii) and native oysters (Ostrea lurida), occur as deep as 15 feet below MLLW.

All Willapa Bay tide flats and shallow channels, seaward of the highway river crossings are AMBS for Dungeness crab and Pacific oysters (Kyte 1981). Crab are discussed in detail in Section 3.3.2.

The WDF sampled benthic invertebrates associated with commercial oyster beds in 1982, 1983, and 1984 (Tufts 1984b, Hurlburt 1985). Although data is preliminary, a tentative species list is presented in Appendix E.

3.1.2.3. Finfish. Limited quantitative sampling of finfish has been conducted in Willapa Bay (COE 1976, Bucknell and Phinney 1975, Buckley, et. al. 1984). The tributaries of Willapa Bay provide spawning grounds for chinook (Oncorhynchus tshawytscha), chum (O. keta), and coho (O. kisutch) salmon; steelhead (Salmo gairdneri); and searun cutthroat trout (S. clarki clarki). Pink salmon (O. gorbuscha) may stray in from the ocean. In addition to juveniles from wildstocks, salmon also originate from WDF operated hatcheries in the Willapa, Nemah, and Naselle river drainages (WDF 1975, Castoldi 1983). In 1982, these hatcheries produced a total of 5,275,515 fall chinook; 1,572,532 chum; and 11,798,183 coho. Most were released into Willapa Bay tributaries (Castoldi 1983). These salmon contribute to the commercial and recreational fisheries in the bay and ocean.

Salmon migrate through the bay at various times of the year, and use it as a nursery area much of the year (Table 1). During their residence in the bay, juvenile salmon undergo physiological changes associated with adaption to a salt water existence. Following these changes the young fish migrate into the northeast Pacific Ocean. Feeding behavior or residence time of salmonid species in Willapa Bay have not been studied. However, they are probably similar to behavior in other West Coast estuaries. Studies have been conducted in Grays Harbor (Section 3.2.2.3).

Adult salmon from other drainages such as the Columbia River feed in the Willapa Bay and have been found in adjacent tributaries. Thus, the bay appears to be be more important to salmon than is indicated by the commercial catch (COE 1976).

Herring, smelt, and anchovies also use Willapa Bay and are a source of food for salmon and other larger fish. Pacific herring spawn on eelgrass in the southern part of the bay in late January and early February (Gardner 1981). The south arm of the bay near Oysterville and the west side of Long Island are listed as an AMBS for Pacific herring spawning (Gardner 1981). Juveniles are present from spring through fall. Anchovies (Engraulis mordax) are in the bay during the summer but spawn in the ocean. Longfin smelt (Spirnichus thaleichthys), an anadromous fish, spawns in the tributaries of the bay between October and December and depend on the estuary for survival.

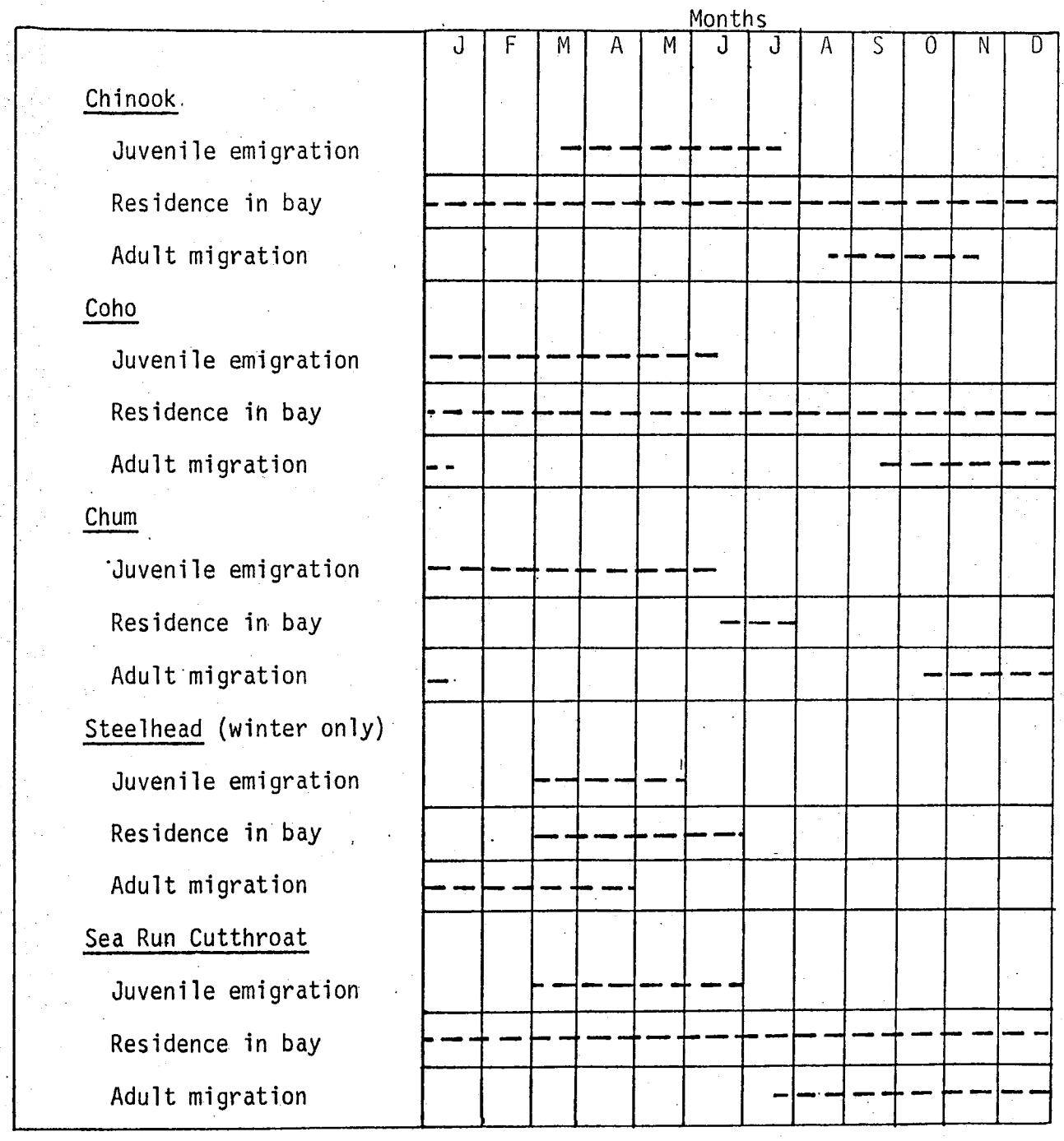
The DEIS reported that surf smelt (Hypomesus pretiosus) spawn near Tokeland during most months (COE 1976, Gardner 1981). The WDF, however, has not been able to confirm smelt spawning anywhere in Willapa Bay.

Information on the food or habitat requirements of these bait fish in Willapa Bay is not available. However, baitfish feeding studies have been conducted in Puget Sound and Grays Harbor (Section 3.2.2.3). These species do not directly support significant fisheries, but as prey of Pacific salmon they are important to the salmonid fisheries. Bait fish feed on plankton including small crustaceans and larvae of various invertebrates.

Green sturgeon (Acipenser medirostris) and white sturgeon (A. transmontanus) are found in Willapa Bay (COE 1976, Gardner 1981). Sturgeon feed on smaller fish and benthic invertebrates such as ghost shrimp, amphipods, and molluscs (Gardner 1981). They are long-lived and mature after 11 years at the earliest. Sturgeon spawn in tributary streams in spring and early summer. WDOE has designated the deeper channels of southern Willapa Bay, the Willapa River and the Naselle River as AMBS for spawning sturgeon. Although sturgeon support a commercial fishery in Willapa Bay, their long maturation time limits the volume that such a fishery can sustain. WDF reports 30,839 pounds of white sturgeon and 25,816 pounds of green sturgeon landed in 1983 from Willapa Harbor.

In 1980 through 1982 WDF conducted trawls to collect juvenile lingcod (Ophiodon elongatus) for transplant experiments (Buckley et al. 1984, Hueckel 1984). While these trawls were not quantitative, they were standardized so catch per unit effort may estimate relative abundance. In Willapa Bay, most fish were caught in June (four per trawl) while less than

Table 1. Timing of Salmonid Presence in Willapa Bay and Tributaries.



Sources: USACE 1976 and Phinney and Bucknell 1975.

two fish were caught per trawl in July or August. Most lingcod in Willapa Bay were caught near Grassy Island (Fig. 1). Trawls were also made near Bay Center and the east side of Long Island (Hueckel 1984). Many of the trawls were made over intertidal areas during high tide. In addition, WDF biologists monitoring Sevin applications occasionally find a few juvenile lingcod trapped on oyster beds by the out-going tide. Although these observations indicate that juvenile lingcod use Willapa Bay, no estimates of juvenile abundance are available.

The WDF also analyzed stomach contents of juvenile lingcod from Willapa Bay, Grays Harbor and the Pysht River in the Strait of Juan de Fuca (Buckley et al. 1984). The most important food items were fish (86 percent) and crustacea (12 percent). Species found in lingcod stomachs included mysids, crangonid shrimp, unidentified crustacea, sandlance, herring, and rockfish.

Incidental observations made during Sevin treatments and studies in other estuaries indicate that flounder and sole use Willapa Bay as a nursery area. No commercial fishery exists for these species inside the bay, but they contribute to ocean fisheries after maturing (COE 1976). These flat fish feed on benthic invertebrates transferring productivity from the benthic to the pelagic (organisms in the water column) communities. The Willapa River between Range Point and South Bend is designated as an AMBS for starry flounder (Gardner 1981).

The American shad (Alosa sapidissima), a species introduced from the Atlantic coast, has spread into Willapa Bay. The shad feed on planktonic crustaceans and occasionally on small fish. It spawns in the freshwater tributaries of the bay, eats food similar to that of juvenile salmonids and may be a competitor for the ecological niche now occupied by salmonids.

3.1.2.4. Birds. Appendix F contains a list of birds known to use the Willapa Bay estuary (Wahl and Paulson 1981, Widrig 1980, "Willapa Bay National Wildlife Refuge Checklist"). Willapa Bay includes the Willapa National Wildlife Refuge which contains 9,600 acres of Federal land and open water and 10,000 acres of state tidelands and water (COE 1976) (Fig. 1).

Willapa Bay is an important feeding and resting area for herons, waterfowl, eagles, shore birds, gulls, terns, and alcids and, on occasion, for sooty shearwaters. A large percentage of these birds are migrants. Willapa Bay is one of the four major estuaries along the Pacific flyway which provide important resting and feeding habitat. Habitat losses in San Francisco Bay and other coastal estuaries on the flyway have apparently caused increased usage of Willapa Bay and Grays Harbor in recent years, particularly by black brant and canvasback ducks.

Willapa National Wildlife Refuge was established in 1937 to provide a protected wintering area for Pacific black brant (Branta bernicla). The extensive beds of eelgrass in Willapa Bay supply these birds with food. Black brant winter on the refuge from October through May. Winter

populations peak at about 2,000 birds and the spring migration in mid-April peaks between 5,100 and 5,790 brant (Hidy 1984). Counts done by the U.S. Fish and Wildlife Service in 1982 and 1983 indicate all brant are gone from the bay by June 1.

Willapa Bay also serves as an increasingly important wintering habitat for the canvasback (Aythya valisineria) in the western United States. These birds migrate to their northern breeding grounds in April and May and are only occasionally sighted during the summer (Hidy 1984).

In addition to the waterfowl that use Willapa Bay, 38 species of shorebirds have been recorded. About 31,000 shorebirds were observed near Leadbetter Point one April. The most abundant species seen is the western sandpiper (Widrig 1981). The red knot is seen in April and May during its spring migrations.

The birds in Willapa Bay use both open water and tidal flats for resting and feeding. While observed numbers provide information on resting use and population levels, little information is available on feeding habits in Willapa Bay. Several intensive studies on shorebird and waterfowl feeding have been conducted in Grays Harbor (Section 3.3.2) and probably describe feeding habits of birds in Willapa Bay. No quantitative information exists for either bay on the bird use of oyster beds.

Many areas in Willapa Bay have been mapped as AMBS during fall, winter, and/or spring for mallard, pintail, American wigeon, brant, Canada goose, red knot, least sandpiper, and dunlin (Jordan 1981). Near Leadbetter Point is an AMBS for black bellied plover and white-fronted geese. Important areas (not designated as AMBS) have also been mapped for canvasback, bufflehead, long-billed dowitcher, and western grebe. The only summer AMBS is for the snowy plover on Leadbetter Point (Jordan 1981).

Raptors in Willapa Bay are discussed in Section 3.3.

3.1.2.5. Mammals. Harbor seals (Phoca vitulina) and gray whales (Eschrichtius robustus) have been observed in Willapa Bay. Several areas within the bay are important harbor seal haulout grounds designated as AMBS (Gardner 1981). These AMBS are isolated sand bars distributed throughout the bay. These change location frequently due to erosion and deposition (Gardner 1981).

Based on sightings by residents of the area, single gray whales occasionally enter the bay and remain for varying periods. In April and May 1984, a single whale was frequently observed in the southern part of the bay (L. Weigardt 1984). No sightings of gray whales are known June through August.

3.1.3. **Willapa Bay Fisheries.** Willapa Bay is probably the most productive bay on the Pacific Coast (Hedgpeth and Obrebski 1981). Because of its excellent water quality (see Section 3.1.1.3), excellent circulation, abundant wetlands, and prolific biota, the bay is an optimum environment for several commercially important species. As a result, the Willapa Bay supports a number of commercial and recreational fisheries.

It also serves as a nursery area for immature crab and finfish which contribute to the fisheries. The largest and most valuable fisheries are oysters, Dungeness crab, and salmon. The recreational and commercial harvest of salmon is not discussed because no impacts are anticipated.

3.1.3.1. Dungeness Crab. The Dungeness crab fishery is one of Pacific County's most important industries along with forest products, cranberries, oysters, and salmon. Annual crab landings from Willapa Bay and their landed values are presented in Table 2. Crab prices per pound vary widely during the season. Prices are low at the start of the season in December, and increase as the harvestable stocks decline. Data presented in Table 2 compares landings from Willapa Bay and the entire Washington coast. Also listed in Table 2 is the percent that Willapa Bay catches contribute to the coastal total.

Table 2. Willapa Bay and Total Washington Coastal Crab Landings. (Pounds and values in thousands.)

Year	Landings				
	Total Coastal		Willapa Bay		
	Pounds	Value	Pounds	Value	Percent of Total
1975	6,617	$3,596	446	$250	7
1976	6,924	4,110	239	123	3
1977	12,754	6,376	382	191	3
1978	5,859	3,808	485	316	8
1979	8,522	3,261	656	328	8
1980	5,963	3,876	413	269	7
1981	2,446	1,957	335	189	14
1982	2,797	2,517	209	327	8
1983	5,174	4,638	363	270	7
1984	3,405	5,108	210	315	6
10 year ave:	5,999	4,025	374	258	6

Data provided by WDF.

After the DEIS was issued, information on Dungeness crab biology in Grays Harbor became available (Armstrong et al. 1984). Extrapolations of this data to Willapa Bay were made by Hulburt (1985). The results are discussed here and in Section 4.2.2.1.

Abundant immature crabs in shallow portions of Willapa Bay indicate that the bay is an important nursery area for Dungeness crabs (Armstrong et al. 1984, Hedgpeth and Obrebski 1981). In the spring, very small young-of-the-year (YOY) crabs on oyster flats hide in eelgrass, among shells, and in burrowing shrimp holes (Tufts 1984b, Hurlburt 1985). These juveniles grow through successive molts, and usually move off the tidal

flats into adjacent channels and subtidal habitats by July and August. Many juveniles and adults move back into intertidal areas at high tide to feed. Most young crabs probably migrate into the warmer open ocean during the winter and return to the bay in the spring (Armstrong et al. 1984). Three to four year old male crab reach a width of 6.25 inches and a weight of about 1.7 pounds. These males then enter fisheries in the bay and the open ocean (Stevens 1982, Kyte 1981).

The natural mortality rate for adult crabs has been estimated at about 20 percent per year (Stevens 1982). In addition, the commercial fishery is approximately 80 to 90 percent effective. Together, natural mortality and commercial fishing remove most adult males of each year class. Females are not taken in the fisheries and continue to reproduce. The death rate of YOY juveniles may be as much as 98 percent in their first year, primarily due to predation (Stevens 1982, Armstrong et al. 1984, Diamond 1983). Mortality rates of older juveniles are not known.

3.1.3.2. Oysters. Oyster culture has traditionally been Willapa Bay's principal marine fishery. Native oysters covered intertidal and shallow subtidal areas before 1850. These stocks were drastically reduced by overharvesting and competition from introduced species (Hedgpeth and Obrebski 1981, COE 1976, Shotwell 1977). Presently, only the Pacific oyster from Japan is commercially cultivated extensively. For many years, Japan was the only source of oyster seed, but local sources have been developed in the Northwest. A number of oyster hatcheries operated in Willapa Bay, and hatchery-reared foreign and domestic seed is being tested for growth and disease resistance (Wilson 1984, Weigardt 1984). Also, WDF manages 10,000 acres of oyster reserves in Willapa Bay which provide natural oyster seed. The WDF shellfish laboratory at Nahcotta on the Long Beach Peninsula manages and conducts research on oysters and other shellfish species.

Approximately 37,000 acres, 85 percent of the tidelands in the bay, are classified as oyster lands by Pacific County. Of this, only 2,500 acres produces market-quality oysters to support the industry (Tufts 1985). The industry and Pacific County classify this ground as high quality "growing" and "fattening" ground. It is the only area where oysters will fatten to market standards. Some oyster seed is planted on this ground and grown to market size. Also, one or two year old oysters are moved here from other ground to fatten prior to harvest. The annual Willapa Bay oyster production requires harvest of 800 to 1000 acres of fattening ground each year. To maintain production, Sevin is used to control burrowing shrimp on the fattening ground. Since the beginning of the Sevin program, about 2,200 acres have been sprayed in the bay, excluding repeat treatments. Of this, about 80 to 90 percent (1870 acres) are top quality fattening ground (Tufts 1985). Thus about 75 percent of the fattening ground has been treated at least once since 1963.

As shrimp populations on an oyster flat increase, they slowly raise the level of the flat, burying and smothering any seed or adult oysters present. According to historical accounts (Sayce 1961, 1976; Shotwell 1977) these shrimp were not a significant problem until the 1957-58 El Nino when shrimp populations increased markedly (Section 3.1.3.2.2). To

meet this threat to the oyster stocks, methods to reduce shrimp populations without harming the estuarine environment and biota were studied by WDF (Westley 1970).

Oyster production from Willapa Bay is compared with the total Washington production from 1975 through 1984 in Table 3. Willapa Bay produces about 50 percent of Washington's total oyster harvest.

Table 3. Willapa Bay Pacific Oyster Landings.
(Landings and values of oyster meats in thousands)

	Landings			
Year	Pounds	Gallons	Value	Percent of Total
1975	2,301	263	$2,867	48
1976	2,459	281	3,167	45
1977	2,997	344	4,317	49
1978	3,328	380	5,540	58
1979	3,080	352	5,924	50
1980	2,820	322	5,593	54
1981	3,135	358	5,513	55
1982	3,091	353	5,535	51
1983	2,351	269	4,932	42
1984	2,651	303	5,845	42
10 yr. Average	2,849	326	4,923	49

Data provided by WDF.

3.1.3.2.1 The Oyster Industry. Oyster culture is one of the major industries in southwest Washington and has increased in relative importance following declines in the timber and fishing industries. The broad tidelands and rich waters of Willapa Bay and Grays Harbor offer ideal conditions for culture of Pacific oysters. Oyster culture began in these bays with harvest of Olympia oysters during the mid-1800's. Pacific oyster culture began in the 1930's after introduction of Japanese oyster seed. Annual harvest from the bays reached 1.2 million gallons during World War II. Total Washington production peaked around 1955 and declined through the mid-1970's. In 1976, Willapa Bay and Grays Harbor production reach its historic low at only 263,000 gallons. This decline was due in part to competition from imported oysters. Recently, production has increased slightly and averages 350 to 400 thousand gallons per year from the coastal bays.

As oyster production declined, growers reduced their operations and concentrated on the most productive grounds. Currently the center of the industry is the 2,500 or so acres of fattening ground. Consequently, large

areas of potential culture ground remains available. Although productivity in the bay has generally declined (Westley 1962), significantly increased production is possible if market conditions improve. Most of this ground would require treatment for burrowing shrimp before it could be used.

In 1984, Willapa Bay and Grays Harbor oyster production was 366,000 gallons of oyster meat with a wholesale value to $7.1 million. Twenty-eight companies currently farm oysters in the two bays and employ over 400 people. The total payroll of these growers is around $3.9 million. Additional jobs are created indirectly. WDF estimates that for every person employed in the harvest of fish and shellfish, 1.5 to 5.0 additional jobs are generated in support activities (or 1,000 to 2,400 total jobs). Most of this employment is concentrated in Pacific and Grays Harbor counties.

3.1.3.2.2. The 1983-1984 El Nino Emergency. The growth and condition of Pacific oysters and of estuarine biota in Willapa Bay is partially influenced by the influx of nutrients from upwellings of cold oceanic waters that are well-documented features of the southern Washington Coast. These upwellings are frequent but unpredictable. However, El Nino events may periodically interfere with this upwelling, reducing the nutrients in the bays. These are related to extraordinary meterological changes in equatorial weather involving a significant weakening of the trade winds. This causes the sea water to warm and the sea level to rise over large areas of the Pacific (Reed 1984). One manifestation of an El Nino in the Northeast Pacific is an extended period of warmer water (+1 to 2°C) off the coast (Reed 1984). This warmer water inhibits cold water upwelling which limits the amount of nutrients available to nearshore and estuarine biota.

In 1982, an El Nino in the eastern tropical Pacific Ocean significantly affected conditions on the Washington coast (Reed 1984). This event apparently reduced Pacific oyster growth because nutrients were not available for phytoplankton production upon which the oysters depend. Also, populations of burrowing shrimp increased in the bay. This increase also occurred after the 1957-58 El Nino. Another result of the El Nino may be the increased recruitment of young Dungeness crab to Willapa Bay and Grays Harbor.

Because of this decreased oyster condition and growth, twice the normal number of oysters had to be harvested to maintain production, revenues, and markets (Hurlburt 1985). This bared and removed from production almost twice the normal amount of oyster land by spring 1984. Some of this bare ground was immediately planted with oyster seed to attain an additional season's growth.

3.2 GRAYS HARBOR

Grays Harbor differs from Willapa Bay in several important aspects. These include geography, water quality, the extent of oyster cultivation, the presence larger human populations, and the presence of heavy industry. Because of the greater use by industry and humans, Grays Harbor has been the subject of substantially more environmental research. The recent harbor and channel dredging activities of the U.S. Army Corps of Engineers (COE) have generated considerable environmental research.

The following account of existing conditions in Grays Harbor is based primarily on research conducted under the auspices of the COE and WDOE in relation to both dredging and an "estuary management plan." Where conditions are similar to those in Willapa Bay, reference is made to Section 3.1. Common biological elements of the two bays are discussed in Section 3.3.

Pacific oyster culture in Grays Harbor is limited to North and South bays and their immediate vicinity (Fig. 2) because of unsuitable water quality in the eastern part of the harbor. Thus, the discussion of existing conditions in Grays Harbor is generally limited to these areas.

3.2.1. **Physical Environment.** Grays Harbor is one of the Pacific Coast's six major estuary systems. Located on the southern Washington coast, this bay lies 110 miles south of the Strait of Juan de Fuca, about 45 miles north of the mouth of the Columbia River, and 8 miles north of Willapa Bay. The estuary is approximately 13 miles across at its widest point and narrows to less than 100 yards in its upper reach nearly 32 miles from the estuary's ocean entrance (WDOE 1983). The three corners of the bay are defined by the Chehalis River which flows into the eastern portion of the harbor; North Bay, which receives the waters of the Humptulips River; and South Bay, into which the Elk and Johns rivers flow (Fig. 2). At MHHW, Grays Harbor occupies about 91 square miles or 54,708 acres (WDOE 1983). Of this area, 53 square miles (33,606 acres) are exposed at mean lower low water (MLLW).

Geologically, the estuary is a drowned portion of the Chehalis River Valley and is continually filled by with riverborne sediments and oceanic materials. The predominant physical feature of the estuary is the vast amount of intertidal mud and sandflats (WDOE 1983). These flats are broken by numerous shallow channels created by ebbtide flows and river discharges. Historically, three main channels ran east to west - the North, Middle, and South channels - all with depths of 17 to 20 feet MLLW with areas of shoaling. North Channel has been dredged for navigation and is the major ship channel to Aberdeen and Cosmopolis. Meanwhile the other two channels have shoaled to shallow depths (WDOE 1983).

3.2.1.1. Water Quality. The estuary is a partially mixed system in which tides dominate over river flows causing nearly complete mixing of fresh and salt water. In summer, the low fresh water inflow and the large estuary volume contribute to poor circulation in the central portion of the bay. Pollutants entering this area are not flushed rapidly and reduce the water quality in the basin. The mid-reach of the estuary from Cosmopolis to a line between Point New and Markham has historically had poor water quality (WDOE 1983).

Substandard water quality in Grays Harbor comes from both point and nonpoint sources. The major point sources are municipal and industrial discharges which adversely affect dissolved oxygen levels, turbidity, color, and bacterial levels. The wood products industry discharges the largest volume of oxygen demanding wastes, particularly sulfite liquors. These are considered the primary water quality problem in the estuary.

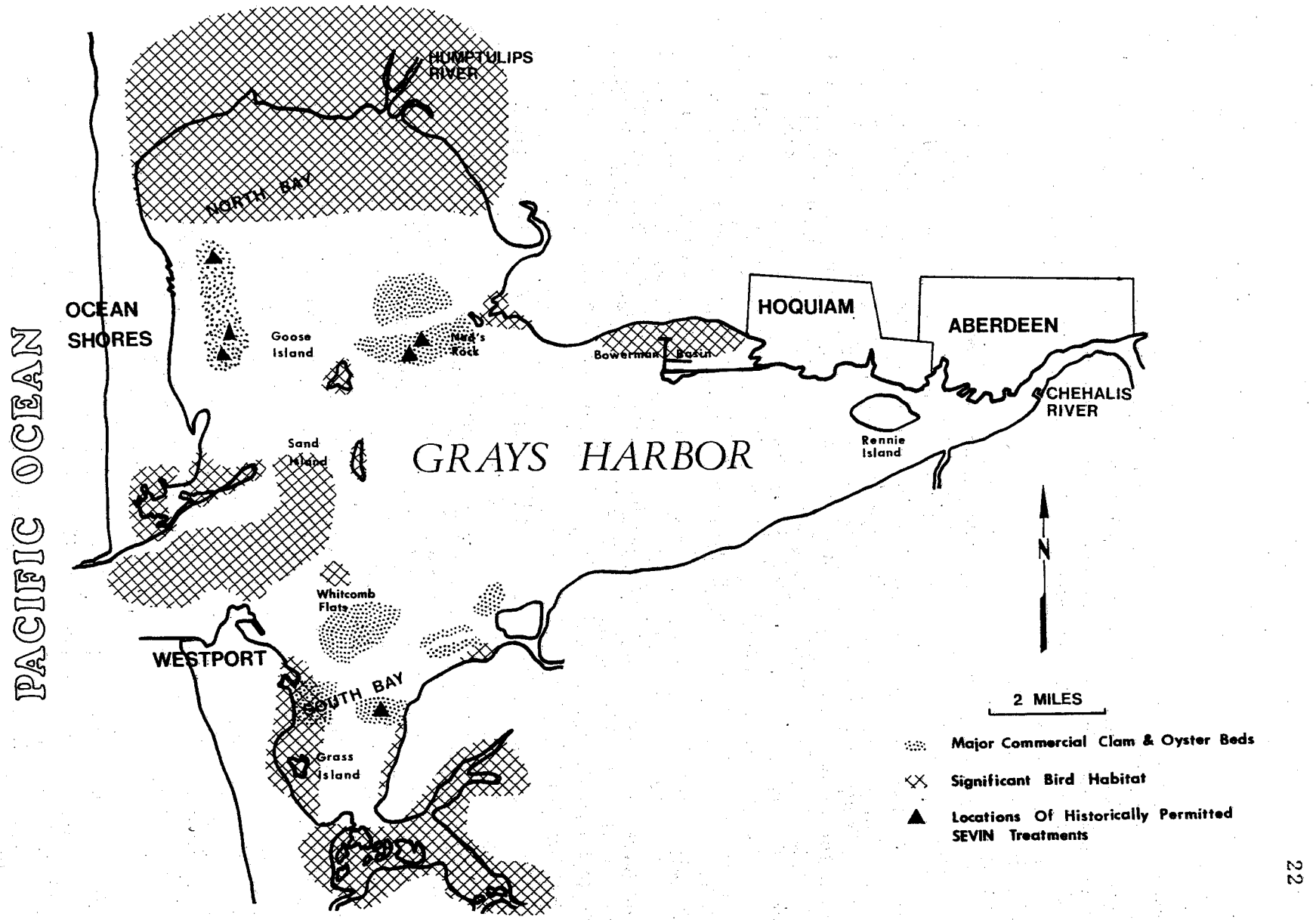


FIGURE 2. Map of Grays Harbor with Areas of Oyster Culture and Locations of Sevin Treatment

Nonpoint source contamination includes runoff from urban development, garbage and wood waste land fills, septic tank leachates, dredging, and log storage wastes (WDOE 1983). The overall water quality of Grays Harbor is seriously affected by the estuary's declining capacity to assimilate wastes. The level of past and present industrial discharges has had a major effect on water quality. Accumulated wastes, heavy sedimentation from the Chehalis River and upwellings of low oxygen water contribute to low oxygen levels in the water (WDOE 1983).

3.2.2. **Estuarine Biota.**

3.2.2.1. Plants. Substantial areas of native vegetation remain in and around the Grays Harbor estuary. Vegetation provides habitat (nesting and shelter) and food (seeds and detritus or decaying organic matter), stabilizes soils (minimizing erosion and siltation), helps to filter toxic substances from surrounding waters, and absorbs organic and mineral nutrients.

Extensive tidal marsh areas are located from the central portion of the estuary below Aberdeen throughout North and South bays. These marsh areas border much of the harbor and occupy about 4,800 acres (WDOE 1983).

Eelgrass occurs throughout the estuary below Aberdeen at tidal elevations between -3 feet (ft) MLLW and +6 to +7 ft MLLW. As in Willapa Bay two species of eelgrass occur in Grays Harbor: common eelgrass (Zostera marina) and European eelgrass (Z. noltii) (WDOE 1983). A large area in western North Bay around Oyhut Channel and another between Point New and Hoquiam is designated an AMBS for the eelgrass Z. marina (Gardner 1981).

With twenty-nine species, the algae community of Grays Harbor appears more diverse than that found in Willapa Bay (WDOE 1983, Thom 1984), however, considerably more research has been conducted in Grays Harbor (Section 3.1). Among the most abundant and conspicuous algae are three species of green algae (Enteromorpha spp.), a brown algae (Fucus distichus), two red algae (Polysiphonia hendryi and Porphyra sanjuanensis), and a complex of tube dwelling and filamentous diatoms. Macroalgae distribution is limited by availability of stable hard substrate (e.g., logs, roots, boulders, oyster shell) for attachment. No emergent vegetation exists on mudflats, and the predominant flora is restricted to epibenthic green and blue-green algae with diatoms dominating the phytoplankton. No attached vegetation exists and epibenthic algal production is low on bare sandflats (WDOE 1983, Thom 1984).

3.2.2.2. Invertebrates. Planktonic and benthic invertebrates in Grays Harbor are similar to those described in Section 3.1.2.2. Appendix G contains a list of benthic invertebrates and finfish species recorded from Grays Harbor, some of which probably also occur in Willapa Bay (Section 3.1). None of the sites from which this species list was compiled were active oyster beds.

WDOE has designated all tidal flats and shallow channels from inside the harbor entrance to Cosmopolis as AMBS for Dungeness crabs (Kyte 1981).

3.2.2.3. Finfish. The fishes of Grays Harbor are essentially the same as described for Willapa Bay (Section 3.1.2.3). Pacific salmon, steelhead, and cutthroat trout use the estuary for migrations and juvenile rearing. Several other fish species discussed for Willapa Bay also occur in Grays Harbor. No AMBS for fish has been designated in the vicinity of the oyster flats in North and South bays (Gardner 1981).

Most of the research on fish in Grays Harbor has been conducted in the vicinity of harbor and channel dredging and dredge spoil disposal. Information is limited on fish use of commercial oyster beds in Grays Harbor.

WDF collected lingcod in the lower parts of North and South bays during the summers of 1979 through 1982. The highest number of lingcod were taken in June and July of 1980 and averaged 13 and 14 fish per trawl, respectively (Buckley et al. 1984). Substantially lower numbers were taken during other months and years. The most fish were caught near the entrance of South Bay between Westport and Whitcomb Island (Hueckel 1984). The stomach contents of some of the lingcod collected in Grays Harbor were examined for prey items and are discussed in Section 3.1.2.3.

Simenstad and Eggers (1981) conducted a study on juvenile salmonids, bait fish, and flatfish in Grays Harbor in relation to dredging operations. It found that juvenile salmonids and English sole feed over lower intertidal and shallow subtidal areas; such habitats could include Pacific oysters beds. Young salmonids and sole fed mostly on small crustaceans, including harpacticoid copepods, cumaceans, and amphipods. Hurlburt (1985) reported only low abundances of amphipods on an oyster tract in Willapa Bay.

3.2.2.4. Birds. A variety of birds use Grays Harbor. Total bird populations peak in April and May when over 1 million birds stop during their northward spring migration. Appendix F lists bird species known to use the Grays Harbor estuary.

Grays Harbor is an important wintering area for waterfowl. They are least abundant during May, June, and July (Smith and Mudd 1976). Some nesting and brooding occurs in the dense vegetation of the marsh areas. Mallards are the most abundant nesting waterfowl. Other waterfowl species observed during the summer include pintail, green-winged teal, cinnamon teal, American wigeon, northern shoveler, greater and lesser scaup, white-winged and surf scoters, ruddy duck, red-breasted merganser, American coot, and white-fronted goose (Smith and Mudd 1976, Kalinowski et al. 1982).

A large variety of migrating and wintering shorebirds use estuarine habitats. Several studies have been conducted during the winter and spring seasons, but comprehensive counts during the summer are lacking (e.g., Smith and Mudd 1976, Herman and Bulger 1981, Kalinowski et al. 1982). During spring migration, 24 species of shorebirds use the bay. The western sandpiper is the most numerous. Herman and Bulger (1981) concluded that Grays Harbor supports more shorebirds during spring migration than any other estuary on the Pacific Coast south of Alaska. Paulson (1984) made partial counts of shorebirds over a 10-year period on

the north side of Grays Harbor. High counts for each species were tabulated to indicate population trends. The lowest use of the bay by shorebirds occurred during June with 4,194 birds and 10 species tabulated; the most abundant were short-billed dowitcher and sanderling. In July, the fall migration begins with an influx of western sand pipers. A tabulated shorebird total of 44,088 with 17 species was recorded in July. The population drops again in August with 10,177 shorebirds and 17 species tabulated; the western and least sandpipers were most abundant.

Shorebird distribution depends on tide levels. They prefer areas where tideflats are present, such as dredge disposal sites, harbor islands, and Ocasta beach (Kalinowski et al. 1982). While these areas account for only 3 percent of the shoreline of Grays Harbor, 26 percent of all shorebirds were observed in these areas during the spring.

Shorebirds use deeper water areas of the bay as feeding sites including rhinoceros auklet, common murre, marbled murrelet, pigeon guillemot, and parasitic jaeger. Other waterbirds observed in the outer bay and deeper waters of both North and South channels include loons, grebes, shearwaters, petrels, and cormorants. Gulls and terns are abundant during the summer months and often nest in the same areas. Whitcomb, Sand, and Goose islands are important nesting colonies, especially for the Caspian tern. The largest identified Caspian tern colony on the West Coast occurs on Whitcomb Island (WDOE 1983). Double-crested cormorants have relatively small nesting colonies on Sand Island and Ned Rock.

AMBS for various species are located throughout the harbor. Species observed in the fall, winter, or spring include mallard, pintail, American wigeon, canvasback, Canada goose, red knot, least sandpiper, dunlin, black turnstone, and rhinoceros auklet (Jordan 1981). During the summer Goose Island is an AMBS for the glaucous-winged gull, western gull and rhinoceros auklet.

3.2.2.5. Mammals. Marine mammals are observed in Grays Harbor throughout the year. The harbor seal is the most abundant. They both travel and feed in the estuary (Smith and Mudd 1976). The seal population is estimated to be 500 seals during the winter and 1,400 during the summer (WDOE 1983). They feed on bottom fish over subtidal and intertidal areas, and occasionally on salmon. Grays Harbor may have the largest breeding colony of harbor seals in Washington and Oregon (WDOE 1983). The pupping season occurs in May, June, and July when seals disperse to areas throughout the harbor. The WDOE designated five areas in North Bay, six in "Central" Bay, and one in South Bay as AMBS for harbor seal haul out grounds (Gardner 1981). Northern sea lions, harbor porpoises and gray whales have also been observed in the bay occasionally.

3.2.3. **Grays Harbor Fisheries.** In contrast to Willapa Bay, annual landings of shellfish in Grays Harbor are relatively low. The most important species are salmon, Dungeness crab, and oysters. The recreational and commercial harvest of salmon is not discussed because significant impacts are not expected.

3.2.3.1. Dungeness Crab. Grays Harbor is an important rearing area for juvenile Dungeness crab. However, only relatively small commercial catches of crab are made in Grays Harbor. Table 4 summarizes crab landings in the bay from 1975 to 1984. The table shows that crab landings from Grays Harbor have averaged about 1 percent of the total coastal catch but vary widely from year to year.

Table 4. Grays Harbor Dungeness Crab Landings and Values. (Landings in thousands)

	Landings		
Year	Pounds	Value	Percent of Total
1975	80	$47	1.3
1976	21	12	0.3
1977	67	37	0.5
1978	18	9	0.3
1979	35	19	0.5
1980	75	40	1.4
1981	4	2	0.2
1982	19	11	0.7
1983	45	26	0.9
1984	51	30	1.5
10 yr. average:	42	23	0.9

Data provided by WDF.

3.2.3.2. Oysters. Oysters are a minor industry in Grays Harbor. In contrast to the 35,000 acres designated as oyster lands in Willapa Bay, about 600 acres are used in Grays Harbor for oysters (T. Hayes 1984, Morris 1984). Of this about 50 percent is owned by a single company. This 600 acres is less than 2 percent of the total tidelands in Grays Harbor. Table 5 summarizes the production of oysters in Grays Harbor from 1977 to 1982.

Under EPA criteria for the use of Sevin (discussed in Section 2.2) no more than 100 acres may be sprayed in Grays Harbor each year. Very little Sevin has been used in Grays Harbor; only five spray permits have been issued since the inception of the Sevin program (Tufts 1980c, Morris 1984).

Table 5. Grays Harbor Pacific Oyster Landings and Values. (Landings and values in thousands.)

Year	Landings Pounds	Landings Gallons	Value	Percent of Total
1975	319	36	$392	7
1976	478	55	620	9
1977	367	42	527	6
1978	490	56	816	9
1979	440	50	842	7
1980	261	30	521	5
1981	639	73	1,124	11
1982	725	83	1,301	12
1983	779	89	1,463	13
1984	551	63	1,215	9
10 yr. average:	506	58	832	9

Data provided by WDF.

3.3. WILLAPA BAY/GRAYS HARBOR COMMON ELEMENTS

3.3.1. **Burrowing Shrimp.** Both species of burrowing shrimp are indigenous to and very abundant in Willapa Bay and Grays Harbor. Ghost and mud shrimp are shrimp-like crustaceans. They live in the sediments, constructing and maintaining extensive burrow complexes. These burrows range from 10 to over 20 inches (250 to 500 mm) deep and usually have two or more openings to the surface.

Ghost shrimp are characterized by a pale pink body with a large, broad abdomen. The first pair of legs have well developed claws that are slightly dissimilar or very unequal depending on the animal's sex. Mature adults range from 2 to 4 inches (51 to 102 mm) in length.

Ghost shrimp feed by continually digging in sandy sediments and accumulating detrital particles on appendage hairs. The organic material is ingested when these hairs are cleaned. Since ghost shrimp prefer clean, well-sorted sand rather than muddier substrates, they must process a large amount of sediment (Bird 1982). Excavated sediment and feces are deposited at burrow entrances, forming conspicuous mounds which gradually raise the level of the tidal flat. According to observations by oyster growers and WDF biologists, ghost shrimp tend to soften a sand flat. The ghost shrimp remove binding particles of silt, clay, and organic material which are deposited with excavated sand as unconsolidated sediment on the surface.

The principle breeding period for ghost shrimp in the Pacific Northwest is late spring and early summer. The exact time depends on when the water warms. McCrow (1972) found that ghost shrimp become inactive and retreat to deeper (below 500 mm) burrows when exposed to low temperatures. Ghost shrimp normally produce three or four major broods of planktonic larvae every six weeks from March through August (McCrow 1972). Larvae pass through five planktonic zoeal stages, lasting about six weeks, in nearshore coastal waters (Johnson and Gonor 1982). Summer high tides carry some larvae into coastal estuaries where they settle on suitable substrate. Bird (1982) found that female ghost shrimp mature and produce eggs at about 24 months in Oregon estuaries. Growth rates ranged from 15.7 mm to 22.4 mm per year depending on location.

Mud shrimp are usually reported to be smaller than ghost shrimp, about 50 to 60 mm in length. However, in Willapa Bay and Coos Bay, they are the same size or larger than ghost shrimp (Rudy and Rudy 1983, WDF observations). A mud shrimp is bluish in color with green and orange variants, and their claws are equal in size. Their burrows are more complex than those of ghost shrimp and usually have three surface openings (MacGinitie and MacGinitie 1968). As their name indicates, mud shrimp prefer a muddier habitat with sediments that are less well sorted than those occupied by ghost shrimp (Bird 1982). The WDF has found both ghost and mud shrimp in the same area apparently using the same sediments.

Mud shrimp are suspension feeders. They filter detritus and organic particles from water pumped through their burrows. Compared to ghost shrimp, mud shrimp significantly increase the organic content of the sediments. The shrimp secrete organic material to cement their burrow walls and deposit undigested organic material as feces at the burrow entrances (Bird 1982).

Mud shrimp apparently breed in winter months when most egg bearing females are observed (Bird 1982). Bird found that mud shrimp post-larvae settle to the bottom in late winter and early spring. These young-of-the-year grow to about 0.7 to 1.1 inches (17 to 28 mm) by the following winter. Females grow by about one inch (26 mm) per year and produce eggs when they reach approximately 2.5 inches (60 mm).

Burrowing shrimp can significantly affect the benthic community in which they live. These effects are to be expected since it is well documented that deposit feeders can significantly affect benthic organisms (Bird 1982). High densities of ghost shrimp (over 100 grams biomass per 0.1 m^2) reduced both species composition and abundance in benthic communities. Species groups whose numbers were reduced by dense ghost shrimp populations were deposit feeding polychaetes, bivalves, and tube dwelling tanaids and amphipods (e.g. Corophium spp.) (Bird 1984, Posey 1985).

Mud shrimp cause less sediment disturbance than ghost shrimp and appear to have less effect on other invertebrate organisms. Bird (1984) found that the infaunal composition in colonies of ghost shrimp was a "selective subset" of that found with mud shrimp colonies. He observed higer densities of ghost and mud shrimp than are observed in Willapa Bay oyster tracts and these lower densities may have less effect on the

benthic community. Preliminary observations by WDF also suggest that increased burrowing shrimp abundance reduces diversity and abundance of other infaunal organisms. However, studies similar to those by Bird (1984) and Posey (1985) have not been done in relation to the Sevin spray program.

Ghost shrimp are also subject to predation which may limit their lower range on the beaches during the summer (Posey 1985). Posey found that the staghorn sculpin (Leptocottus armatus) was an important predator in summer months.

Burrowing shrimp also contribute substantial biomass to the intertidal community. Bird (1984) found high densities of ghost shrimp to be 420 to 770 individuals per square meter (/m^2) (502 to 921 per square yard; /yd^2) in Sand Lake estuary. The biomass of this population was about 1.7 kilograms per square meter (kg/m^2) (3.1 pounds/yd^2 or 15,004 lbs/acre). Other Oregon estuaries sampled by Bird had smaller populations. Ghost shrimp populations decrease with distance from the estuary entrance.

Densities of mud shrimp were the highest in the Salmon River estuary (52/m^2; 62/yd^2). The highest biomass reported was 2.6 kg/m^2 (4.9 lbs/yd^2 or 23,643 lbs/acre) in the Sand Lake estuary (Bird 1984).

A single estimate of burrowing shrimp biomass is available from Willapa Bay or Grays Harbor. A single sample was taken in 1982 from a population of mud shrimp in northern Willapa Bay. Burrow hole density was 45 to 50/yd^2 and yielded 20 to 25 shrimp/yd^2. Average shrimp weight was 1.1 ounces. The estimated biomass was 6,655 to 8,319 lbs/acre (.75 to .93 kg/m^2) (Tufts 1984a).

3.3.2. **Dungeness Crab.** The Washington Dungeness crab fishery is the state's largest crustacean fishery with average landings of around 7.7 million pounds annually. About 80 percent of the crab are harvested along the Washington coast. The average landed value of the coastal fishery is about $4 million based on an ex-vessel price of $1.50/lb. Between 100 and 150 boats participate in the fishery which may directly employ 450 people.

Only male crab are harvested. The minimum harvestable size is 6.25 inches across the back; crab generally reach this size after four years. The average harvested crab weighs 1.7 pounds. The abundance of crab is highly variable with annual landings ranging from 12.8 to 2.4 million pounds. Abundance generally follows a ten year up and down cycle.

Dungeness crab bred offshore in the open ocean. Following egg hatching and pelagic larval growth, many of the megalopae (final planktonic larval stage) are carried inshore by tidal and wind-driven currents and enter estuaries in the spring, April and June. Many older juveniles (age 1+) and some adult crab also re-enter the estuary. These larval crab settle and adopt the benthic life style of adult crab. Young-of-the-year crab (YOY) grow rapidly in the estuaries over the following summer and early fall reaching approximately 30 to 40 mm in carapace width. Most of these young crab apparently return to the ocean in the late fall to overwinter in warmer ocean waters (Armstrong et. al. 1984). Another

portion of these young juveniles may stay in the estuaries, buried in the sediment and overwintering in a dormant state (Armstrong et al. 1984).

Population levels of juvenile Dungeness crab within the estuary vary considerably by season and year depending upon oceanographic and biologic conditions. Armstrong et al. (1984) preliminarily estimated that the lowest crab abundance occurred in the winter (753,000 crab) and peaked in the summer (29 million crab) in Grays Harbor.

These studies also show that crab abundance was highly dependant upon substrate type. No YOY crab were found on bare sand and mud while the highest abundances were found among oyster and clam shell and eelgrass. Armstrong (pers. comm. 1985) has concluded that shell enhances a barren beach making it suitable for juvenile crab. Abundance in these habitats averaged over 400,000 YOY crab per acre.

Intertidal crab abundance changes dramatically during the summer. In May Armstrong et al. (1984) observed 405,000 YOY crab per acre. By June through September this number declined to between 8,000 and 40,000. Predation by fish and birds apparently resulted in only 2 to 24 percent of these crab surviving to the end of summer. WDF biologists also suggest that these small crab, as they grow larger, can no long find cover and protection on the beach and consequently move into deeper water. They observe that few crab remain on the beds by July. This is the primary reason Sevin treatments are restricted to the months of July and August.

No estimates of crab abundance have been made in Willapa Bay, However, it is likely that this larger bay supports a larger population. The preferred habitat of these young crab is shell and eelgrass. In Willapa Bay, eelgrass beds cover about 15,000 acres. At 400,000 YOY crab per acre, a population of 6 billion (6×10^9) may occur in late spring. Another 15,000 acres are used for oyster culture, but there is no estimate of the amount of acreage with shell densities which would support crab. Also, in some areas oyster culture may overlap eelgrass beds. It is likely that 5,000 to 15,000 additional acres of crab habitat are provided by the oyster shell planted on the beds. This represents an additional 2 to 6 billion YOY crab which would not survive without the habitat provided by the oyster shell. The total population of YOY crab shortly after settlement in May may, therefore, reach 8 to 12 billion. Based on the observed population decline in Grays Harbor, the YOY population may decline to between 0.2 and 1.2 billion by the July/August Sevin spraying.

Note that crab populations are highly variable from year to year and these results may not be indicative of all or even average years. Research is continuing in Grays Harbor through 1985 and limited work will be conducted in Willapa Bay. It is obvious that these are important areas for Dungeness crab and that additional study is needed to understand the population dynamics of these crab and their relation to the commercial fisheries of the bays and the Pacific Ocean.

3.3.3. **Birds**. Smith and Mudd (1976) and Kalinowski et al. (1982) conducted food habit studies on wintering waterfowl, shorebirds, and terns in Grays Harbor. Studies of waterbird food habits in summer have not been

conducted. However, their prey requirements at this time of year are expected to be about the same as at other times, since the same bird and food groups are present.

Waterfowl feed primarily on aquatic plants including eelgrass, salt marsh plant seeds, and invertebrates such as amphipods, worms, and insect larvae. American wigeon feed almost exclusively on eelgrass although an occasional amphipod is taken. Amphipods and salt marsh plant seeds have each been shown to be the main food prey for mallards in separate studies (Kalinowski et al. 1982, Smith and Mudd 1976). This variability may be due to the variety of habitats mallards use for foraging. Green-winged teal feed on invertebrates.

Shorebirds forage on the tideflat and spend the majority of daylight hours here. Probing in the mud with elongated bills, shorebirds locate and extract the small invertebrates that constitute their food. Different substrates are used to various extents by each species. Small sandpipers, dowitchers, and red knots forage on mud flats with a high silt content, while sandier substrates are preferred by the plovers (Kalinowski et al. 1982). Turnstones usually forage among rocks, substrate that occurs only in small areas in Grays Harbor and Willapa Bay (Smith and Mudd 1976). Dunlin, western sandpiper, and least sandpiper are largely restricted to estuarine mud flats. In these areas of finer sediments, the amphipods Anisogrammarus confervicolous and Corophium spp., which are preferred prey, are abundant.

Invertebrates comprise the bulk of the dunlin's food, although vegetation, primarily salt marsh plant seeds, supplements the diet (Smith and Mudd 1976). Annelid worms formed 11.7 percent of total food items, nematode worms 1.4 percent, molluscs 1.9 percent, and arthropods 72.6 percent in Smith and Mudd's study. The amphipods Corophium spp. and A. confervicolous were the most numerous arthropods eaten. Kalinowski et al. (1982) found that amphipods comprised 44.8 percent of the dunlin's diet. Other major food items were tanaids (a small benthic crustacean) (31.1 percent), insect larvae and egg cases (9.5 percent), and annelids (6.0 percent). Amphipods were the most important food for dunlin and western sandpipers wintering in western Washington.

Western sandpiper diets consist of oligochaetes (50 percent), salt marsh seeds (29.1 percent), and amphipods (12.2 percent) (Kalinowski et al. 1982). Smith and Mudd (1976) found annelid worms, arthropods, and nematode worms made up approximately 60 percent of the sandpiper's diet and salt marsh plant seeds 40 percent.

Due to small sample sizes, no quantitative analysis was made on food of long-billed dowitchers, sanderlings, and least sandpipers (Smith and Mudd 1976). Important food items appear to be amphipods (Corophium spp.), molluscs (Macoma baltica and Mya arenaria), and polychaete worms. Sanderlings feed on insects, oligochaetes, salt marsh seeds, and eelgrass; while least sandpipers prey on terrestrial insects and gammarid amphipods (Kalinowski et at. 1982).

Caspian terns take a wide variety of fish while feeding over shallow intertidal areas. Of the 31 fish species identified, shiner perch was the most frequent prey. Chum salmon and Pacific staghorn sculpin were next in importance (Smith and Mudd 1976).

Several of these important food organisms, including amphipods and small clams, were found on an oyster bed in Willapa Bay (Hurlburt 1985). No information is available on the presence of these invertebrate or bird species in Grays Harbor oyster growing areas.

Wetlands and waterways of Grays Harbor and Willapa Bay may be particularly important to raptorial birds. The northern harrier (marsh hawk) is the most common raptor in these Grays Harbor habitats (Smith and Mudd 1976). Other common raptors include great horned owl and redtailed hawk. In winter short-eared owl, merlin, American kestrel, Cooper's hawk, sharpshinned hawk, bald eagle and peregrine falcon were seen hunting along the wetland shorelines of Grays Harbor (Smith and Mudd 1976, Herman and Bulger 1981, Kalinowski et al. 1982). All of these species, except the bald eagle, are known to prey upon shorebirds. Grays Harbor supports significant numbers of these birds from October through May.

3.3.4. **Threatened and Endangered Species.** Three species of birds and one whale that are listed as Federally and state threatened or endangered species have been observed in Willapa Bay and Grays Harbor. These are the peregrine falcon (Falco peregrinus, Federal and state threatened), the bald eagle (Haliaeetus leucocephalus, Federal and state threatened), the brown pelican (Pelecanus occidentalis, Federal and state endangered), and the gray whale (Federal endangered).

The peregrine falcon has been rarely seen in Willapa Bay during the fall, winter, and spring seasons. However, they may use the bay on a regular basis (Dobler 1984).

Peregrines use Grays Harbor regularly during the fall, winter, and spring months. Six individuals were seen within Grays Harbor during the winter months in 1983 to 1984 (Dobler 1984). Occasional sightings of peregrines were made during the summer season. Dobler (1984) suggests that these birds may be nonbreeders. Ned Rock in North Bay (Fig. 2) was a preferred site for one peregrine for winter territory.

Peregrines feed almost exclusively on birds. A winter feeding study showed that shorebirds comprise 50 to 60 percent of their prey and passerines (song birds) 30 percent. The remainder is other birds such as waterfowl and petrels (Dobler 1984).

The brown pelican has been observed infrequently in both Willapa Bay and Grays Harbor (COE 1976, Smith and Mudd 1976). In 1983, an unprecedented early arrival of brown pelicans occurred in both areas in late May (Mattocks et al. 1983). Up to a dozen pelicans remained in Grays Harbor and Ilwaco through June and July (Mattocks et al. 1983). Other sightings have occurred from Ilwaco to La Push, 75 miles north of Grays Harbor.

Bald eagles use the shorelines and surrounding uplands year- round in both Willapa Bay and Grays Harbor. Several active nest sites are located in the vicinity of these coastal areas (Washington Department of Game records). Both adults and juveniles may perch in trees along the shoreline. They may occasionally forage over the tideflats.

The gray whale is a regular spring and fall migrant off the coast and occasionally wanders into Willapa Bay and Grays Harbor. See Sections 3.1.2.5 and 3.2.2.5 on Willapa Bay and Grays Harbor marine mammals for occurrences in these areas.

3.3.5. **Estuarine Food Webs.** Various aspects of the "Existing Conditions" discussed in Section 3 are interrelated as parts of the estuarine food web. This relationship is based mostly on organic detritus (fine decomposing particulate debris). It is brought into the estuary by freshwater tributaries and generated within the bays and the ocean by the breakdown of plant and animal tissues. Phytoplankton and detritus serve as the basic food source for the primary consumers (Simenstad et al. 1979). These consumers include benthic and planktonic crustaceans such as shrimp, amphipods, and harpacticoid and calanoid copepods. The bivalve molluscs such as mussels, clams, and oysters are also primary consumers. The crustaceans in turn serve as important food sources for bait fish (herring and smelt), juvenile salmonids, and shorebirds (Cordell and Simenstad 1981, Simenstad and Eggers 1981, Simenstad et al. 1979). Some of these crustaceans, smaller clams and young oysters serve as food for Dungeness crabs. A portion of the clams and the oysters are harvested directly by humans while others serve as food for gulls, crows, river otters, racoons, and other predators. Salmonids, waterfowl, bottomfish, crabs, and other species feed on the benthic and planktonic invertebrates and plants, then are harvested by humans and other secondary or tertiary consumers.

An example of a short and direct food chain within this complex web is from organic detritus and phytoplankton to amphipods and copepods to the gray whale which feeds directly on benthic invertebrates. Another example,evident from Sevin treatments, is consumption of detritus by ghost shrimp which are preyed on by staghorn sculpins. These fish are in turn eaten by Caspian terns. Many other such food chains, with more links involving many of the same components, compose the estuarine food web (Fig. 3).

Research reported by Simenstad et al. (1979) helped define such food webs in the several marine habitats in northern Puget Sound and the Strait of Juan de Fuca. However, such research is apparently just beginning in Grays Harbor and Willapa Bay. The data reported by Tufts (1984b), Hurlburt (1985), Cordell and Simenstad (1981, 1983), Simenstad and Eggers (1981), Kalinowski et al. (1982) and others must be consolidated to be able to completely define the critical food webs of Willapa Bay and Grays Harbor.

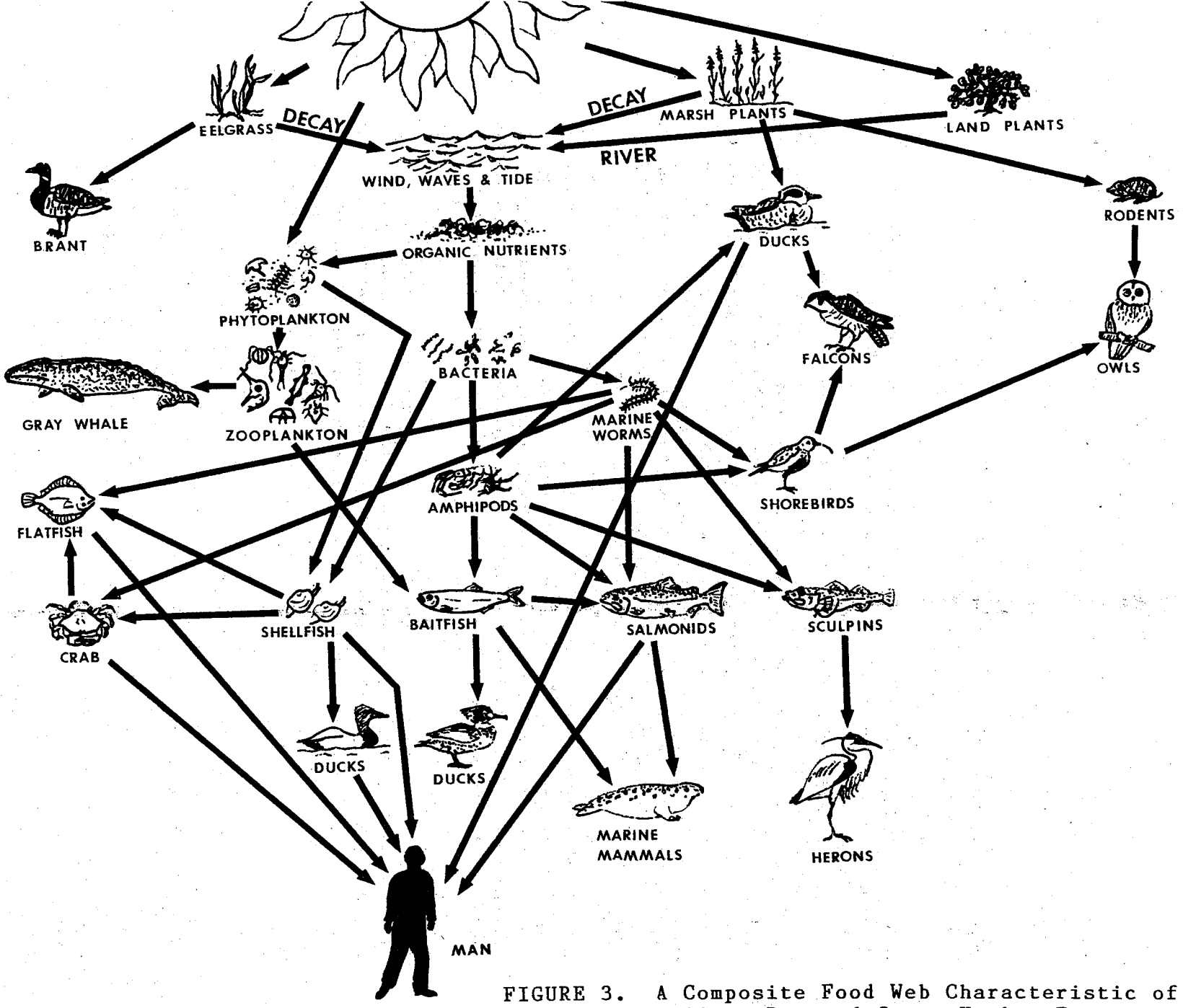


FIGURE 3. A Composite Food Web Characteristic of the Willapa Bay and Grays Harbor Estuaries

4.0 IMPACTS OF SEVIN

The insecticide carbaryl (1-naphthyl-N-methylcarbamate) is a "carbamate" sold under the trade name Sevin 80S by the Union Carbide Company. It is a sprayable, broad-spectrum insecticide which possesses both contact and systemic toxicity. Because of its wide-spectrum, low-hazard (Mount and Oehme 1981), and short- term residual properties (Lichtenstein et al. 1966), Sevin is one of the most widely used insecticides in the U.S. In 1974, Sevin was the most used insecticide on forests in the United States. Sevin is also the most commonly used insecticide in dog and cat flea powder and collars (Appendix B).

Use of Sevin by the Willapa Bay and Grays Harbor oyster growers is regulated by EPA under a Special Local Needs Pesticide Registration (EPA SLN No. WA-760021). Each application is supervised under special pest control permits issued by WDF. From 1963 to 1980, an average of 1,738 pounds of Sevin was used each year for treatment at a rate of 10 pounds active Sevin per acre (lbs/acre). This has amounted to a total of 29,475 pounds during that period (see Appendix D). On most ground with substantial populations of burrowing shrimp, growth of significant oyster crops probably would be severely inhibited without Sevin treatment (Tufts 1980a and Section 4.2.6.2.).

4.1. CHEMICAL BEHAVIOR OF SEVIN

Various studies have shown that the concentration of Sevin applied to Willapa Bay and Grays Harbor mud flats diminishes rapidly. This is due in part to hydrolysis in alkaline sea water accelerated by relatively high summer temperatures. The mud flat acts to rapidly adsorb Sevin, removing it from the water column without subsequent release (Sayce 1970). In addition, Sevin is rapidly diluted by the incoming tide. These factors apparently do not diminish the effects of Sevin on burrowing shrimp. The insecticide begins to show results within 30 minutes of treatment and its action appears to be facilitated by warmer temperatures. The range of values reported for persistence by various authors are probably due to environmental differences which affect the rate of decay in both laboratory and field experiments.

Sevin conforms to the general carbamate formula $(CH_3)R_1NC(O)OR_2$. It is almost insoluble in water with a solubility of less than 1 percent (Mount and Oehme 1981).

The intertidal estuary environment in summer apparently accelerates decomposition of Sevin. Under abiotic (without life) conditions, Sevin is removed from the environment through hydrolysis to 1-naphthol, which further undergoes degradation to carbon dioxide (Karinen et al. 1967). In sea water the stability of Sevin and its hydrolytic product, 1-naphthol, is controlled by pH, temperature, alkalinity, sunlight, dilution and biotic degradation. Temperature increases in water and the presence of mud increase the rate of Sevin hydrolysis. Sevin and 1-naphthol decomposition are also highly dependant upon the pH of the water. Lamberton and Claeys

(1970) observed that 1-naphthol decomposition was most rapid at pH 8.2, which is coincident with the pH of seawater.

In the estuarine environment, Sevin degrades abiotically and through microbial transformation. Yeasts and filamentous fungi can convert Sevin or 1-naphthol to water soluble products. Of the microorganisms studied by Sikka et al. (1975), marine bacteria did not appear able to convert Sevin to water-soluble products to any great extent. Filamentous fungi were more effective at this process than yeasts. The first hydrolysis product, 1-naphthol, is broken down more quickly than Sevin. Filamentous fungi break down Sevin to a greater degree than bacteria or yeast do (Sikka et al. 1975). Whether these microorganisms are present on oyster tracts at the time of Sevin treatments is unknown.

In experiments by Karinen et al. (1967), Sevin was added to sea water in aquaria with and without mud. After 38 days at 8°C, 10 percent of the Sevin added to the control (sea water without mud) had hydrolized. In contrast, after four days at 20°C, 55 percent of the Sevin was hydrolized in sea water with mud. The rate of decomposition approximately tripled between 10°C and 20°C and the addition of mud.

Mud adsorbed Sevin from water (Liu et al. 1981, Karinen et al. 1967). Degradation of carbaryl in mud is controlled by temperature and the presence of oxygen. Warmer, well-aerated conditions markedly accelerate chemical breakdown. This behavior was also demonstrated by Karinen et al. on a mud flat in Yaquina Bay, Oregon. When carbaryl was applied to mud flats, it was rapidly removed from water through adsorption by bottom sediments, degrading to carbon dioxide. At 7.5°C to 14.5°C, Sevin concentration in intertidal mud dropped from 10.7 parts per million (ppm) to 3.8 ppm in the first 24 hours after treatment. It did not fall below 1 ppm until after eight days and was still detectable (0.1 ppm) after 42 days.

In comparison to the laboratory studies above, Sayce (1970) conducted field experiments on Willapa Bay oyster beds during actual treatment. Sevin was applied at 10 pounds per acre. Sevin concentrations in mud declined from 1.1 ppm to 0.06 ppm in four days and to 0.01 ppm after eight days. Sevin or its degradation products were not detectable sixteen days after treatment. In 1983 the WDF tested intertidal mud from an oyster tract sprayed with 10 pounds per acre. Levels dropped from 11.0 ppm to 0.3 and 1.1 ppm (results of 2 samples) in 24 hours (Hurlburt 1985).

The WDF has also tested tidal waters flooding over treated oyster tracts. In 1963, Chambers (1970) conducted tests in Quilcene Bay with Sevin applied at 10 pounds per acre. On one test plot, the first one-half inch of water had a maximum concentration of 3.22 ppm (average 1.55 ppm). When the tide reached a depth of six inches, the level of Sevin had dropped to 0.08 ppm at the surface and 0.11 ppm at the bottom. In a similar test in Quilcene Bay with 10 pounds of Sevin per acre, tidal water contained up to 1.2 ppm of Sevin on the same day as spraying (Chambers 1970). In the same test, water taken from the sprayed plot one day and 14 days following spraying contained Sevin at 0.37 and 0.16 ppm, respectively. The lower

level approached the limit of sensitivity for the assay method used. The persistence of Sevin observed by Chambers may be due to Sevin-containing sediments which contaminated the water samples.

The WDF repeated these water analyses in 1984 in Willapa Bay (Hurlburt 1985). Tidal water flooding over an oyster tract sprayed with 10 pounds of Sevin per acre contained an average of 10.6 ppm in the first inch of water. Within 30 minutes (at a water depth of 14 inches) Sevin was not detectable at 0.1 ppm in a test for Sevin and 1-naphthol combined. Only 0.001 to 0.002 ppm of Sevin were found by a second, more sensitive method. Water temperatures on the incoming tide declined from 20°C to 16°C as water depth increased.

High water temperatures (15.7 to over 20°C) are experienced in Willapa Bay and Grays Harbor during July and August, the months during which Sevin spraying is permitted (Section 3.1.1.2, WDOE records). Temperatures on sun-warmed mudflats are probably even higher than those recorded in subtidal areas by WDOE (Hurlburt 1985).

4.2. EFFECTS OF SEVIN ON MARINE LIFE

Sevin sprayed in Willapa Bay and Grays Harbor affects organisms other than the target species. Sevin inhibits the enzyme acetylcholinesterase, disrupting nerve transmission in arthropods. This may result in respiratory muscle paralysis or reduced heart rate (bradycardia). Sevin enters organisms through the integument or the digestive tract (Armstrong 1971). While highly toxic to arthropods such as crab and shrimp, the toxicity of Sevin to other organisms varies widely. Even within an animal or plant group, the susceptibility to Sevin may vary considerably. In addition, the hydrolysis product 1-naphthol can be more toxic to some organisms than the parent compound.

4.2.1. **Plants.** In tests on planktonic algae associated with waste stabilization ponds (Chlorella spp.), Sevin inhibited growth at continuous concentrations above 0.1 ppm. Chlorella degraded Sevin very little (Christie 1969). Cole and Plapp (1974) also found that Sevin at 1 ppm weakly inhibited growth and photosynthesis in Chlorella. Conversely, the increased nitrogen from the abiotic degradation of Sevin stimulated cell growth and carbon fixation in the freshwater alga Scenedesmus (Stadnyk et al. 1971).

Ukeles (1962) tested growth in pure cultures of marine phytoplankton exposed to toxicants. Growth of two of the five species tested was completely suppressed at 1 ppm of Sevin. Growth resumed when these species were placed in Sevin-free water. Butler (1963) detected a 16.8 percent decrease in productivity of a natural phytoplanktonic community during a four-hour exposure to 1 ppm Sevin. The variation in results indicates that algae species are affected differently by Sevin. A study by Butler et al. (1975) indicates that Sevin's impact on algae may be inconsequential since the rapid, abiotic breakdown of Sevin prevents significant interaction with planktonic algae.

Growth of diatoms and other benthic or planktonic algae may be temporarily inhibited by Sevin treatments of oyster tracts. These effects would probably last as long as Sevin concentrations remained above 1 ppm. Within one to eight days of treatment, Sevin concentrations in the sediment drop below this level (Section 4.1). High temperatures and available light make July and August peak growth months for benthic algae as well as facilitating Sevin decomposition. Algal production may be inhibited by Sevin in the water at concentrations above 0.1 ppm. Planktonic algae would probably be exposed to such levels for less than 30 minutes. Epibenthic algae may experience these levels in the sediment for several weeks. Any inhibition during this time may be compensated for after degradation of the Sevin, and is limited by the small volume of water affected. Information is not available on Sevin's effects on benthic macroalgae or eelgrass associated with oyster flats; however, these effects are expected to be very limited and short-term.

4.2.2. **Invertebrates.** A variety of estuarine organisms have been experimentally exposed to Sevin in the laboratory (Andrews et al. 1968) and in the field (Lindsay 1961, Haven et al. 1966) for control of oyster drills, burrowing shrimp, and pea crabs. In the laboratory, pea crabs were killed when the oyster hosts were exposed to 10 ppm. In field tests, a mixture of Sevin and other chemicals eliminated ghost shrimp, but had little effect on oyster drills.

In studies in Willapa and Quilcene bays, sub-lethal effects from Sevin exposure caused polychaete worms to leave their burrows, exposing the worms to predators (Chambers 1970). However, Armstrong and Millemann (1974) observed no polychaete mortalities after spraying plots in Yaquina Bay, Oregon. In laboratory experiments, 1 ppm Sevin significantly reduced feeding activity of the lugworm Arenicola cristata (Tagatz et al. 1979).

The effects of Sevin on bivalve shellfish varies with species and situation. Armstrong and Millemann (1974) found that gaper clam populations (Tresus capax) were reduced by 58 and 69 percent on tracts sprayed with 5 and 10 pounds per acre, respectively. On these same plots, bentnosed clams (Macoma baltica) were reduced by only 9 and 28 percent. Chambers (1970) observed some mortalities of bentnosed and soft shell clams in Willapa Bay and Quilcene Bay studies. Sevin is also toxic to blue mussels, Pacific oysters, and cockles in concentrations ranging from 2.3 to 7.3 ppm in 24 to 96-hour exposures (Stewart et al. 1967, Butler et al. 1968).

Butler (1970) indicated that pesticides may cause sub-lethal effects such as reduced shell thickness in oysters. Continuous exposure to 1 ppm carbaryl caused a 40 percent reduction in normal oyster egg development and totally prevented normal development at 4 and 10 ppm (Davis 1961). However, studies on oyster beds sprayed with Sevin at 10 pounds per acre revealed no oyster mortalities in either juveniles or adults (Sayce 1970). The apparent difference in sensitivity is due to the difference in laboratory and field conditions. Bioassays expose oysters continually to constant insecticide concentrations for up to 96 hours. In contrast, when tidelands are sprayed, the resident biota is subjected for a short period to a diminishing insecticide concentration (Section 4.1).

Sevin is 30 to 300 times more toxic to crustaceans than to molluscs (Stewart et al. 1967). On the other hand, molluscs are more sensitive under test conditions to 1- naphthol. Sevin's effectiveness on crustacea and its apparent lack of persistence in the environment has made Sevin the primary means of control for burrowing shrimp. Chambers (1970) found that burrowing shrimp began exhibiting mortalities within 30 minutes of exposure to Sevin. Stewart et al. (1967) tested LD_{50} values (the concentration that produces paralysis or death in 50 percent of the test subjects) for burrowing shrimp; after a 24-hour test period they were 0.03 to 0.09 ppm.

The 24-hour LD_{50} for shore crabs (Hemigrapsus oregonensis) was 0.06 to 1.05 ppm and for Dungeness crabs 0.55 to 0.70 ppm. Adult Dungeness crabs developed irreversible paralysis within six hours after ingesting cockles exposed to 1 ppm Sevin for 24 hours (Buchanan et al. 1970). In field experiments, Tegelberg and Magoon (1970) found low mortalities among adult Dungeness crabs externally exposed to Sevin. Twelve mature crabs were placed in traps on an intertidal area and subjected to sprayed Sevin. Among this group, five escaped, one died, and six lived. Twenty-nine adults were placed on the same ground one day after spraying. Only 2 of these crabs died. In experiments by WDF (1975) and Tegelberg and Magoon (1970), no effects were observed 5 to 10 days following exposure.

These experiments and those by Buchanan et al. (1970), appear to show that adult crabs are more resistant to Sevin than are burrowing shrimp. The resistance of the adults is evident when crabs are exposed to the actual conditions present when intertidal areas are treated. However, juveniles, especially young-of-the-year, are susceptible to externally applied Sevin. Crabs of all ages are especially vulnerable to ingested Sevin in the form of contaminated clams or burrowing shrimp (Buchanan et al. 1970, WDF 1975).

The timing of Dungeness crab egg hatching is one of several factors WDF considered to determine the time of year Sevin would least impact crab populations. Crab eggs usually hatch in late January to late March (Armstrong et al. 1984). By mid-spring most larval crabs have settled out and are no longer present in the water column in appreciable numbers. After settling into benthic habitats, the young crabs grow rapidly and usually move from intertidal areas to the subtidal habitats in sloughs and channels by early summer. Post-larval crabs are rarely observed on exposed oyster beds in mid-summer, whereas they are commonly encountered in May and June (Barry and Northup 1984). At the time of Sevin treatment in July and August, crabs are not usually observed on the beds at low tide (Tufts 1984a).

4.2.2.1. Benthic Community Impacts. Since Sevin is known to be toxic to a wide variety of estuarine organisms, it could affect the condition of a community as a whole. In contrast to the extensive knowledge of Sevin's impacts on individual species, only one study has been conducted on impacts at the community level.

Tagatz et al. (1979) found that development of experimental laboratory animal communities was altered when continually exposed over 10 weeks to a solution of Sevin and triethylene glycol in seawater. Mollusc numbers decreased insignificantly with increasing Sevin concentrations.

Arthropod species decreased significantly in developing communities exposed to Sevin concentrations of 0.011 and 0.103 ppm. In Tagatz et al.'s experiments, the amphipod Corophium acherusicum was particularly sensitive to Sevin. Abundance of this species significantly declined at 0.001 ppm and was absent at higher concentrations. It was also found that Sevin affected the relative species abundance. For instance, some annelid worm species increased under higher concentrations while other annelids and nemertean worms decreased sharply. Tagatz et al.'s experiments exposed organisms to very low concentrations for up to 70 days.

Tagatz et al.'s (1979) experiments were at low concentrations for 70 days and are not directly comparable to the field situation in Willapa Bay and Grays Harbor. During treatment, initial Sevin concentrations could be 100 times higher than Tagatz et al. but may decay to lower levels within an hour. The sediment concentrations after 24 hours are 3-10 times higher than those that Tagatz et al. This could affect developing communities where susceptible species such as Corophium sp. may spawn immediately prior to treatment and encounter toxic sediments at the time of settlement.

Many benthic organisms are susceptible to prolonged exposure to Sevin at concentrations lower than the short-term concentrations observed by WDF (Westley 1970, Hurlburt 1985) and Karinen et al. (1967). It is unlikely that Sevin or 1-naphthol remains in sediments for 10 weeks to produce exposure times similar to Tagatz et al.'s. However, according to the data on Sevin persistence in sediment (Section 4.1), invertebrates associated with the sediments may be subjected to lethal or inhibiting exposures for a period of days to several weeks.

An indicator of the residual toxicity of the sediments is the burrowing shrimp themselves. An average of 5 to 10 percent of the treated shrimp survive. In some cases treatment is required again within a year; on average it is required every six years. Shrimp appear to begin recolonizing the treated beds during the next spawning season. These shrimp grow and additional shrimp settle and inhabit the bed. Over time the population increases. The beds eventually deteriorate to the point that treatment is necessary.

Reduction of the burrowing shrimp may increase the abundance and diversity of organsims associated with the oyster beds. WDF has compared tracts with different densities of burrowing shrimp (Table 6). None of the tracts had been treated within the prior two years. This showed that tracts with less than 5 burrows/m^2 averaged 21 epifaunal and infaunal species and 522 organisms. Tracts with over 10 burrows/m^2 averaged 12 species and 111 organisms. The tracts with low shrimp abundance also supported oysters and eelgrass, which may have contributed to the species abundance. These observations are consistent with those of Posey (1985) who noted that high shrimp densities were associated with reduced abundance and diversity of infauna on Oregon beaches.

Table 6. Effects of Burrowing Shrimp Abundance on Species Diversity and Abundance.

Shrimp Holes/m^2	Species Number/m^2	Organisms Number/m^2	Eelgrass Turions/m^2	Oysters Present
1-2	21	399	10-14	yes
4.5	22	645	24	yes
8-10	18	187	present	yes
16	5	35	0	no

Sevin treatment initially kills sensitive species on the tracts. It may inhibit recolonization of the tracts for up to several weeks, until the Sevin in the sediments decomposes completely. While Table 6 shows that infauna will re-inhabit the sprayed tracts, only preliminary assessments have been made on the rate of recolonization. Hurlburt (1985) reported preliminary results of infaunal studies showing slightly reduced infaunal species, but increased total biomass, 60 days after treatment. Neither the reductions nor the increases are statistically significant.

The rate at which a sprayed bed recovers depends upon the residual toxicity of the sediments, the suitability of the sediments for various species, and the spawning cycle of the various species. Organisms spawned at the same time may be eliminated from treated tracts, if spawning occured prior to treatment or the organisms settled to the bottom while the sediments are still toxic. Recolonization may not occur, except by immigration, until spawning occurs the next spring or summer. Species which spawn shortly after treatment may recolonize very rapidly; for example, Corophium sp. appears to spawn in the fall shortly after treatment. Some species, especially those with longer life cycles, may take several years to return to pre-treatment abundance. The primary example is the burrowing shrimp where pre-treatment abundance is re-established after about 6 years, on average. Invertebrate spawning and recruitment are highly variable from year to year and will consequently affect the rate of recolonization.

Reduction of high density burrowing shrimp populations and addition of oysters to a mud flat may increase the diversity and abundance of associated invertebrate communities. The oyster shell affords hard substrate for attachment of algae and encrusting invertebrates such as barnacles, anemones, and mussels (Hurlburt 1985). Also, the shell and algae provide cover for mobile species such as Dungeness crab. Since dense populations of burrowing shrimp can reduce both numbers of species and organisms (Section 3.3.1), removal of the shrimp could allow more space and resources for other species. In addition, the apparently rapid degradation rate of Sevin in both sediments and water would probably prevent inhibition of community development. Limited studies have been conducted on the effects of Sevin on benthic infauna and on the effects of burrowing shrimp on these organisms and the overall productivity of the beaches.

The effects of Sevin on benthic communities are mitigated by the present restriction of treatments to mid-summer. Research in Grays Harbor (Albright and Bouthilette 1982) and Oregon (Posey 1985) has shown that populations of small benthic crustaceans such as amphipods, tanaids, and cumaceans are lowest at this time. This is partially due to intense predation pressure by juvenile finfish, especially salmonids, and migrating birds in the spring and early summer. These populations recover rapidly through reproduction and recruitment later in the summer and fall.

In summary, it appears that the use of Sevin in Willapa Bay and Grays Harbor has short-term impacts on benthic communities of the treated tracts and an area of less than 20 feet around the treated area. These short-term impacts change the habitat of the sprayed oyster beds. However, they do not have any observed impact on the estuary. Such an impact is unlikely since the area sprayed is less than one percent of the area of either bay.

Long-term effects have not been quantified, but appear limited to changes in the intertidal habitat. The burrowing shrimp population is significantly reduced. The oyster beds become firmer and can support oysters. This change may be beneficial because the community which develops after the treatment may have more organism diversity and a higher abundance of many of the species affected by Sevin. Burrowing shrimp populations apparently do not recover for several years. However, preliminary information from WDF studies in Willapa Bay (Section 3.1.2.2.2) and research in Oregon and in Grays Harbor indicates that reproduction and recruitment may compensate for short-term impacts to other benthic organisms in a matter of months. Additional research is required to assess the long-term effects to estuaries of regular, annual Sevin application.

4.2.2.2. Dungeness Crab. While adult crabs die after feeding on burrowing shrimp killed by Sevin, very young crab can be killed through direct exposure. Routine assessments of crab mortalities began in 1976. These assessments provide a relative index of crab losses year to year. They do not estimate the total crab killed or their relation to the total crab populations of the bays. Thus, information is lacking on the actual extent of incidental mortalities to crab.

In the years 1976 through 1984, an average of 241.3 acres per year were treated in Willapa Bay and Grays Harbor (7.6 percent in Grays Harbor). A 9-year average crab kill for all ages was 31.7 crabs per acre or 10,461 crabs per year (Table 7). A more accurate yearly average is obtained by excluding the 1976 and 1984 data. 1984 was an unusual year compared to the previous eight years; and 1976 was the year mortality assessments were started, so the data may not be comparable. Thus, the adjusted average mortality from 1977 through 1983 was 29.5 crabs per acre per year and 7,956 crabs total per year.

Based on sampling of crab mortalities from 1979 through 1983, an average 58 percent of all crabs killed were male (Tufts 1984). Of these male crabs, 34 percent were one year old or less; 30 percent were young-of-the-year with a carapace width of less than 40 millimeters. Two year old crab comprised 59 percent of the mortalities, seven percent were three years old, and 0.2 percent were legal size.

In 1984 a very large year class appeared as young-of-the-year on the beds and remained through September. Studies of the 1984 Sevin treatments found 78.3 crabs per sprayed acre were killed in Willapa Bay and Grays Harbor. Of these, 77 percent were young-of-the-year. The remainder were principally one year old juveniles. WDF delayed some treatments until August, which the data show reduced mortalities: Willapa Bay treatments in July killed about 92.6 crabs per acre, while August spraying killed only about 57.9 crabs per acre. Details of crab mortality assessments and other studies are reported by Hurlburt (1985).

Mortalities of crab from natural causes and fishing are discussed in Section 3.1.2.1. It is unknown how much optimum habitat is available in the bays. Based on Armstrong et al. (1984) the total population of the bays may be over 700 million during the treatment period. The annual crab mortality indice can be used to give an estimate of true mortalities. Thus, using the indice, the unusually high 1984 crab lossess would represent less than 0.01 percent of the population. If the indice under-represents actual losses by half, the 1984 crab losses would still be less than 0.01 percent of the population. Due to natural mortality, less than 1,000 of these crab would have survived to enter the fishery.

Table 7. WDF Estimated Dungeness Crab Mortalities in Willapa Bay and Grays Harbor (1977 through 1984).

			Crabs Killed		
Year	Acres Treated	Permits Approved	Average per Acre	Range per Acre	Total per Year
1977	162	7	25.8	a	4,180
1978	149	11	18.1	a	2,697
1979	314	14	16.5	a	5,181
1980	251	15	5.0	a	12,726
1981	120	7	56.3	20.9- 99.4	5,730
1982	272	16	28.3	3.4-158.6	10,572
1983	244	19	56.4	0.6-659.9	14,608
1984	490	23	78.3	5.8-294.1	38,407
Average	250	14	41.8		10,461

a. Counts of crab mortalities from individual tracts are not available for these years. These data are from Tufts (1980b and 1983a).

The addition of oysters may enhance the productivity of the benthic community (see Sections 4.2.2.1. and 4.2.7.). Oyster shell and associated algae are important to very young Dungeness crab (Armstrong et al. 1984). The bottom dwelling animals supply the crabs with food while algae and

oyster shells provide shelter and additional micro-habitats for prey (Armstrong et al. 1984, Hurlburt 1985). By providing a more optimum habitat for young juvenile crab, the restoration of oyster culture on a tract could help increase Dungeness crab populations.

4.2.3. **Finfish.** Since many marine fish pass their early growth stages in estuaries, possible effects from the use of Sevin are important. The sensitivity of juvenile coho salmon, rainbow trout and adult threespine stickleback to Sevin were tested by Katz (1981) in standing water bioassays at 20°C (68°F) for 48 hours. The median tolerance limits for the coho were 0.997 ppm, for rainbows 1.6 ppm, and for sticklebacks 10.4 ppm in 25 parts per thousand seawater. Post and Schroeder (1971) reported similar results. In bioassays conducted by the U.S. Fish and Wildlife Service, the concentration of Sevin causing a 50 percent mortality in juvenile white mullet over 24 hours was 4.25 ppm, while the same mortality in juvenile longnose killifish occurred at 1.75 ppm (Butler 1963). The concentration of Sevin causing a 48-hour, 50 percent mortality to juvenile mullet was 2.5 ppm and to young killifish was 1.75 ppm. Cope (1965) determined the following fish tolerance limits for Sevin as measured by 50 percent mortality after 48 hours at the indicated temperatures: channel catfish at 19.0 ppm, 24°C; bluegill at 2.5 ppm, 24°C; and rainbow trout at 2.0 ppm, 13°C. Also, Korn (1973) reported that only low accumulations of Sevin occurred in channel catfish after 56 days of exposure.

These data show that salmonids appear to be the most sensitive to Sevin. This is substantiated by results of additional experiments performed by Macek and McAllister (1970). The susceptibility to several pesticides, including carbaryl, of five fish families (12 species) was tested in 96-hour static bioassays at 13°C. The 50 percent lethal concentration of carbaryl for juvenile coho salmon was 0.764 ppm. Also, Macek and McAllister (1970) rated coho and perch over the other species as the most susceptible to Sevin.

Sevin concentrations which proved lethal to coho, 0.997 and 0.764 ppm, occur in water for only a period of hours after treatment. Existing information indicates that chum and coho juveniles are not present in the bay at the time of Sevin spraying (COE 1976, Phinney and Bucknell 1975, Simenstad 1983) but that young chinook may use the bay. Studies have not been conducted on salmonid use of the water over treated oyster tracts at the time of spraying. Chinook present over or near a treated tract would be only briefly exposed to Sevin at very low concentrations.

The only observed fish mortalities have been of small fish which were trapped in shallow pools by the outging tide and directly exposed to Sevin during treatment. Chambers (1970) conducted tests on oyster beds in Grays Harbor. Dead blennies, gobies, sculpins, and sticklebacks were commonly seen immediately after spraying. Small sole and flounder were less frequently killed. In addition, WDF regularly observes small numbers of dead staghorn sculpin, eelpout, and, on rare occasion, juvenile lingcod on treated oyster tracts. In 1984 over 200 young lingcod were found on a single sprayed tract in the Stony Point area of Willapa Bay (Northup 1985); they had been trapped in a tide pool on the outgoing tide. In previous years, lingcod were observed only occasionally and then in limited numbers

(less than 10 per tract). Because of their low frequency, fish mortalities have not been routinely recorded and the actual losses are unknown.

Tests have not been conducted on the toxicity of Sevin to the fish found in Willapa Bay or Grays Harbor. Observations, however, indicate that small fish trapped in tidepools and directly exposed to Sevin can be killed. Sculpins and other fish associated with shallow water areas are most likely to be exposed. While juvenile lingcod are only occasionaly observed on the beds, their presence indicates that they use the intertidal areas to some degree. That as many as 200 dead juvenile lingcod were killed on one tract in 1984 shows that this use may be extensive at times. The reason for this abundance is unknown. Juvenile lingcod feed primarily on small fish and epibenthic shrimp (Buckley et al. 1984). While stomach content analyses were not conducted on the lingcod observed in 1984, their presence may be due to feeding on the unusually abundant young-of-the-year crab.

No dead fish have been observed on the tide following treatment. The sensitivity of various fish to shrimp containing Sevin is unknown. It is also unknown which fish use the water over the beds and feed on dead shrimp or other organisms. To completely assess the impact of treatment, studies are needed to assess fish use of the areas during the treatment period and fish sensitivity to Sevin through direct contact and ingestion of killed organism.

Sevin treatments could indirectly affect juvenile salmonids, lingcod and other fish that feed on benthic invertebrates, if a significant portion of the available population were eliminated during critical periods. Many fish species in Willapa Bay prey on benthic crustaceans (Section 3.1.2.3). Bottom (1983) stated that total elimination of the amphipod Corophium in Tillamook Bay, Oregon, could be detrimental to chinook salmon. However, the effects of amphipod losses in smaller areas (such as those allowed for Sevin treatment in Willapa Bay) would likely be mitigated by amphipod migration, reproduction and recruitment (see Sections 4.2.2 and 4.2.2.1). Significant losses of amphipods or other fish prey are minimized under the existing Sevin spray program, by restrictions on the area that can be sprayed each year. Additional studies on the effects of treatment on prey organisms is needed.

In any one summer, a maximum of 0.8 percent of the total tidelands in Willapa Bay are treated because of the 300-acre limit set by WDF and EPA. Also, EPA guidelines limit treatment to less than 50 contiguous acres in the same area. In addition, timing of spraying is during the period of minimial abundance of juvenile salmon (especially chinook) which would be feeding on these small crustacea. Thus, the impacts to amphipod populations and to juvenile salmon through reduction of the food chain are minimized.

4.2.4. **Birds.** Birds may consume Sevin in the form of contaminated invertebrates and fish. According to several experimental studies, birds are relatively resistant to the effects of Sevin. The concentration of Sevin in feed required to cause 50 percent mortality (LD_{50}) over a 5-day period was 5,000 ppm for 2-week old mallards, pheasants, and bobwhite and coturnix quail (Pimental 1971). Tucker and Crabtree (1970) listed lethal

oral dosages for pigeons as 1,000 to 3,000 milligrams of Sevin per kilogram of bird body weight (mg/kg). Lethal dosages were listed by these authors for 2-month old coturnix quail as 2,290 mg/kg, for 3-month old mallards as 2,179 mg/kg, for adult Canada geese as 1,790 mg/kg, and for 3 to 12 month old sharp-tailed grouse as 780 to 1,700 mg/kg. Information was not found on Sevin toxicities for bird species normally found in the vicinity of treated oyster beds.

These studies have shown that birds exposed to high doses of Sevin do not accumulate the chemical or 1-naphthol in any tissues other than skin. After being dusted with four grams of five percent Sevin three times daily for four days, chickens had 19.3 ppm of Sevin in their skin (Johnson et al. 1983). This concentration fell to 2.15 ppm after seven days. Only trace amounts of Sevin were found in other tissues and none of the insecticide was found in any eggs produced by the dusted chickens. Feeding poultry large doses of Sevin produced the same results. Small amounts, in the range of parts per billion of Sevin residues, were detected in tissues and eggs only after oral doses of 1,000 to 2,500 mg/kg. These residues dropped to zero within 7 to 10 days (Kuhr and Dorough 1976).

Since relatively high doses of Sevin are required to produce mortalities in birds, they are not expected to experience significant impacts from Sevin use. For example, a 1 pound gull would have to eat 200 pounds of poisoned shrimp to attain a 1,000 mg. dose of Sevin. Tufts (1980c) and other WDF biologists frequently observe gulls, curlews, plovers, and turnstones feeding on recently sprayed tracts. Distressed birds have not been observed during any treatment.

A source of indirect effects on estuarine birds could be a reduction of prey resources and loss of feeding habitat. This impact is identical to the situation with fish (Section 4.2.3). Significant losses of bird prey resources are unlikely under the present Sevin treatment program, because of the limited area treated each year and the relatively low abundance of birds during this time.

4.2.5. **Mammals.** The effects of Sevin on marine mammals has not been determined. However, since Sevin is used extensively on agricultural lands, numerous tests have been performed on terrestrial mammals.

The results of Sevin intake by mammals appears to be related to animal size and whether the particular species can metabolize or chemically alter Sevin. Claborn et al. (1963) studied residue levels in fat, brain, liver, kidney, heart, and muscle of cattle, sheep, goats, and hogs fed or sprayed with Sevin. No lethal or sublethal effects were seen from spraying twice a week for 2 weeks or from feeding Sevin contaminated food for 27 days. Insignificant Sevin residues were found after spraying and none after feeding. In guinea pigs and rats, 85 percent of radioactively labeled Sevin administered to the animals was recovered in urine within 24 hours (Menzie 1969). Rat livers are capable of degrading Sevin to 1-naphthol and water-soluble metabolites. The 50 percent mortality rate for mule deer was 200 to 400 mg/kg of body weight when the animals were given dosages orally in capsule form (Tucker and Crabtree 1970).

The results of chronic exposure to Sevin were studied by Carpenter et al. (1961) on rats and dogs. Rats fed for two years on a diet containing 200 ppm of carbaryl did not show significant deviations from controls. Rats fed 400 ppm had weight depression and some pathological changes in kidneys and livers. Dogs in a one year study tolerated 400 ppm in their diet. A 250 mg/kg dose showed no adverse physiological response in these dogs. However, dogs given 375 and 500 mg/kg orally showed clinical signs of toxicity.

A Sevin application of two pounds per acre to a grassland delayed cotton rat reproduction causing a reduced population (Barrett 1968). In laboratory tests by Barett (1968), Sevin was given orally at 1.1 milligrams per day per individual for 10 days to cotton rats weighing from 140 to 150 grams. The number of litters and the number of females giving birth were reduced 50 percent. In the same field study, there appeared to be no effects on either the house mouse or the old-field mouse population.

Mammals are not expected to frequent the mud flat spray areas of Willapa Bay and Grays Harbor immediately following treatment. If they did, the high dosages required to produce even sub-lethal effects should not be encountered during initial spraying. It would probably be difficult for a marine mammal to accumulate sub-lethal doses by feeding on sprayed organisms.

4.2.6. **Effects on Humans.** The effects of Sevin on workers in Sevin production factories and on volunteers have been studied. In human volunteers given daily oral doses of 0.06 and 0.13 mg/kg of body weight, no electroencephalograph (EEG) changes were noted. However, a slight increase in individual clinical abnormalities, such as cramps, were observed in the high dose group (Wills et al. 1968). The studies conducted on Sevin factory workers concluded that solid formulations of Sevin (dust and wettable powder) were poorly absorbed. These workers were exposed at a rate of 73.9 milligrams per hour (mg/hr) and 59.0 mg/hr dermally (for formulating workers and sprayers respectively), and 1.1 mg/hr and 0.09 mg/hr through respiration (Comer et al. 1975).

Few instances of fatal poisoning have been documented. In a report by Farago (1969), the death of a man exposed to Sevin was attributed to a negative response to 2-PAM therapy (subsequently prohibited). Kuhr and Dorough (1976) reported an incident in which a 19-month-old child died; a dosage was not given.

The potential carcinogenic effects of Sevin are of concern, especially in light of the known effects of other modern chemical compounds. Conclusive evidence of cancer as a direct result of Sevin exposure has not been documented for humans. However; nitrosocarbaryl is known to form in the stomach in the presence of nitrite and carbaryl; it is a carcinogen (Mount and Oehme 1981).

The hazards to humans from sprayed Sevin and other insecticides were assessed in detail in an environmental impact statement on gypsy moth suppression and eradication prepared by the U.S. Department of Agriculture (1985). Various literature sources reviewed in this EIS indicated that

Sevin's potential for causing birth defects, inheritable defects, or cancer was very low; for cancer the risk was one chance in a million.

Effects on humans, if any, from use of Sevin in Willapa Bay and Grays Harbor would probably result from consumption of organisms exposed to Sevin or through skin contact during handling of the insecticide. However, no effects are expected since sprayed areas are not open to recreational shellfishing. Also, the rapid breakdown of Sevin and the relatively long period (three years) before harvest of oysters from sprayed beds precludes human ingestion of Sevin.

4.2.7. **Effects on Food Webs.** All Willapa Bay and Grays Harbor biological resources and their human users are interdependent through estuarine and ocean food webs. Indirect effects on all components of these food webs can be generated through significant, direct impacts on single principal parts. Thus, the use of Sevin on ghost and mud shrimp could theoretically impact fish, bird, mammal, and human users (consumptive and non-consumptive) of these resources.

Sevin is not accumulated by any food web component or transmitted to higher levels in the food chains. After hydrolization to 1-naphthol, Sevin apparently continues to break down, eventually leaving only carbon dioxide, water, and, possibly, methane (Karinen et al. 1967). No chemically active radical group remains to contaminate the estuarine environment.

The 300 acres of maximum treatable area in Willapa Bay represents about ten percent of the intertidal ground under cultivation for oysters and only 0.8 percent of the total tidelands in the Bay. In Grays Harbor, the 100 acres allowed for spraying is only 0.3 percent of the total tidelands in the bay. While localized disruptions may occur, the use of Sevin by the commercial oyster industry is not expected to cause significant impacts on the estuarine ecosystem when applied at current levels.

4.2.8. **Economic Effects.** Beneficial impacts accrue as the result of oyster culture on treated beds. The southwest Washington oyster industry annually produces a crop worth over $7 million. Much of this is spent in the local economy and directly supports over 400 jobs.

It is unknown to what extent the oyster culture industry would decline if burrowing shrimp control ceased. The major oyster grower has stated that he would cease operations without the Sevin program. The growers estimate that 75 to 80 percent of the culture grounds would be unusable for oyster culture without treatment. While this estimate has not been confirmed, it may be used to present a worst case scenario for the effect of disallowing burrowing shrimp control. It should be noted, however, that the productivity of the beds is directly related to the profitability of oyster culture. Reductions in productivity will reduce the profit to the grower until, at some point, production is no longer economically feasible. It is unknown at what point raising oysters is no longer profitable.

If the burrowing shrimp control program ended, the oyster industry would not cease completely. Traditional culture may be feasible in a few

areas. In addition, alternative methods would likely develop (e.g., raft and stake culture). These alternative methods, however, may create greater environmental impacts than the Sevin program. These methods are more expensive than on-bottom methods and produce an oyster which is not always suitable for the major markets. Development of these methods may lag behind the decline in the current industry, resulting in a period of lost income and employment. It would probably take 10 to 20 years for the industry to be fully affected by termination of the Sevin treatment program.

Once an oyster bed is closed, it may not be to resume oyster culture as new control and culture methods develop. The influential oyster industry has been a major protector of water quality near the culture areas. Without the industry pollution from upland development would likely increase. Once the areas were polluted, it is very unlikely that oyster culture or other shellfish culture could be resumed. Consequently, any cessation of oyster culture is likely to be permanent.

It is impossible to predict the full effects of ending the treatment program. On average, 207 acres require treatment each year to maintain the industry at the current levels. Based on average production per acre, the area treated annually produces about $500,000 each year. An 80 percent reduction in the industry would eventually cause an annual loss of $5 million and over 300 jobs. Up to 2,000 jobs may be affected indirectly.

Specific examples of the burrowing shrimp's effect on oyster production are limited. In 1957, a 14-acre oyster tract could not be cultured due to shrimp infestations. In 1971 this bed was treated with Sevin and in 1972 it was replanted with oysters. A second crop planted in 1976 produced 24,000 gallons of oyster meat in 1979 (worth $460,000 at current prices). Tufts (1980a) estimated that, without treatment, only 7,200 gallons of oysters would have been produced; the cost of production then would have exceeded the income.

Another example occurred in Grays Harbor in 1984 where 81 acres were planted with oysters in the spring. By the time the beds were treated in August, 43 percent of the seed had been killed by the effects of burrowing shrimp. The grower estimated that this represented a lost harvest of almost $330,000. The same grower states that they will be unable to plant 100,000 to 150,000 gallons of seed in 1985, because the Grays Harbor spraying was curtailed in 1984 to protect young crab. This seed represents a harvest worth about $1.2 to $1.9 million.

5.0 MEASURES TO MITIGATE ADVERSE IMPACTS

5.1. REQUIRED MEASURES

To minimize impacts to crab and the environment, WDF has developed a series of procedures to assess the beds proposed for treatment, to control treatment, and to assess the impacts. These procedures are presented in Section 2.3.

5.2. ADDITIONAL MITIGATION MEASURES

The following measures have been suggested to further reduce impacts on the environment:

1. More intensive surveying of crab populations near the tracts before spraying may allow treatment to be rescheduled when the abundance of susceptible crab is high.

2. Known Dungeness crab populations may be drawn away from potential spray areas by baiting prior to spraying. Studies on this measure were conducted in conjunction with the 1984 Sevin treatments and are described by Hurlburt (1985) (see Appendix G).

3. Reduce the concentration of Sevin sprayed from 10 pounds per acre of active carbaryl. Such studies are being conducted by WDF to determine their feasibility.

6.0 UNAVOIDABLE ADVERSE IMPACTS

The following unavoidable adverse impacts are expected:

1. Loss of biota (mainly crustaceans and finfish) will occur on each tract sprayed. The magnitude of the loss will depend on the faunal composition and numbers at the time of spraying, and the numbers of Dungeness crab able to move in from adjacent areas to feed on poisoned shrimp. Severe losses will be incurred by the target species, ghost and mud shrimp. Incidental losses that may be significant locally may occur among other invertebrates, including polychaete worms and bivalves, and possibly among fish, such as lingcod and sculpins. These effects are limited to the treated beds and do not significantly affect the overall biota of the estuary.

2. The diversity of organisms is temporarily reduced as a result of spraying. The long-term impact, however, may be to increase overall diversity and abundance.

3. For some birds and fish, productivity of foraging areas on the tracts may be temporarily reduced. Sprayed tracts are expected to support increased numbers of prey species within less than one year.

7.0 ALTERNATIVES TO THE PROPOSAL

7.1. MECHANICAL CONTROL

In mechanical control, harrows, rollers, or other equipment turn or compact the substrate. The bottom sediments are "tilled" or compacted to disrupt or kill burrowing shrimp. Tilling would be nonselective and large quantities of desirable aquatic animals and food resources could be destroyed. The bottom sediments would be severely disrupted which could affect most benthic organisms and demersal fish. Also, substantial increases in turbidity may occur in water standing on the flat and in the incoming tidal water, which could affect fish trapped in tidal pools and other fauna. Growers who have tried mechanical control methods say that the physical disturbance seems to stimulate burrowing shrimp population into increased activity (L. Weigardt 1984). This may be a result of the softening that results from plowing or from the response of surviving shrimp to burrow damage.

Rolling would compact the intertidal sediments probably destroying all benthic organisms. In addition, this mechanical action probably would cause fine sediment (fine sand, silt and clay) to surface increasing the turbidity in associated water. Also, rolling probably forms a hard, compact bed composed of well sorted sand. This substrate probably would support little or no vegetation (L. Weigardt 1985). Oyster grower L. Weigardt attempted in 1957 to treat burrowing shrimp infested oyster beds by rolling. According to this grower, the equipment and labor involved in the process cost $85,000 in 1957 dollars (the area treated was not reported).

7.2. SURFACING BEDS

Plastic sheeting could be used as a surface covering over infested beds to suffocate burrowing shrimp. The sheeting would be weighted and would remain in place over a period of days. This process could be very expensive in materials and labor. Also, some loss of plastic could be expected which would form a long lasting pollutant. In addition, such action would be non-selective and probably kill all benthic plants and animals. Substantial increases in hydrogen sulphide concentrations may be expected.

7.3. OTHER INSECTICIDES

An alternate insecticide could be used to control burrowing shrimp. A number of different chemical methods for burrowing shrimp control were assessed before Sevin was adopted. Among the substances tested were

Polystream, orthodichlorobenzene (1,2-dichlorobenzene), Lindane (Hexachlorocyclohexane), and furnace oil (Lindsay 1961, Haydock 1963, Havert et al. 1966). The first three are chlorinated hydrocarbons which are now known to have long-term residual toxicity to a wide range of organsims (Ware 1983). Furnace oil also would have extensive adverse effects including tainting adult oysters and poisoning a wide range of other species. The tests found that the effectiveness of all these substances was enhanced by the addition of Sevin. It was found that Sevin was at least as effective as more hazardous chemicals (Chambers 1970, Westley 1970). Since the initial screening of chemical control methods in the 1960's, no new chemicals have been tested in Willapa Bay. Literature reviews of new chemicals proposed as alternatives have indicated a probable increase in both adverse impact and persistence.

7.4. ALTERNATIVE GROWING METHODS

Several alternate approaches are available for oyster culture. Many of these are described by Bardach et al. (1972). A shift to these suspended culture methods generally produce an oyster which is not compatible with the established, national market. The only known method that probably would not be affected by burrowing shrimp is raft culture, where oyster shell is suspended on ropes supported by a floating raft or buoys. This approach requires a large, protected water body that does not support other uses such as fishing or recreational boating. In addition, raft culture cannot be conducted on intertidal grounds, which are the property owned by the growers. This approach probably would not be suitable or acceptable for Willapa Bay because of the large number of rafts or buoyed lines that would be required to support the amount of oysters that are presently grown on intertidal flats. This off-bottom culture would probably occupy most of the subtidal area of the bay. Also, much of the water surface would not be usable because storms could cause extensive losses to floating structures left in exposed parts of the bay.

A number of culture methods suspend oysters on off-bottom lines or racks supported by stakes or poles driven into the mud. These are used to a limited extent in Puget Sound and Grays Harbor and some growers are testing these approaches in Willapa Bay. While these methods support oysters above the mud, they are still susceptible to burrowing shrimp activities. A grower in Grays Harbor has found he must place stakes closer together to support the lines containing oysters as burrowing shrimp populations increase. He must also use longer and longer stakes. Eventually a point is reached where the area is not usable because it is not cost-effective to maintain the long-line system on the softer bottom (B. Engvall 1984).

It is likely that these alternative methods are applicable for limited production in some areas and situations in Grays Harbor and Willapa Bay. However, in order to maintain the large production described in Section 3.1.3.2, on-bottom or bed culture appears to be the only practical approach.

7.5. NO ACTION

If no measures were taken to control the infestation of oyster beds by ghost and mud shrimp, the shrimp population would probably spread, causing severe economic hardship to the oyster growers and associated human communities. Studies on conditions in Willapa Bay and Grays Harbor where oysters are not grown, but burrowing shrimp are present, have not been conducted.

7.6. POSTPONE ACTION

It is not fully known what the consequences of reducing or discontinuing the present treatment program would be to the ecosystem. Impacts to both target and nontarget organisms would be reduced. The burrowing shrimp infestation would spread. The reason for postponing ghost shrimp control action would be to wait until a totally acceptable control method was developed or additional studies could be completed.

8.0 INFORMATION NEEDS

As noted in several places in this EIS, additional information is required to completely assess the impacts from burrowing shrimp control through use of Sevin. The most notable data gap is the lack of information on the biology of burrowing shrimp and of the benthic community associated with oyster culture and shrimp infestations in Willapa Bay and Grays Harbor. In addition to this specific problem, a number of other important areas need extensive study. WDF, WDOE, and the program proponents are preparing study plans to answer the questions defined in this EIS. The following list summarizes the data gaps. Each topic listed includes the EIS section where the particular information need is discussed more fully:

- Biology of burrowing shrimp and oyster dominated communities, including ecological controlling factors such as predation (Sections 3.1.2.2.2 and 3.1.2.3);
- Fate of Sevin and its hydrolytic products in estuarine water and sediment and their distribution (Section 4.1);
- Direct toxicity (through contact and ingestion) of Sevin to invertebrates and fish associated with treated oyster tracts (Sections 4.2.2 and 4.2.3);
- Indirect effects of the control program through disruptions in the estuarine food web and habitats (Sections 3.1.2.2, 3.1.2.3, 4.2.2.1, and 4.2.7);
- Mitigation measures including reduced Sevin concentrations, seasonal timing, application methods, need and impact assessment, and chumming (Section 5.0, Appendix G).

- Use of oyster beds and adjacent intertidal habitats by birds and fish, especially salmon, lingcod, and juvenile flatfish. These studies should identify what species are on the beds and are exposed to Sevin, and what they are doing onthe beds (Sections 3.1.2.3, 3.1.2.4, 3.2.2.3, 3.2.2.4, 4.2.3, and 4.2.4.).

- The uptake of Sevin by benthic invertebrates and their consumers and the length of time that their carcasses remain toxic.

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10. WRITTEN COMMENTS

This section contains comment letters on the draft EIS. We sincerely thank those agencies and individuals who responded; these letters and statements reflect time and effort on their part. These letters express views on both sides of the issue. Responses follow each comment letter and are keyed to numbers in the letter.

In response to these comments and to new information obtained since the DEIS was issued, we have made extensive revisions in the EIS. When a comment warranted a revision, the response to the letter references the appropriate section of the EIS.

CITY OF HOQUIAM
HOQUIAM, WASHINGTON
98550

OFFICE OF THE FINANCE DIRECTOR
JOANN STOVER

July 3, 1984

RECEIVED
JUL 10 1984
SHELLFISH ADMINISTRATION

Mr. Duane Phinney, Chief
Habitat Management Division
State of Washington
Department of Fisheries
Mail Stop AX-11
Olympia, Washington 98504

SUBJECT: SEVIN TREATMENT OF OYSTER BEDS/WILLAPA BAY/GRAYS HARBOR

(1) In response to your draft environmental impact statement for control of ghost and mud shrimp on privately-owned oyster beds in Willapa Bay and Grays Harbor, and your request for comment on same, the City Council of the City of Hoquiam, at their regular meeting held Monday, July 2, 1984, made the decision to reply negatively. Thank you very much for the information you submitted.

Joann Stover
Finance Director

JS:sl

Response to the City of Hoquiam.

1. Comment acknowledged.

Spec from: Pesticides F Copy: DNR

Department of Natural Resources
OLYMPIA, WASHINGTON
98504

BRIAN BOYLE
Commissioner of Public Lands

SHL CULT
HAB MGMT DP

July 30, 1984

CODED
AUG 1 1984
MARINE FILES

Duane Phinney
Chief-Habitat Management Division
Department of Fisheries
AX-11
Olympia, WA 98504

Dear Mr. Phinney:

The Department has the following comments on the Draft EIS on the use of SEVIN in Willapa Bay and Grays Harbor.

(1) The Section on birds fails to discuss the impact of sublethal doses that may be stored in body fat. Upon migration this fat would be mobilized causing bird mortality.

Otherwise this document appears complete and well written.

Sincerely,

David Jamison
Director
Marine Research and Development Center

pl

cc: Dan Barth
File

Dep
cc: Hurlburt ✓
Zelo

Response to David Jamison, Washington Department of Natural Resources.

1. Sevin is not known to accumulate in the body fat of birds or other animals. Revised Section 4.2.4 contains information on bioaccumulation of Sevin in relation to exposure by birds.

JOHN SPELLMAN
Governor

cc: Hurlburt

IAN TVETEN
Director

STATE OF WASHINGTON

WASHINGTON STATE PARKS AND RECREATION COMMISSION

7150 Cleanwater Lane, KY-11 • Olympia, Washington 98504 • (206) 753-5755

July 25, 1984

HABITAT MANAGEMENT

TO: Duane Phinney
Chief, Habitat Management Division - Fisheries

FROM: David W. Heiser, E.P.
Chief, Environmental Coordination

SUBJECT: 35-2650-1820 (E-2683)
DEIS - Use of the Insecticide SEVIN
to Control Ghost and Mud Shrimp in
Oyster Beds of Willapa Bay and Grays Harbor,
Leadbetter Point State Park and Others

Thank you for the opportunity to review and comment on this Environmental Impact Statement.

Our concerns relate to the impact upon recreational activities of Willipa Bay and Grays Harbor and any possible adverse effects upon non-target species. You have indicated some small crabs are poisoned in the treatment process and that the material is applied during July and August, the "...periods of lowest fish and shellfish abundance." While this may be true, it is also true there are often large numbers of recreationists out using the resources during summer vacation periods.

(1) Certainly, it would seem appropriate to make sure that the recreating public is aware of the treatment program and the duration of area closure. The area to be treated at Stackpole Harbor is directly in front of the east side of Leadbetter Point State Park. It might be wise to post information signs at key access sites so that visiting members of the public will be aware of the program.

(2) Finally, I am concerned by comments in the cover letter which indicated that the spray program might be undertaken while the EIS was in process because this was "an emergency". If the program has not already begun, I would ask that you contact the park manager at Fort Canby State Park, who manages the Long Beach Peninsula area park lands. He can be reached at (206) 642-3334.

Thank you for the opportunity to provide comments on your program.

at

cc: Dennis Lundblad, Department of Ecology
Fort Canby State Park Manager

Response to the Washington State Parks and Recreation Commission.

1. The areas that are treated with Sevin in the vicinity of the Leadbetter Point State Park are well offshore and clearly marked with no trespassing signs. In addition, all oyster ground in Willapa Bay is privately owned or leased and trespassers are often actively prosecuted.

2. This letter was received after spraying had been completed in the referenced area.

Spec Permit: Pesticides & PR: Assoc & Clubs

FRIENDS OF THE EARTH

2 August 1984

SAL CULT
HAB MGMT DP

AUG 03 1984
CENTRAL FILES

Mr. Duane Phinney
Chief-Habitat Management Division
Department of Fisheries
Mail Stop AX-11
Olympia, Washington 98504

We have recieved a copy of the to the Draft Environmental Impact Statement concerning the use of the insecticide Sevin to control Ghost and Mud shrimp in oyster beds in Willapa Bay and Gray's Harbor. The following are the comments of the Northwest office of Friends of the Earth.

General Comments

There are several major problems with this EIS. The writing is poor, and the statement is also hampered by a lack of lack of information on key subjects, incomplete data, and erroneous conclusions drawn from the evidence presented.

More Specific Comments Are as Follows:

1 On page 3 it cites Figures 1 and 2 showing where oysters are grown and where Sevin has been used and is proposed for use in Willapa and Grays Harbor. This is incorrect. Figure 1 does not show proposed 1984 treatment areas. We requst that Figure 1 be redrawn adding this information. We find no information in the text describing any site specific areas or possible impacts in the EIS. In particular we fail to understand why a proposed treatment site is shown east of Ocean Shores in Grays Harbor, far removed from any indicated commerical clam & oyster beds. We request that the EIS be rewritten to examine in detail each individual spray tract and provide specific species usage for each. In addition, since an emergency permit has been granted which, in effect, allows the proposed action to proceed for 1984 in the absence of an EIS, all data generated by the 1984 "emergency" spraying effort should be incorporated in a new draft EIS.

2

3

4 On page 9, it is stated that the relationship between channels, shallower connecting sloughs, and the tidal flats is highly dynamic. This is not taken into account in the rest of the EIS. Upon the incoming tide, the insecticide will be picked up and dispersed, by the dynamic forces present, and there is no realistic way of predicting where it will go, or what species will be placed into contact with it.

Northwest office 4512 University Way NE Seattle, Washington 98105 (206) 633-1661

2 August 1984
Mr. Duane Phinney
Dept. of Fisheries

This combined with the fact that the bay will take over two tidal cycles to completely flush means that there will be several hundred pounds of Carbaryl and 1-naphthol in the waters of the bay for twenty-four hours. In what way will the bay's flushing rate influence the persistance and spread of Sevin?

5 On page 11 there is a discussion of turbidity. What are the parameters of JTU's, (Jackson Turbidity Units), and what does this have to do with the use of Sevin? Without knowing what a JTU means, it is not possible to make any use of this information.

6 On page 13, paragraph three, the EIS states that in the typical sediments on oyster beds, " the percentage of organic compounds, volatile solids, is low." What does this mean? Is this going to be affected by the spraying of Sevin? Will this influence the rate at which Sevin is absorbed or decomposed in the sediments? Again, this is information which is useless as presented, and ignored in the rest of the EIS.

7 On page 20, in the section dealing with salmonids, and their presence in the bay, it can be seen that Chinook occur in all three phases listed, (juvenile migration, residence in the bay, adult migration) during July and August, (the months of spraying). Coho reside in the bay during these times, as do Chum, and Sea Run Cutthroat reside in the bay, and also have adult migrations at these times. Given these facts, as well as the statement that salmonids are the fish most sensitive to Sevin, how can the conclusion be drawn that "It is unlikely that significant impacts will result to salmonids of any age group from the use of Sevin,"? Especially considering the bays rates of flushing.

8 Also, the silver smelt spawn on coarse sandy beaches near Tokeland for "most months of the year." Which months do they spawn, and where are these beaches more specifically?

9 The EIS lists seven areas of major biological significance within Willapa Bay. It is obviously an environmentally important bay, and the use of Sevin could have long-term negative effects on the wildlife in and around the bay. In what ways will these AMBS be affected, and what is being done to protect these areas?

10 In the section dealing with Gray's Harbor, the EIS states, page 28, "the overall water quality of Gray's Harbor is seriously affected by the estuary's declining capacity to assimilate wastes." If there is a problem with water quality, municipal and industrial discharges, is it wise to further pollute the estuary with Sevin? What are the possible synergistic effects of municipal and industrial wastes and Sevin?

11 In the discussion of bird populations, (page 29), the EIS states that in the summer season, no comprehensive counts have been performed. Isn't this important information if effects on birds are to be determined?

67

2 August 1984
Mr. Duane Phinney
Dept. of Fisheries

Another factor to be considered, is the possible effects of Sevin use on waterfowl and other birds. On pages 30 & 31, amphipods are listed as 92.6% of a group of mallards' prey items, and as the most important food item for dunlin and western sandpipers, as well as very important for long-billed dowitches, sanderlings and least sandpipers. Are there any studies or sightings of birds feeding in recently sprayed areas? (12)

The pupping season for harbor seals falls within the spraying period, and this poses a threat to these creatures. Also, peregrine falcons, an endangered species, could be threatened through the consumption of shorebirds which have been feeding on poisoned or contaminated amphipods, molluscs, polychaete worms, arthropods and crustaceans, all of which are adversely affected by Carbaryl. Have there ever been any studies done on peregrine feeding habits or buildup of Sevin in the prey birds? (13)

In the discussions of the food webs in the estuaries, certain questions shoul be answered. What are the effects of Carbaryl on photoplankton and zooplankton? This would seem to be very important, as the food web rests on these tiny creatures.The entire EIS seems to avoid looking at the ecosystem effects. While there may not be any noticable disasterous effects from the sprayings, in thirty years or so, could not the spraying completely change or destroy the ecosystems of the estuaries? The EIS looks at only one year, and the effects of one spraying. What are the cumulative effects of the introduction of Sevin into the estuarine environment several times per year, over an extended period of time? (14)

As for Carbaryl, and the section on Impacts of Sevin, the EIS has several inaccuracies and more incomplete information. On page 37, the decomposition of Carbaryl is discussed. The EIS fails to identify what the final decomposition products are. "Possibly methane," is a meaningless phrase, as it could also possibly be DDT, PCB's, or cyanide. How can a chemical even be considered for use when its hydrolytic products are unknown? What are the products of Carbaryl decomposition? (15)

The data used is contradictory to that found in the literature, both in terms of persistance and toxicity levels. The EIS states that the experiments by Sayce(1970) found that Sevin concentrations were only 5.5% of the initial concentration after four days, and that 1-naphthol was less than 1 ppm after eight days. (16)

A study done by NOAA, "Estuary Use of Sevin", found that 2.2 ppm were present after eight days, and 0.1 ppm after four days, in the sediments. This eight day quantity would be lethal to 50% of the following species: Coho salmon, amphipods, Dungeness crabs and there larvae, and numerous other creatures. Also this level will have impacts on the growth and feeding of Gaper, bent-nosed, and cockle clams. All of these will suffer from the rate given by the EIS also. The EIS is also very confusing at this point, (page

2 August 1984
Mr. Duane Phinney
Dept. of Fisheries

38), as it switches from pounds/acre, to percent, and finally to parts per million. This is either poor writing, or a weak attempt to confuse the reader and distort the data.

On page 42, the conclusion drawn from table 8 is completely erroneous. Study plot 1, which had never recieved Sevin treatment, had the highest number of both species and organisms. Thus, the conclusion that Sevin use is a necessary element in the estuarine ecosystem can not be supported. (17)

What are the data for the number of crabs killed by the sprayings in the last five years? Also, in what way would placing baits outside of the spray area prevent the crabs from eating poisoned and dead shrimp? (18)

Human health effects from exposure to Carbaryl are also understated. Carbaryl has been shown to cause birth defects in beagle dogs, rabbits, and Guinea pigs. It has been shown to cause spontaneous abortions in Rhesus monkeys at low doses. It has been found to cause mutations in mammalian cells and bacteria, and it is a borderline carcinogen. It has also been shown to increase sperm cell abnormalities in workers exposed to Carbaryl. This data suggests that Sevin presents a risk to humans and other mammals. (19)

The EIS also reports, page 47, that Carbaryl combines with nitrites, found in all cured meats and in our own body chemistry, to form a strong carcinogen. This is another danger to humans which should be considered.

Conclusions and Recommendations

For these reasons, Sevin should not be used in the estuaries of Gray's Harbor and Willapa Bay. The EIS fails to address the site specific impacts of the proposed action and does not comply with the SEPA regs. The alternatives presented deserve more than a paragraph each. How is it possible to make any intelligent decision or analysis if the other alternatives are not described in as much detail as the proposed action? Please consider alternatives to the use of Sevin which provide greater protection for the Willipa Bay and Grays Harbor Estuary ecosystems. (20)

Thank you for the opportunity to comment on this draft EIS.

Sincerely,

Bradford C. Miller
Research Assistant

Response to Bradford C. Miller, Friends of the Earth

1. Figures 1 and 2 have been corrected.

2. This EIS is for the burrowing shrimp control program rather than for a single application of Sevin. The number and locations of individual tracts proposed for treatment vary each year (See Appendix A and Figs. 1 and 2).

Each oyster or razor clam tract is inspected prior to pest control permit approval, before spraying, and again immediately after Sevin application. During these inspections, general conditions and the number of burrowing shrimp are noted, but specific conditions and species usage are not recorded. At this time, quantitative site specific information is not available from any oyster growing tract.

Areas east of Ocean Shores are used for oyster culture and the map has been corrected to show this.

3. Results of studies conducted during the 1984 Sevin treatments have been used to extensively revise the DEIS. Complete details on the 1984 treatments are presented in a WDF Progress Report by Hurlburt (1985). The Executive Summary of this report is included in the FEIS as Appendix H. The WDF and WDOE do not feel that circulation of another, revised DEIS is appropriate.

4. Section 4.1, on the chemical action of Sevin in the presence of estuarine water and mud, has been clarified and revised. Willapa Bay tides disperse and dilute Sevin and flush it from the bay. In addition, Sevin in seawater has been shown by laboratory and field testing to decompose rapidly, dropping to concentrations of less than 0.1 ppm in as little as 15 minutes and, at most, within a few hours.

5. The abbreviation JTU stands for Jackson Turbidity Unit. It is a common measure of turbidity in water and is the accepted by EPA and WDOE. The information on natural turbidity levels in Willapa Bay is presented as background because suspended sediment, biota, and other water quality factors influence degradation rates of Sevin as explained in Section 4.1.

6. This information is provided to describe the oyster bed environment. When Sevin is sprayed on an oyster bed, it is adsorbed onto sediments which are organically rich and biologically active. The effect of different substrates on Sevin decompostion has not been studied.

7. Section 4.2.3. on the potential impacts to finfish has been expanded and revised. Insufficient information is available with which to totally assess the effects of Sevin treatments on juvenile salmonids, lingcod, or flatfish.

8. The information on surf smelt spawning was reported by the US COE (1976). The WDF has not been able to confirm this observation in its records. Section 3.1.2.3 has been revised.

9. The AMBS were established by WDOE in 1981 to describe biologically important areas in Washington State marine waters, and to aid planning decisions. They are listed in this EIS as part of the descriptive process necessary to properly assess the potential impacts of the Sevin treatment program. The organisms within these AMBS would be subject to the impacts described in Section 4.2. No agency takes specific action to protect these areas.

10. As explained in the revised Section 4.1 of the EIS, Sevin degrades rapidly and completely in estuarine waters. Thus, pollution of these waters probably would not occur from Sevin use as described in the EIS.

Synergistic effects are unlikely since other pollutants are not present over the oyster flats. Also, Sevin and its degradation products would probably be diluted and broken down enough to prevent synergistic action by the time they could contact the polluted areas in the upper harbor.

11. Based on the literature, no toxic effects are expected in birds. However, food organisms on the sprayed beds may be temporarily reduced. Little is known about bird use of oyster beds in relation to Sevin treatments. Additional information would be useful to fully assess if any affects on estuarine bird populations occur.

12. Section 4.2.4, on the effects of Sevin treatment on birds, has been expanded and revised. At this time, there are no known quantitative records or studies of birds feeding on treated or untreated oyster beds. Quantitative studies on the effects of Sevin spraying on bird prey items have not been conducted (Section 4.2.2). The sightings of birds on treated oyster beds referred to in Section 4.2.4 were qualitative assessments, without determinations of numbers or feeding behavior.

13. The information presented in Section 4.2.5 indicates that Sevin is not a threat to any warm-blooded mammal, young or adult. Also, any Sevin or 1-naphthol that could be contacted by harbor seals would likely be diluted to concentrations far less than 1 ppm (see Section 4.1) and would be decomposing into even less toxic compounds.

14. The effects of carbaryl on phytoplankton are discussed in the revised Section 4.2.1. Similar studies have not been done on zooplankton except on the larvae of commercially important shellfish. Zooplankton in the tidal water initially contacting sprayed oyster beds could experience some mortalities. These probably would be limited in extent because of the relatively small area that is sprayed at any one location and the rapid degradation of Sevin to non-toxic levels in seawater (Section 4.1).

The EIS examines effects on individual organisms at all levels of the estuarine trophic web and assesses the impacts on benthic communities and marine food chains. Information for assessing overall effects on the ecosystem level is not available. General information needs are discussed in Section 8.0.

15. Cited literature in Sections 4.1 and 4.2 indicates that decomposition of Sevin is complete to water, carbon dioxide, and nitrogen. Only one source, Karinen et al. (1967) stated that methane could be an end product. Because of its chemical structure, it is not possible for Sevin to change into DDT, PCB, or cyanide.

16. Section 4.1 has been revised and clarified. Section 4.2 on impacts to various organisms has also been revised.

Most of the discrepancies between studies reported in this EIS and in the NOAA review are probably due to differences in test conditions, especially temperature.

17. This information on recolonization was found to be inconclusive; it is discussed in revised Section 4.2.2.1.

18. Data for crab kills since 1976 are presented in the revised Section 4.2.2.2.

Chumming or baiting outside the tract perimeter appears to attract crab that may otherwise move into the sprayed area to feed on poisoned animals. During the time these crab remain at the bait, the Sevin has a chance to decompose or be diluted and dispersed to less toxic levels. Chumming is discussed in the WDF Progress Report by Hurlburt (1985); the Executive Summary of this report is included in this EIS as Appendix H.

19. Section 4.2.6 on human health effects has been revised with new information from an EIS on gypsy moth control. Exposure of humans to significant amounts of Sevin could occur only during spraying. These activities are controlled by both the oyster growers and WDF, and contact with Sevin is not expected. Also, the studies cited in Section 4.2.6 indicate that prolonged exposure to relatively large dosages of carbaryl is necessary to induce animal birth defects. Sevin probably is not ingested orally during or after spraying, making the combination of carbaryl with nitrites unlikely.

20. Section 7.0 on Alternatives has been revised and expanded. Sufficient information is not available on the listed alternatives to discuss them in as much detail as the existing Sevin treatment program. The mechanical and chemical alternatives were investigated before the advent of SEPA and full details on their effects and feasibility are unavailable. Because the expected impacts from many of the alternatives were more severe than those caused by Sevin, no additional studies were conducted on them. Studies are planned for several of the alternatives, including reduced concentrations and baiting.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
847 NE 19th AVENUE SUITE 350
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August 3, 1984 F/NWR5

Mr. Duane Phinney, Chief
Habitat Management Division
Washington Department of Fisheries
Mail Stop AX-11
Olympia, Washington 98504

Dear Mr. Phinney:

We have reviewed the Draft Environmental Impact Statement (DEIS) "Use of the Insecticide SEVIN to Control Ghost and Mud Shrimp in Oyster Beds of Willapa Bay and Grays Harbor" from the Department of Ecology and Department of Fisheries.

We hope you will accept our comments as constructive recommendations intended to improve the quality of the final EIS and contribute to a reduction or resolution of the conflict between shrimp and oyster growers. This problem is a particularly difficult one for fisheries managers having responsibilities for both the protection of fisheries habitat and the promotion of aquaculture. The application of a poison to public waterways for the benefit of private industry raises serious questions regarding the protection of public trust resources and public versus private costs and benefits. It is ironic that the industry in question is an aquaculture industry which historically has suffered hardships due to other kinds of estuary degradation, namely sewage introduced into public waters. (1)

The issue of spraying pesticide onto estuary tideflats raises the following policy questions relative to aquaculture in public waters.

1. To what extent should aquaculture be allowed to adversely affect other public trust resources?
2. Is aquaculture which is severely disruptive of the natural environment compatible with multiple-use management of estuaries?
3. Do we have sufficient information to judge whether public benefits from this private industry outweigh public losses?

There is little question, based upon laboratory and field studies of its toxicity, that SEVIN sprayed onto tideflats causes massive mortalities. Mortalities necessarily result in changes in species diversity, abundance and natural productivity. What has never been carried out, to our knowledge, is a quantitative assessment of the resultant community changes and their longevity. Apparently there have been no thorough, quantitative assessments of the benthic infauna and epifauna of Willapa Bay on "control" tideflats, nor have there been impact assessments adequate to quantify the rate of (2)

recolonization of tideflats following spraying. Thus it is not known whether sprayed tideflats are restored to near-normal natural community composition and productivity in one year, three years, ten years, or more. The fact that the shrimp (which are the target of the poison) recolonize so slowly that 41% of the tracts treated since 1963 have needed treating only once (Westley, 1981) suggests that other crustacean populations could experience comparable long-term depressions.

The relationship between animals and sediment is a critical factor governing the distribution of benthic epifauna and infauna (Gray, 1974; Rhoads, 1974). The proportion of deposit-feeders is greatest on unstable mud bottoms while suspension-feeders (e.g. oysters) are largely restricted to muddy sands and sands. Deposit-feeders such as the ghost shrimp Callianassa californiensis commonly burrow through the substrate in a process called bioturbation. This process recycles nutrients, allows oxygen to penetrate further into the substrate, and produces quantities of fecal pellets available to coprophagous benthos. This process is also responsible for the incompatibility of deposit- and filter-feeding populations. The elimination of bioturbating species can result in the sediment surface becoming firm and stable, as demonstrated by an oil spill in Buzzards Bay (Rhoads, 1974) and the application of SEVIN to Willapa Bay. However, deposit-feeding animals can be expected to re-establish themselves in sediments of suitable grain size.

The DEIS did not provide much information on the relative distribution of mud, muddy sand, and sand in Willapa Bay. This would seem significant in assessing the problem. While there may be a perception that ghost shrimp are spreading, thereby rendering the substrate unsuitable for oysters, there is the possibility that distribution of sediments in the bay bottom itself is changing, thus enlarging the habitat for this animal and reducing the habitat for oysters. (3)

Another factor which has not been considered in the DEIS is the relative distribution of Callianasa and the mud shrimp Upogebia pugettensis. Apparently both shrimps are considered pests and their eradication is sought by oyster growers. However, Upogebia, like oysters, is a filter feeder. It builds stable burrows in the mud. Martin Pozzi, who has conducted his dissertation research at the University of Oregon on the distribution and limiting factors governing shrimp in Coos Bay estuary, observes that mud occupied by low to medium densities of Upogebia is firmer than mud lacking shrimps. It seems possible that spraying areas on the basis of the presence of "burrows", without determining which species is present, may be illfounded. We strongly suggest careful evaluation of the relative impacts of these species on oysters, their distribution relative to grain size and tidal height, and historic trends in sedimentation in the bays. Pozzi's dissertation may provide clues to reducing competition between shrimp and oysters based upon an understanding of their respective ecological requirements, reproductive cycles, etc.

The DEIS does not address how it was determined that greater than five shrimp holes per year constituted need for treatment. If there have been studies of oyster growth rate relative to shrimp densities, that information should be included. It is noteworthy that Rhoads (1974) successfully grew (4)

Crassostrea virginica and Mercenaria mercenaria in the near bottom turbidity zone by placing them on racks which held them a few centimeters above the unstable bottom.

(5) The DEIS alluded to a reduced population of other invertebrates when shrimp are present, but no quantitative data are presented. Pozzi has documented reduced densities of several invertebrates in the presence of Callianasa, but highest densities of some animals in a "halo" around the shrimp beds. Again, we recommend evaluating his work for better information on community interactions.

Additional Observations and Recommendations

General Comments

(6) 1. The document does not acknowledge serious data gaps, such as population densities and species diversity of the tideflats, population recovery rates after spraying, sediment grain size distribution, etc.

(7) 2. The references and data selected for inclusion were not comprehensive and their selection appears biased. Additional pertinent literature exists (including pertinent facts omitted from cited literature) which substantially expands upon or contradicts some of the DEIS' findings.

(8) 3. The heavy reliance upon personal testimony by permit applicants and others with a vested interest in the practice of spraying seems inappropriate for a document of this nature. There is also an excessive reliance upon subjective observations.

Specific Comments

(9) Page iii. "License and Permits Required" should include the Special Local Needs Pesticide registration discussed on page 6.

(10) Page 6, Section 2.3, Criterion 2. The phrase "under EPA guidelines..." seems somewhat misleading. It is our understanding that the 400 acre limitation is part of the special Washington state label but is not an EPA guideline. We are unaware that EPA has guidelines for the application of SEVIN to estuaries since generally SEVIN is restricted by EPA from waterways altogether. (Witness the caution on the general SEVIN label reproduced on page 81: "CAUTION! May kill shrimp and crabs. Do not use in areas where these are important resources.")

Page 6, Section 2.3, Criterion 3. Similarly, it seems misleading to cite "the EPA label." It is our understanding that the Washington State Department of Agriculture issued the Washington label for use of SEVIN in Washington estuaries, and the EPA did not act to disapprove it, which they have the authority to do within 90 days of issuance. It is our understanding that this

is distinct from the general SEVIN label for terrestrial uses duplicated in the DEIS.

(11) Pages 12 and 13, Estuarine Sediments. Sediment deposition volumes and patterns may have changed from those which existed decades ago when native oysters predominated in these bays. Agriculture, logging, channel dredging, and other human activities have contributed to sedimentation. Consequently the areas suitable for oyster culture may have been reduced. The only data presented to describe the sediments of present commercial flats (page 13) are limited to a flat near Leadbetter Point at the mouth of the bay, which would be expected to be more coarse than the rest of the bay. It would be beneficial to provide specific information about the sediment grain size distribution along with sediment requirements of commercial oysters, since sediment-animal relationships are fundamental to the problem being addressed.

(12) Page 14, 3.1.2.2.2. We suggest deletion of Willapa Bay from the title for Appendix D page 87. As noted on page 14, this list of animals was derived from sampling in Grays Harbor only. The source (reference) for Appendix D should be noted.

(13) Page 15, para. 1. The text's description of "areas of major biological significance" for eelgrass communities in Willapa Bay appears to encompass tracts of commercial clam and oyster beds. Eelgrass beds are the basis of extremely important communities having a high diversity of animals, many of which are sensitive to SEVIN. The eelgrass also tends to consolidate sediments, which presumably is beneficial to oysters. Eelgrass has so many benefits—as food for brant, substrate for herring spawning, refuge for crabs and numerous other animals, etc., that its importance is generally undisputed.

Unfortunately eelgrass communities are affected by intensive oyster culture, both SEVIN spraying and dredging. Jack Waddell (1961) determined there was a reduction in eelgrass on oyster beds in northern California which was related to the length of oyster culture and the number of oyster dredging operations that had occurred. The eelgrass density was reduced by an average of 33 percent in oyster beds with no history of dredging, to a mean of 71 percent on beds dredged three times. He concluded that the perennial nature of eelgrass does not allow it to maintain itself under conditions of periodic disturbance such as occurs in mechanical oyster harvest.

(14) Page 15, last para. Tidal flats are "areas of major biological significance" (AMBS) for Dungeness crabs. This suggests that direct application of poisons to tideflats is likely to affect crabs, which are very sensitive to SEVIN. It is further noted that tidal flats are AMBS for Pacific oysters. We presume that the Pacific oyster is the introduced (Japanese) oyster, rather than the native oyster. It would be useful to clarify this for the public.

(15) Page 16, Fin-Fish. All species of salmon pass through estuaries, but their period of residency is highly variable and not well studied. Chinook salmon show the longest periods of juvenile residency in estuaries, up to several months (Levy, 1984). Meyers (1980) found that hatchery-reared coho released in June were present up to three months in Yaquina Bay. The availability of their preferred food during this period of estuary residence influences the

growth rate of young salmonids and their subsequent survival. Their growth rate at this time probably is a significant factor in the return rate of harvestable adults (Levy, 1984). For this reason the destruction of benthic food organisms over a few hundred acres of tideflats in midsummer should be carefully evaluated.

While most salmonids migrate down the rivers in the spring, some are likely to be using the estuary in June, July, and August when spraying takes place. In fact, some WDF hatchery releases take place just prior to and during the time of spraying (Castoldi, 1983; Hill, 1984). Some examples of releases into Willapa Bay and Grays Harbor tributaries during this period follow.

Fall Chinook	2 million	fingerlings	May 24, 1982	- Naselle River
	.96 million	"	May 23, 1982	- Fork Cr.
	.8 million	"	June 1, 1982	- Grays River
	1.4 million	"	June 2, 1982	- N. Nemah River
	2.3 million	"	May 26, 1983	- Naselle River
	1.5 million	"	June 1, 1983	- N. Nemah River
Coho	1.6 million	fingerlings	June 8, Aug. 20, 1982	- Chehalis & Naselle River
	30,000	"	July 6, 1982	- N. Nemah River
	.3 million	"	Aug. 22, 1982	- N. Nemah River
	.3 million	"	Aug. 12, 1982	- Fork Creek
	.1 million	"	May 9, 1983	- Willapa River

Also of concern are marine species including flatfish which enter the estuaries for various periods to feed and/or rear.

(16)

Page 16, first para. and page 17, Table 1. We are concerned that very little quantitative information on the benthic biota of Willapa Bay is provided. The relative abundance of animals on oyster beds listed in Table 1 is interesting, but does not provide a means of quantitative comparison of tideflats with and without oyster beds, nor between oyster beds with and without SEVIN use, etc. The data from Table 1 (Tufts, 1984) is unpublished, hence not readily available for review. If there are useful biological data from the reported monitoring of SEVIN spraying on tideflat biota since 1973, they should be reported.

(17)

Page 22, para 1. Willapa Bay is recognized as vitally important as feeding habitat for birds migrating along the Pacific flyway. The small crustaceans of the tideflats which provide much of the food for migrating shorebirds are sensitive to extremely low levels of SEVIN. Besides comprising food for shorebirds, these animals provide food for starry flounder, salmonids, and other fish. These crustaceans typically reproduce in the spring and summer. Since SEVIN is sprayed in the summer its effect on the annual population cycle for these invertebrates could be substantial. For this reason it is important to know the natural populations of benthic infauna and the effects of SEVIN on rates of recolonization and subsequent spring population levels.

(18)

Page 23, 3.1.3. Recreational clamming exists but "does not constitute a major fisheries." The influence of SEVIN on the availability of recreational clams should be considered. For example, does the reduction of clams on oyster beds reduce seeding of clams on recreational clam flats? The DEIS notes that study of SEVIN application in Yaquina Bay found up to 69% mortality on juvenile edible gaper clams (Armstrong and Millemann, 1974). Four other species of clams were also significantly reduced following test applications of SEVIN to tideflats.

(19)

Page 23, 3.1.3.1. Willapa Bay "is an important nursery area for Dungeness crabs." During July and August juveniles are reported to be in channels and subtidal areas adjacent to oyster grounds. We suggest documenting this if possible. It seems likely that these crabs move out of the channel to feed across the tideflats when the tide comes in. There they would be exposed to SEVIN leaching from muds sprayed on the low tide. In any case the waters moving from the flats into the channels and nearby subtidal areas would contain SEVIN following spraying. Since juvenile crabs are susceptible to extraordinarily minute concentrations of SEVIN, it seems likely that they would be poisoned.

(20)

Page 37, 4:1 Chemical Behavior of SEVIN. The information on persistence is incomplete. Karinen et al., 1967, found that carbaryl and 1-naphthol persisted for six weeks in a mudflat in Oregon. The DEIS presents the most optimistic rather than worst case scenario for SEVIN breakdown in the environment.

(21)

Pages 38-46, 4.2. Effects of SEVIN on Marine Life. More consideration of the toxic effects of SEVIN's hydrolytic product 1-naphthol seems appropriate. More information on invertebrate toxicity of SEVIN also seems warranted. There are several laboratory and field studies on toxicity to various invertebrates which are pertinent but not included.

(22)

The statement that "...it is clear that crabs are fairly resistant to sprayed SEVIN" is to some extent contradicted by measurement of a 96 hr EC50 of 0.26 ppm for adult Dungeness crabs and 0.25 ppm for late juveniles (Buchanan et al. 1970). Furthermore, crab mortalities of up to 159 per acre during the 1982 spraying (permit 8205, Bay Center) argue against this conclusion. Crab mortalities are variable, difficult to predict, and difficult to control.

(23)

Page 43, Table 8, A Summary of Sampling Results.... We have not examined the unpublished manuscript (Tufts, 1984) from which these data are extracted. It is not evident to what extent grain size, sediment organic content, tidal height and salinity were considered as variables which influence benthic populations in addition to oyster presence and history of spraying. The history of oyster dredging, which impacts eelgrass and also benthic populations, should be considered as well. Benthic samples should be screened on mesh not exceeding 0.5-0.6 mm to ensure inclusion of the majority of small crustaceans important as food for fish and birds.

(24)

(25)

Page 48. The estimates of reduction in oyster production which might result if spraying were discontinued were apparently provided by oyster growers who

have an economic interest in the practice. While their unique knowledge of their own operations cannot be argued, it does not seem appropriate to rely solely on their estimates in a document of this nature.

The estimate by two growers that without SEVIN treatments 75-80% of the oyster land in Willapa Bay would be unuseable is not readily reconciled with other figures in the DEIS: 37,000 acres of oyster beds, 4000 acres of "prime" oyster beds, a total of 2,947 acres treated since 1963. Perhaps the 75% is derived from a belief that if nearly 3000 acres out of 4000 prime acres had not been sprayed they would be unusable. We suggest trying to determine the extent to which shrimp reduce production as contrasted with rendering beds unuseable for oyster production. To what extent would production from 37,000 acres be reduced if spraying were discontinued? (26)

Page 49, 5.0. Measures to Mitigate Adverse Impacts. 9. It is not clear why rates of less than 10 lbs. active carbaryl are not generally allowed. We recommend a discussion of the test applications of 5 lbs./acre in Oregon and an explanation of why this rate is not used. (27)

Our agency remains very concerned with the impacts of SEVIN upon nontarget organisms including zooplankton, benthos, and fish. Disruption of the estuarine food chain which supports recreational and commercial fisheries should not be undertaken without certain knowledge of all ecological ramifications including fisheries impacts. Thank you for the opportunity to comment on this DEIS. A bibliography with sources cited above is enclosed. (28)

Sincerely,

Dale R. Evans
Division Chief

Enclosure: 1

cc: Washington Department of Game
Environmental Protection Agency
U.S. Fish and Wildlife Service; ES offices in Portland and Olympia; Regional office
Oregon Dept. of Fish and Wildlife
Oregon Dept. of Land Conservation & Development
F/NWR, FM/42, F/S1, F/NWC5, F/NWC6
GC/NW

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Response to Dale R. Evans, National Marine Fisheries Service.

1. These are questions which WDF and WDOE must deal with in managing the resources and protecting the water quality. This EIS provides information for these agencies to make policy decisions. In addition, this EIS is on the control of burrowing shrimp with Sevin, not on the merits of oyster culture. It should also be noted that aquaculture has helped protect the water quality of Willapa Bay. The NMFS should be able to help answer these questions as it is a signatory agency of the National Aquaculture Act.

2. It is true that Sevin treatments cause mortalities in the target species, burrowing shrimp, and in other benthic crustaceans such as amphipods and Dungeness crabs. As discussed in the revised Sections 4.2, 4.2.1, and 4.2.2, these losses may not be significant because less than 1 percent of the total tidelands in Willapa Bay are exposed to Sevin. It is not known whether recolonization occurs on treated ground at the same rate as on untreated areas. The recolonization studies by WDF that were presented in the DEIS were inconclusive. However, they do indicate that recoloniztion does occur. Additional studies are needed to better assess the effects of Sevin on the rate of recruitment. These are planned.

3. The process of reducing bioturbating species to achieve a firmer and more stable substrate is the objective of the Sevin treatment program. The eventual recolonization by burrowing shrimp is the reason that retreatment is needed.

It is likely that the sedimentary structures of Willapa Bay are gradually changing. However, no monitoring of these changes has been conducted. This EIS presents the only data available on grain size distribution. There have been no studies to map the distribution of sediments in relation to oyster culture.

Martin Posey was contacted during the revision of the DEIS and some of his preliminary findings are included in Sections 3.3.1 and 4.2.2. Neither the WDF nor the oyster growers differentiate between species of burrowing shrimp when evaluating the need to treat an oyster tract. The assessment is based on the relative firmness of the ground. This procedure is discussed in the WDF Progress Report by Hurlburt (1985); the Executive Summary of this report is included in this EIS as Appendix H.

4. Determining sufficient need for treatment is not based solely on the number of burrows, but also on the condition of the oyster flat at the time of inspection and on its projected condition during the next three years. The 1984 Sevin treatments are described in the WDF Progress Report by Hurlburt (1985) and include an explanation of the process for assessing the need for Sevin treatment.

Some oyster growers in Willapa Bay and Grays Harbor use off-bottom culture. They find that excessive concentrations of burrowing shrimp cause the stakes supporting the racks to sink, bringing the oysters into contact with the mud. This is discussed further in Section 7.4. Also, note that off-bottom culture of a scale to replace current oyster production would probably cause significant impacts, as well as change the nature of the tidelands in the two bays.

5. Section 3.1.2.2.2. has been revised. Burrowing shrimp interaction with benthic communities is presented in Section 3.3.1. Preliminary findings by Martin Posey are also discussed in this section.

6. The EIS has been extensively revised. Specific data gaps are acknowledged where appropiate and in Section 8.0.

7. A more careful literature search and review was made following issuance of the DEIS. With this new information, some conclusions in the DEIS were changed, but most of the conclusions remained unchanged. New information on marine fish in Willapa Bay and Grays Harbor became available after the DEIS was issued. Finally, a large amount of data resulted from the 1984 Sevin treatments. All of this new information has been used to revise and expand the EIS.

8. As discussed above, the general ecology of Willapa Bay has not been extensively studied. Much of the available long term information comes from WDF and the oyster growers, who have extensive experience with conditions in the bay. While the opinions of the oystermen may be biased, they have extensive information, often spanning generations, that is invaluable. Every effort was made in writing this EIS to use data that were accurate.

9. This registration is not included in the list, because it is not a license or permit that must be issued each time Sevin is used.

10. Appendix D includes additional correspondence between WDF and EPA clarifying the registration of Sevin for use in Washington.

11. As stated under comment number 3, information is not available on sediment grain sized distribution in Willapa Bay. Studies to map sediment types in the bay are not planned at this time.

12. The title of this Appendix has been corrected.

13. Aquaculture operations such as dredging are not within the burrowing shrimp control program and are outside the scope of this EIS.

14. The EIS acknowledges that Sevin is toxic to crabs. Section 3.1.3 identifies the Pacific oyster as the introduced, not the native, oyster.

15. Sections 4.2.2 and 4.2.3 have been revised and expanded. The use of oyster beds or of any other area of Willapa Bay by juvenile salmonids has not been studied.

16. See the revised Section 4.2.3.

17. See the revised Section 3.1.2.2.2. Available data are presented or summarized in the FEIS.

18. See the revised Sections 3.1.2.2.2, 4.2.2 and 4.2.3. Information on the use of oyster beds by birds before or after Sevin treatments is not available.

19. The WDF 1982, 1983, and 1984 benthic sampling did not find any recreationally important clam species (see Section 3.1.2.2). The habitat that oyster are grown in is generaly not suitable for hardshell clams.

20. Sections 4.2.2.1 and 5.2 have been revised and expanded with information from the 1984 spraying and with studies conducted in Grays Harbor. Also, the WDF Progress Report by Hurlburt (1985) presents details of the 1984 Sevin treatments, including the use of "chumming" to keep juvenile crab off treated tracts. A summary of this report is presented in Appendix H.

21. Karinen et al. (1967) performed their studies under spring conditions when mud temperatures were cooler, inhibiting Sevin decomposition. This work and other research is discussed in the revised Section 4.1.

22. Upon receipt of these comments, another comprehensive literature review was conducted . The referenced laboratory and field studies cound not be found. See the reply to Comment Number 7.

23. Section 4.2.2.2 has been revised and clarified.

24. See Sections 3.1.2.2, and its subsections, and 4.2.2.1 and the WDF Progress Report on the 1984 Sevin treatments.

25. See response to Comment Number 8. Sections 3.1.3.2 and 4.2.6.2 have been revised and expanded.

26. Sections 3.1.3.2 and 4.2.6.2 have been revised to answer this concern.

27. Initial experiments (Chambers 1969) showed that concentrations of 10 lbs/acre were effective in shrimp control. At lower concentrations effectiveness was less predictable, increasing the probibility of re-treatment. With an improved data base and better understanding of Sevin's activity in this environment, it may be possible to tailor application rates to specific tracts, reducing the total Sevin applied. Tests to determine the effectiveness of reduced concentrations are being planned and will be conducted in 1985.

28. According to the information in Section 4.2, it is unlikely that the estuarine food chain is disrupted by the existing burrowing shrimp control program. Less than one percent of the tidelands in Willapa Bay are subjected to Sevin treatments each year. Other factors limit impacts to the food chain: the rapid Sevin degredation in warm summer weather conditions; general absence of large numbers of migratory birds; and relatively lower populations of benthic crustaceans. The regulation and supervision by WDF significantly reduces the impacts of Sevin treatments.

Spec Proj Reports & Dep Director

Dept
cc: Zelig
Hurlburt

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
2625 Parkmont Lane, S.W., Bldg. B-3
Olympia, Washington 98502

RECEIVED
AUG 22 1984
SHELLFISH ADMINISTRATION

August 17, 1984

RECEIVED
AUG 21 1984
HABITAT MANAGEMENT

Mr. Duane Phinney
Habitat Management Division
Department of Fisheries
Mail Stop AX - 11
Olympia, Washington 98504

Dear Mr. Phinney:

We have reviewed the draft environmental impact statement (DEIS) for control of ghost and must shrimp in oyster beds of Willapa Bay and Grays Harbor. In general, the DEIS is well written and adequately identifies expected impacts.

We fully support the mitigative measures currently in effect and encourage the incorporation of Suggested Measures, Section 5.2, into the spraying program.

We agree with and support the recommendation of the Environmental Protection Agency (letter, August 6, 1984) that the WDF review the Oregon experience in the use of Sevin in oyster beds in that state and incorporate the results of this review in the final EIS.

Specific Comments

Section 4.2, Effects of Sevin on Marine Life, p. 2

(1) Information presented in this section indicates that with an application rate of 10 lbs/acre and an initial 1 L/ft (0.4 in. water depth) on an incoming tide the concentration of Sevin would be 10 ppm. With the solubility of Sevin less than 1%, a probable effective active concentration would be 0.1 ppm. If this assumption is true the 0.1 ppm is as much as 3 times over the amount (0.03 to 0.09 ppm) required to produce paralysis or death in 50% of test subjects (4.2.2. Invertebrates, p. 6).

If a reduction of as little as 1 to 2 lbs/acre could be attained in certain waters, pH, Temp., alkalinities, etc., cooperating, the reduction of toxic materials to the environment (300 to 600 lbs/treated area), and dollar savings to the oyster grower would be substantial over the years.

Section 5.2, Suggested Measures, Item #4, p. 51

We would encourage studies to determine the feasibility of using reduced concentrations of Sevin to control ghost and mud shrimp. The data presented on the chemical behavior of Sevin (4.1, p. 37, pars. 2 & 3) indicate that perhaps the 10 lb/acre application specified (5.1, p. 49, Item 9) may be the optimum concentration but may not be the minimum effective concentration when certain physical characteristics of embayments and water movements/actions are considered.

(2) In regard to the oyster growers to permit a one-time spraying in excess of the current 300 acre limit. If permission is granted it would be an opportune time to assess the effect of reduced Sevin application rates. Also, the oyster growers should be requested to partially fund or subsidize monitoring activities conducted by WDG or DOE since any reduction in future application of Sevin would be a direct benefit to them.

Section 5.2, Suggested Measures, Item #5, p. 51

(3) The initiation of baiting in nontreated areas to draw crabs from the poisoned shrimp would be an excellent deterrent to secondary toxic action of the Sevin.

If possible, we would appreciate an opportunity to observe spraying operations when conducted.

Please contact Mr. Clifford Bosley at (206) 385-1007 or Elaine Rybak at (206) 753-9440, if you have questions concerning our comments.

We appreciate the opportunity for review and comment.

Sincerely,

Charles A. Dunn

Charles A. Dunn
Field Supervisor

Response to Charles A. Dunn, U.S. Fish and Wildlife Service.

1. Your points are well taken. Studies are being conducted to determine whether Sevin applied at reduced concentrations will effectively control burrowing shrimp.

2. These studies were to be conducted during the 1984 treatments. However, due to unexpected problems they were not done and have been rescheduled for 1985.

3. The WDF Progress Report by Hurlburt (1985) reports on the use of baiting in the 1984 Sevin treatments. The technique appears to be quite effective at keeping juvenile crabs off treated beds. More studies are planned for 1985 to confirm this.

Spec Item Pesticides - Corp EIS

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION X

1200 SIXTH AVENUE

SEATTLE, WASHINGTON 98101

REPLY TO ATTN OF: M/S 423

AUG 6 1984

Mr. Duane Phinney
Chief, Habitat Management Division
Department of Fisheries
Mail Stop AX-11
Olympia, Washington 98504

RE: Draft Environmental Impact Statement titled Use of the Insecticide SEVIN to Control Ghost and Mud Shrimp in Oyster Beds of Willapa Bay and Grays Harbor

Dear Mr. Phinney:

Thank you for the opportunity to review and comment on the referenced draft environmental impact statement (DEIS). We found the DEIS to be well written and generally correct in identifying the environmental issues of concern.

We very much encourage the use of the mitigative measures and suggested measures identified on pages 49-51 of the document. Strict management and control of the use of Sevin is critical to minimizing its adverse effects. Additionally, the study measures identified on pages 50 & 51 to reduce the adverse impact of Sevin on Dungeness crab should be actively and aggressively implemented. Most promising of these measures appears to be the baiting of nearby areas to draw crabs away from the area being sprayed.

Our review has identified two areas of concern. These are discussed below:

(1) 1. The discussion of the toxicology of Sevin (carbaryl) is not in sufficient detail to satisfy the many critics of this controversial public program. We recommend that the Washington State Department of Ecology and Fisheries review the Oregon experience in the use of Sevin to control mud shrimp in oyster beds and seek to share some of the aquatic toxicology data base which has already been developed. This information should be summarized and included in the final EIS.

(2) 2. The statements relating to enhancement of habitat for birdlife are misleading. Specifically, the statement on page 46 which says "it is obvious that the use of Sevin enhances rather than degrades the estuarine environment for shorebirds and waterfowl and their raptorial predators" could be construed to mean that Sevin is necessary to create good bird habitat. This is certainly not the case. Use of Sevin should not be promoted as a management tool for enhancement of bird life habitat.

Similar comment applies to the statement made on page 48 that "positive effect on benthic communities and on associated food chains" will result from Sevin application.

If you have questions concerning our comments, please contact Mr. Carl Kassebaum of my staff at (206) 442-1447.

Sincerely,

Robert S. Burd

Robert S. Burd
Director, Water Division

cc: USFWS-Olympia
NMFS
WDE
WDG

Response to Robert S. Burd, Environmental Protection Agency.

1. The exhaustive literature review conducted for the DEIS was checked and supplemented for the FEIS where additional sources were found. Some information from the Oregon studies has been included. It was thought that an over abundance of detail would be detrimental to the understanding of the issues by the general public.

2. These statements have been corrected.

BLACK HILLS AUDUBON SOCIETY

A Washington State Chapter of the National Audubon Society
Mailing Address: P.O. Box 2524, Olympia, WA 98507

August 21, 1984

Mr. William Wilkerson, Director
Washington State Department of Fisheries
115 General Administration Building
Olympia WA 98504

Dear Mr. Wilkerson:

Up to this point Black Hills Audubon Society and the Friends of the Earth have always been staunch supporters of the Department of Fisheries. We have worked closely together with the same objectives when it came to protecting the environment in Willapa Bay and Grays Harbor. We are also very supportive of the commercial salmon, oyster and crab fishing industries that are so important to the economy of Westport, Aberdeen, South Bend and Raymond. But we draw the line at supporting your agency in the use of Sevin in Grays Harbor and Willapa Bay.

(1) We urge you not to rely totally on the use of Sevin to solve what appears to be a serious but temporary ghost shrimp problem. Continued use of Sevin may alter and reduce for years to come the populations of food organisms essential to shorebird, crab and salmonid populations.

(2) Our review of your draft EIS shows that you have been alerted to the serious impacts Sevin has on non-target species. However, long-term trade-offs in damage to crabs, sturgeon, salmonid and food-web organisms have not been quantified. Sevin is not the final answer to controlling ghost shrimp unless you are willing to eliminate all other beneficial uses of the land. The questions raised by NOAA have not been answered, nor have all human health problems been addressed.

(3) We strongly urge you to find control measures for ghost shrimp using biological and mechanical techniques that employ modern integrated pest control management. There may be clues in the facts that ghost shrimp have not always been a problem, nor are they a problem in all areas. What limits them in some areas? Are there organisms equivalent to ghost shrimp in the original home of the oyster Crassostrea gigas, and if so, what is their relationship? Do the shrimp serve any unsuspected useful purpose such as burrowing animals do on land? We believe and urge that some of your resources and staff could be used to conduct a ghost shrimp control research project funded by the Governor's emergency fund. This might come up with a species-specific solution. Broad spectrum chemicals should be a last resort. In all events, we hope you will not risk violation of SEPA by use of Sevin before the final EIS.

We are ready to support you in any way we can but we will strongly oppose any future use of Sevin in Willapa Bay and Grays Harbor. We do not find basis for optimism in the studies cited in the EIS.

Please let us know your views and intentions.

Robert Kavanaugh

Sincerely,
Robert Kavanaugh
Pesticide Committee
Black Hills Audubon Society

cc: Gov. John Spellman
Ernesta Barnes
David Ortman
Russell Peterson

Response to Robert Kavanaugh, Black Hills Audubon Society.

1. See revised Section 4.2 and its subsections.

2. See Section 4.2, especially 4.2.2.1. Also, see the responses to comments by the National Marine Fisheries Service .

3. See the revised Section 7.0.

Orig to Dubois

FORTY-EIGHTH LEGISLATURE
1983-84

SESSIONS SERVED
HOUSE 1945, '47, '49, '59 EX., '61
1961 EX., '61 AND EX., '63,
1953 EX., '65, '55 EX., '67

SENATE: 1981, '81 EX., '83, '83 EX.,
1965, '65 EX., '67, '67 EX.,
1972 EX., '73, '73 EX., '74 EX.,
1975, '75 EX., '76 EX., '77,
1979, 1980, 1981, '82, '83

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Washington State Senate
STATE OF WASHINGTON
OLYMPIA

SENATOR
A. L. "SLIM" RASMUSSEN
TWENTY-NINTH DISTRICT
5415 A STREET
TACOMA, WASHINGTON 98408
TELEPHONE 472-4380
OFFICE
407-B LEGISLATIVE BLDG.
OLYMPIA, WA 98504
TELEPHONE 753-7656
HOTLINE—TOLL FREE
DURING SESSION
1-800-562-6000

Dear Don
AL

August 21, 1984

Hon. Don Moos, Director
Department of Ecology
Olympia WA PV-11

Dear Don,

I appreciate this opportunity to comment on the draft environmental statement on the use of the insecticide Sevin to control ghost shrimp and mud shrimp in oyster beds of Willapa Harbor and Grays Harbor.

(1) Evidence which has been presented to me indicates that Sevin, in its highly toxic state, completely destroys the food chain in these areas. Not only are small crab killed and crab larvae, but the massive mortalities which result destroy all species and result in changes in the diversity, abundance and natural productivity of the sea life of the area sprayed. There is no question that the killing is complete.

(2) Crab fishermen report to me that after Sevin has been sprayed in Willapa Harbor dead crab are found in traps three miles out to sea and across the width of the harbor.

(3) Chinook salmon juveniles reside in these estuaries and the killing of the food chain would have a definite adverse affect on Chinook and other salmon species. Their growth rate is an important factor in the rate of return of harvestable adult Chinook. Shorebirds are also highly dependent on the food chain the Willapa Bay and Grays Harbor.

(4) Heavy dredging by the oyster companies has contributed to the ghost shrimp problem. Dredging should be controlled. Also, the new methods of oyster culture using stakes and ropes and the wire "hang-down" rafts should be considered for these areas.

For these reasons, I strongly recommend that all spraying of Sevin in the affected areas be prohibited. It seems that the loss of crab and other fishlife and the loss of feed habitat for shorebirds alone outweigh the economic gain from spraying for ghost shrimp on a few hundred acres of oyster ground.

Sincerely yours, "Slim"
A.L. Rasmussen

A.L. Rasmussen
State Senator
29th District

Response to Senator A.L. Rasmussen.

1. See the revised Section 4.2, especially 4.2.2.1. Organisms on treated oyster ground are not all killed. Most non-arthropod species, and even some burrowing shrimp, survive.

2. Crab fishermen and WDF have observed periodic die-offs of Dungeness crab along the Washington coast, apparently related to molting . The timing of these losses is coincidental with Sevin treatments. Because of high dilutions and rapid degradation (see Section 4.1), it is very unlikely that Sevin sprayed on oyster beds could affect crabs in the open ocean.

3. See revised Sections 4.2.3., 4.2.4., and 4.2.7.

4. Many oyster growers do not conduct extensive dredging operations, yet still suffer major shrimp infestations. Even oyster growers that use the stake and long-line method of oyster culture (eg. B. Engvall in Grays Harbor) have difficulty with excessive burrowing shrimp populations (see Section 7.4). The cause of the shrimp problem is unknown. Possible factors include increased siltation due to logging, climatic changes, and other activities. Note that shrimp are abundant not only on the oyster beds, but in other parts of Willapa Bay and Grays Harbor.

WASHINGTON DUNGENESS CRAB FISHERMEN'S ASS'N.
P. O. Box Q Westport, Washington 98595 Phone (206) 267-1051

SEPT .14, 1984

MR. ERIC HURLBERT
WASH. DEPT. OF FISHERIES
115 GENERAL ADMINISTRATION BLDG.
OLYMPIA, WA 98504

DEAR MR. HURLBERT:

OUR COMMENTS TO THE DRAFT ENVIROMENTAL IMPACT STATEMENT (DEIS) ON THE USE OF THE INSECTICIDE SEVIN TO CONTROL GHOST AND MUD SHRIMP IN THE OYSTER BEDS OF WILLIPA AND GRAYS HARBOR, ARE AS FOLLOWS:::

(1) 1. FIRST, WE FEEL THAT EVERY EFFORT SHOULD BE MADE TO REACH A DIFFERNET SOLUTION NOT HARMFUL TO CRABS RATHER THAN SEVIN SPRAYING, TO CONTROL GHOST AND MUD SHRIMP IN THE OYSTER BEDS.

(2) 2. WE DESIRE TO NEGOTIATE OR WORKOUT PROBLEMS WITH THE USE OF SEVIN DIRECTLY WITH THE OYSTER GROWERS AND THE WASH. DEPT. OF FISHERIES RATHER THAN USING THE COURTS OR OTHER MORE ANTAGONISTIC METHODS IF POSSIBLE. SUCH METHODS WOULD SERVE TO HURT RATHER THAN HELP THE CRAB AND OYSTER INDUSTRIES.

(3) 3. IN REGARDS TO THE ACTUAL DEIS, WE SUGGEST THAT THE DOCUMENT SHOULD HAVE COMPARED THE OYSTER INDUSTRY WITH THE COSTAL CRAB FISHERY, RATHER THAN WITH JUST THE BAY FISHERY. WE BASED THIS ON THE FEELING THAT CRAB LARVAE ENTER THE BAYS FROM THE OCEANS, AND THE ESTUARIES SERVE AS IMPORTANT SOURCES OF CRAB FROM THE OCEAN FISHERY.

(4) 4. WE ALSO SUGGEST THAT BECAUSE OF THE APPARENT CONTRIBUTION TO THE OCEAN CRAB FISHERY BY THE BAYS, THE COMMERICAL CRAB FISHERMEN ARE WILLING TO TOLERATE SOME INCIDENTAL MORTALITY, BUT CANNOT TOLERATE A HEAVY KILL FROM THE USE OF SEVIN. OUR OPINION IS, THAT ANY AMOUNT OF DECREASED NUMBERS OF JUVENILES IN THE BAYS WOULD MEAN PROPORTIONATLY FEWER ADULT CRAB AVAILABLE TO THE OCEAN FISHERY AS WELL AS THE BAY FISHERY.

-CON'T-

WASHINGTON DUNGENESS CRAB FISHERMEN'S ASS'N.
P. O. Box Q Westport, Washington 98595 Phone (206) 267-1051

(5) 5. BASED ON THE EVIDENCE OF RELATIVELY HEAVY KILLS OF YOUNG OF THE YEAR CRABS. WE FEEL THAT SPRAYING IS POSSIBLY BEING DONE AT THE WRONG TIME OF THE YEAR. OUR OPINION IS THAT THERE MAY BE MUCH LESS MORTALITY OF CRAB IF SPRAYING IS CONDUCTED IN OCTOBER OR FEBRUARY. WE ARE AWARE THAT MOST OF THE LOW TIDES OCCUR DURING THE NIGHT OR EVENING. IT MAY BE POSSIBLE FOR A LIGHTING SYSTEM TO BE USED.

(6) 6. WE FEEL THAT BAITING AROUND THE EDGE OF THE OYSTER BEDS TO KEEP THE CRABS OFF MAY DECREASE THE AMOUNT OF KILL, BUT IT WOULD HAVE TO BE FASTENED TO THE BOTTOM WITHSOME DEVISE, SO THAT IT WOULD NOT FLOAT. IT MAY BE OF SOME HELP TO GET THE ADVISE FROM CRAB FISHERMEN ABOUT BAITING METHODS. WE FEEL THAT THIS ALONE WOULD NOT BE SIGNIFICANT.

(7) 7. THE SAMPLING FOR DETERMINING THE ADBUNDANCE OF YOUNG CRAB ON THE OYSTER BEDS BEFORE SPRAYING ARE IN CONCLUSIVE, AND MUST BE IMPROVED TO ADVOID LARGE KILLS OF CRAB.

(8) 8. WE SUGGEST THAT SOME WAY TO REMOVE THE POISONED SHRIMP FROM THE BEDS BE INVESTIGATED BECAUSE THE QUESTION OF HOW LONG A SHRIMP KILLED BY SEVIN IS POISONOUS IS UNANSWERED.

(9) 9. WE FEEL THAT IF THERE IS YOUNG OF THE YEAR CRAB IN THE SHRIMP HOLES, THAT METHODS OF MAKING THEM LEAVE BE LOOKED INTO.

(10) 10. WE ALSO FEEL THAT THE PROPORTION OF SEVIN BEING USED IN THE SPRAY BE INVESTIGATED.

(11) 11. WE BELIEVE THAT MORE STUDIES ON THE LENGTH OF TIME THAT SEVIN REMAINS IN THE WATER AFTER SPRAYING BE CONDUCTED.

WE HOPE THAT THE PRECEDEING BE OF USE IN COMPLETEING YOU ENVIROMENTAL IMPACT STATEMENT.

SINCERELY,

Ernie L. Summers

ERNIE L. SUMMERS
PRES. W.D.C.F.A.

cc: MICHEAL KYTE, RON WESTLEY, WA DEPT OF FISH

Response to Ernie L. Summers, Washington Dungeness Crab Fishermen's Association.

1. See revised Sections 5.0 and 7.0. The goal of this program is to control the shrimp with minimal impact to crab and other organisms.

2. WDF recognizes the crabbers' concerns and appreciates their cooperation.

3. See the revised Section 3.1.3.1.

4. Comment acknowledged.

5. Based on available information, July and August are the best months for treatment. Winter spraying is currently unfeasible because of the effects of lower temperatures on Sevin degradation rates (Section 4.1), the suspected presence of juvenile salmonids and migratory birds (Sections 3.1.2.3 and 3.1.2.4), the lack of information on the effects of Sevin on benthic communities, the problems related to spraying and monitoring at night, and the poor weather conditions during winter.

6. WDF will conduct additional studies to assess the effectiveness of chumming and to improve the methods of application.

7. More conclusive assessment methods are needed for determining the numbers of young crab present before spraying. WDF is working to improve assessment methods.

8. Comment acknowledged; see the new Section 8.0.

9. It is not known that large numbers of young crab use burrowing shrimp holes for refuge. At this time, there is no known way to stimulate these small crabs to leave any shelter.

10. Studies on the use of lower Sevin concentrations are being conducted.

11. See revised Section 4.1. and the WDF Progress Report by Hurlburt (1985) on the 1984 Sevin treatments.

JOHN SPELLMAN
Governor

STATE OF WASHINGTON
DEPARTMENT OF GAME
600 North Capitol Way, GJ-11 • Olympia, Washington 98504 • (206) 753-5700

FRANK HOWARD
Director

September 26, 1984

Mike Kyte
Ardea Enterprises
527 212th Street S.W.
Bothell, Washington 98011

RE: Use of Sevin to Control Ghost and Mud Shrimp in Willapa Bay and Grays Harbor

Dear Mr. Kyte:

Don Gatlin of our Aberdeen office asked that I put into writing the issues he discussed with you. I apologize for the delay in doing so.

Our primary concerns are for avian populations which make use of benthic organisms in Willapa Bay and Grays Harbor. It is stated on pages 42-44 of the DEIS that benthic communities can be expected to expand in numbers and diversity following Sevin treatment. Questions which we would like answered in the final EIS are: (1) Is recolonization rapid enough so that food sources are not short during periods of maximum use, i.e., migration; and (2) Does increased benthic diversity imply a decrease in species more valuable as food sources?

(1)

Thank you for the oportunity to provide these comments.

Sincerely,

THE DEPARTMENT OF GAME

John Carleton

John Carleton, Applied Ecologist
Environmental Affairs Program
Habitat Management Division

JC:cv

Response to John Carleton, Washington Department of Game.

1. See Sections 4.2.2.1., 4.2.4., and 4.2.7. and the WDF Progess Report by Hurlburt (1985) on the 1984 Sevin treatments. Additional research is needed to answer these questions conclusively.

APPENDIX A
SUMMARY OF GHOST SHRIMP SPARYING
1963 to 1983

Year and Permit no.	Acres	General Area
1963		
6301	25	Stony Pt.
6302	20	Stackpole
6306	25	North River
6309	25	Stony Pt.
6310	25	Stackpole
6313	15	Stackpole
1964		
6408	8	Middle Sands
6409	32	Stackpole
6410	10	N. Long Island
6410	12	Stackpole
6412	1	Bruceport
1965		
6502	12	Oysterville
6503	20	Oysterville
6504	20	Oysterville
6505	8	Oysterville
6509	3	Stackpole
6511	15	Stackpole
1966		
6603	5	Stony Pt.
6608	4	Goose Pt.
6610	21	North Bay
6611	6	Middle Sands
6612	20	Nemah
6614	10	Stackpole
6615	8	Stackpole
6616	6	Stackpole
6617	8	Stackpole
6618	20	Nemah
6619	6	Middle Sands
1967		
6703	10	Stony Pt.
6704	10	Stony Pt.
6705	4	Mill Channel
6706	10	Nemah
6707	10	Middle Sands
6708	5	Bone River
6709	27	Stony Pt.
6710	10	Oysterville
6712	10	Stony Pt.
6713	2	Bone River
6714	2	Palix River
6715	1	Niawakum River
6716	8	Mill Channel
6717	10	Stackpole
6718	20	Nemah
6719	5	Stackpole
6720	15	Stackpole
6721	5	Stackpole
6722	20	Bay Center
6723	20	Bay Center
1968		
6803	23	Stony Pt.
6804	20	S. Peninsula Shore
6805	20	Stackpole
6806	10	Stackpole

Year and Permit no.	Acres	General Area
1969		
6901	2	Stony Pt.
6903	18	Stackpole
6907	4	Bay Center
6908	11	Stony Pt.
6909	12	Bay Center
6911	9	Stony Pt.
6912	13	Upper Willapa R.
6913	30	McDonald Spit
6914	10	Stackpole
6915	20	Stackpole
6916	5	Stackpole
1970		
7001	4	Stackpole
7003	10	Stony Pt.
7004	12	Stony Pt.
7005	20	Stony Pt.
7006	12	Bay Center
7007	10	Stony Pt.
7008	35	Stony Pt.
7009	50	Eagle Rock
7010	10	Whiskey Slough
7011	40	McDonald Spit
7012	5	Mill Channel
7013	30	Bruceport
7014	2	Oysterville
1971		
7100	10	Stony Pt.
7101	20	Bruceport
7102	10	Toke Pt.
7103	20	North River
7107	10	Oysterville
7108	30	Stony Pt.
7110	25	Stackpole
7113	10	Stackpole
7114	12	Stackpole
7115	10	Stackpole
7117	29	Stony Pt.
7120	10	Stony Pt.
7121	34	Palix River
1972		
7201	50	Stony Pt.
7202	8	Palix River
7203	20	Stony Pt.
7204	15	Stony Pt.
7205	10	Stony Pt.
7206	15	Willapa River
7207	30	North River
7208	15	Stony Pt.
1973		
7302	100	North Willapa River
7303	60	Oysterville
7304	5	Stony Pt.
7305	12	Barnacle Knoll
7306	4	Stony Pt., Nemah
7310	30	Cedar River
7312	1.5	Nahcotta

Year and Permit no.	Acres	General Area
1974		
Special Permit 1	25	Stackpole
7401	10	Oysterville
7402	50	Nahcotta
7403	10	Stony Pt.
7404	48	Willapa River
7406	20	North River
7407	10	Oysterville
7408	5	Nemah
7410	15	Stackpole
1975		
7501	20	Nemah
7502	3	Stony Pt.
7504	10	Stony Pt.
7509	20	Willapa River
7510	15	Stony Pt.
7511	5	Bay Center
1976		
7601	15	Stony Pt.
7602	7	Stony Pt.
7604	50	Hawks Pt.
7605	15	Stackpole
7606	12	Middle Sands
7607	50	McDonald Spit
7608	10	Stackpole
7609	10	Grays Harbor
1977		
7701	40	Oysterville
7702	64	Palix River
7703	8	Nahcotta
7704	5	Nahcotta
7705	15	Nemah River
7706	20	Oysterville
7707	10	Stony Pt.
1978		
7801	5	Stackpole
7802	10	Stackpole
7803	30	Naselle River
7804	20	McDonald Spit
7805	8	Stackpole
7806	10	Willapa River
7808	20	Oysterville
7809	8	Nahcotta
7810	28	North River
7812	5	Stony Pt.
7813	5	Palix River
1979		
7901	30	Stony Pt.
7902	5	Nahcotta
7903	1	Nahcotta
7904	15	Middle Sands
7905	54	Seal Spit
7906	38	Stackpole
7907	30	North River
7908	15	Pterson
7909	40	Nahcotta
7910	26	Stackpole
7911	20	Stackpole
7912	10	Stackpole
1913	20	Stony Pt.
7914	10	Nemah River

Year and Permit no.	Acres	General Area
1980		
8001	3	Goose Pt.
8002	3	Stony Pt.
8005	5	Nahcotta
8006	5	Nemah
8007	5	Middle Island Sands
8008	40	Willapa River
8009	25	North River
8010	25	Nemah
8011	30	Bruceport
8013	20	Stackpole
8014	5	Stackpole
8015	20	Stackpole
8016	30	Nemah
8017	20	Stackpole
8018	15	Oysterville
1981		
8101	40	Cedar River
8102	11	Willapa River
8103	16.5	Nahcotta
8104	11.5	Nemah
8105	19.5	Bay Center
8106	25	Oysterville
8107	4	Bay Center
8108	15	Bay Center
8109	14	Bay Center
8110	8	Stackpole
8111	8	Oysterville
8112	20	Stackpole
8113	3	Seal Spit
8114	4	McDonald Spit
8115	30	Anderson
1982		
8201	40	Cedar River
8202	8	Nemah
8203	8	-----
8204	7	Stackpole
8205	20	Bay Center
8206	50	Cedar River
8207	40	Anderson E.
8208	40	Anderson W.
8209	15	Rambeau M.
8210	30	Rambeau S.
8211	8	Bay Center
8212	2.5	Stackpole
8213	6	Oysterville
8214	10	Mid. Isl.
8215	5	Seed bed
8216	4	Bay Center
8217	3.5	Bay Center
8218	8	Nemah
8201 (GH)	62	Ocean Shores (Grays Harbor)
1983		
8306	35	Bruceport
8307	20	Nahcotta
8308	40	Oysterville
8309	2	Stony Pt.
8310	5	Stony Pt.
8311	10	Anderson
8312	10	Rambo N.
8315	10	Palix-Stony Pt.
8316	18	Stony Pt.
8317	16.5	Stony Pt.
8318	12	Stony Pt.
8322	8	Stony Pt.
8323	8	Stony Pt.
8324	10	Stony Pt.
8325	10	Stackpole
8326	5	Stackpole
8327	5	Oysterville
8328	15	Cedar River
8319	5	Stony Pt.

UNION CARBIDE

Sevin® 80S

CARBARYL INSECTICIDE

For Agricultural or Commercial Use Only

Active Ingredient:
Carbaryl (1-naphthyl N-methylcarbamate) ..... 80% by wt.
Inert Ingredients: ..... 20% by wt.
E.P.A. Reg. No. 264-316

KEEP OUT OF REACH OF CHILDREN

CAUTION

SEE OTHER PRECAUTIONARY STATEMENTS ON SECOND PAGE

IN CASE OF EMERGENCY, TELEPHONE COLLECT (24 HOURS A DAY) IN U.S.A. (304) 744-3487

UNION CARBIDE AGRICULTURAL PRODUCTS COMPANY, INC.
P.O. Box 12014, T.W. Alexander Drive, Research Triangle Park, N.C. 27709.
UNION CARBIDE CORPORATION

SEVIN is the registered trade mark of Union Carbide Corporation for carbaryl insecticide.
APC-05050123
Made in U.S.A.

LIMITED WARRANTY AND DISCLAIMER

1. The manufacturer warrants (a) that this product conforms to the chemical description on the label; (b) that this product is reasonably fit for the purposes set forth in the directions for use when it is used in accordance with such directions; and (c) that the directions, warnings and other statements on this label are based upon responsible experts' evaluation of reasonable tests of effectiveness, of toxicity to laboratory animals and to plants, and of residues on food crops, and upon reports of field experience. Tests have not been made on all varieties or in all states or under all conditions. THE MANUFACTURER NEITHER MAKES NOR INTENDS, NOR DOES IT AUTHORIZE ANY AGENT OR REPRESENTATIVE TO MAKE, ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, AND IT EXPRESSLY EXCLUDES AND DISCLAIMS ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.
2. This warranty does not extend to, and the Buyer shall be solely responsible for, any and all loss or damage which results from the use of this product in any manner which is inconsistent with the label directions, warnings or cautions.
3. BUYER'S EXCLUSIVE REMEDY AND MANUFACTURER'S OR SELLER'S EXCLUSIVE LIABILITY FOR ANY AND ALL CLAIMS, LOSSES, DAMAGES, OR INJURIES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, WHETHER OR NOT BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY IN TORT OR OTHERWISE, SHALL BE LIMITED, AT THE MANUFACTURER'S OPTION, TO REPLACEMENT OF, OR THE REPAYMENT OF THE PURCHASE PRICE FOR, THE QUANTITY OF PRODUCT WITH RESPECT TO WHICH DAMAGES ARE CLAIMED. IN NO EVENT SHALL MANUFACTURER OR SELLER BE LIABLE FOR SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT.

PRECAUTIONARY STATEMENTS

CAUTION

HAZARDS TO HUMANS AND DOMESTIC ANIMALS:
HARMFUL IF INHALED OR SWALLOWED. Avoid Breathing of Dust or Spray. Do Not Take Internally. Avoid Contact with Skin and Eyes.

Wear regular long-sleeved work clothing. Change to clean clothing daily. Wash hands and face before eating. Wash thoroughly after handling.

STATEMENT OF PRACTICAL TREATMENT:
IF SWALLOWED, Induce vomiting and seek medical attention immediately.
IF IN EYES OR ON SKIN, flush eyes thoroughly with water; wash skin thoroughly with soap and water.

NOTE FOR PHYSICIAN: Carbaryl is a moderate, reversible cholinesterase inhibitor. Atropine is antidotal. Do Not Use 2-PAM, opiates, or cholinesterase inhibiting drugs.

ENVIRONMENTAL HAZARDS:
Avoid direct application to lakes, streams and ponds. Do not apply when weather conditions favor drift from area treated. Do not contaminate water, food or feed by cleaning equipment or disposal of wastes.

BEE CAUTION: MAY KILL HONEYBEES IN SUBSTANTIAL NUMBERS. This product is Highly Toxic to Bees Exposed to Direct Treatment or Residues on Crops. Protective Information May Be Obtained from Your Cooperative Agricultural Extension Service.
Do Not Use When Value of Bees as Pollinators is More Important than Insect Control. Before Applying, Warn Beekeepers to Locate Hives Beyond Bee Flight Range Until 1 Week After Application or to Take Other Equally Effective Precautions.

GENERAL INFORMATION

SEVIN 80S is a dry powder for dispersion in water and application as an insecticidal spray in hydraulic sprayers, mist blowers, low gallonage ground equipment and aircraft. The directions on this label are based on tests and field experience relating to (a) effectiveness, (b) possible injury to plants and animals, and (c) residues in food, feed and milk. READ THIS LABEL BEFORE USE. STRICTLY OBSERVE LABEL DIRECTIONS AND CAUTIONS, AND APPLICABLE FEDERAL AND STATE REGULATIONS.

Treated areas may be reentered immediately after the spray has dried.

PREHARVEST AND GRAZING USE INFORMATION AND LIMITATIONS

Tolerances established under the Federal Food, Drug and Cosmetic Act permit the sale of crops bearing probable carbaryl residues when this product is used in accordance with label directions. Do not plant rotational crops not listed on this product label within 18 months following treatment. If used as directed, treated forage may be grazed or used as feed for dairy and meat animals without causing illegal residues in meat or milk. This product may be applied up to and including the day of harvest or grazing of forage crops. Application may be made without removing livestock from area being treated.

PLANT RESPONSE PRECAUTIONS

To avoid possible injury to tender foliage, do not apply to wet foliage or when rain or high humidity is expected during the next two days.
SEVIN injures Boston ivy, Virginia creeper and maidenhair fern. During early season, it may also injure Virginia and sand pines.
Observe label instructions on apple thinning and on combinations with certain herbicides on rice and soybeans.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
Read entire label. Use strictly according to label directions and cautions. Do not use application methods, dosages, concentrations, or frequencies not listed on labeling. Do not apply against target pests or crops not listed on labeling. Do not mix with fertilizers or micronutrients if the resulting spray mixture is incompatible or alkaline.

SPRAY PREPARATION

TO ASSURE A UNIFORM SUSPENSION AGITATE, STIR OR RECIRCULATE ALL SEVIN 80S SPRAY MIXTURES PRIOR TO AND DURING USE. Remove oil, rust, scale, pesticide residues and other foreign matter from mix tanks and entire spray system. Flush with clean water.
Fill spray or mix tank with ½ to ¾ the desired amount of water. Start mechanical or hydraulic agitation. Slowly add the required amount of SEVIN 80S, and then the remaining volume of water. Prepare only as much spray mixture as can be applied on the day of mixing. MAINTAIN CONTINUOUS AGITATION DURING MIXING AND APPLICATION TO ASSURE A UNIFORM SUSPENSION. DO NOT STORE SPRAY MIXTURES FOR PROLONGED PERIODS.

COMPATIBILITY

SEVIN 80S HAS been used without plant injury with most common insecticides, miticides, fungicides, nutrients, adjuvants and petroleum oil as used on citrus. If compatibility of SEVIN 80S with another product and the resulting crop response is unknown, it should be tested on a small scale. Curdling, precipitation, greasing, layer formation or increased viscosity are symptoms of incompatibility. WHEN PREPARING COMBINATION SPRAYS, FIRST ADD SEVIN 80S TO AT LEAST ½ THE DESIRED AMOUNT OF WATER, MIX THOROUGHLY, AND THEN ADD COMBINATION PRODUCTS TO THE MIXTURE, AND THEN THE REMAINING VOLUME OF WATER. DO NOT APPLY TANK MIX COMBINATIONS UNLESS YOUR PREVIOUS EXPERIENCE INDICATES THE MIXTURE IS EFFECTIVE AND WILL NOT RESULT IN APPLICATION PROBLEMS, EXCESSIVE RESIDUES OR PLANT INJURY.
Unstable under highly alkaline conditions. Not effective if used with alkaline materials such as Bordeaux, lime-sulfur and casein-lime spreaders.

APPLICATION

On all crops, use sufficient gallonage to obtain thorough and uniform coverage.
Calibrate spray equipment to deliver the required volume.
Use 50 mesh slotted strainers in spray system and behind nozzles.
Avoid applications just before rainfall as poor insect control may result.
To clean spray system after use, drain and flush with water.

Refer to the Storage and Disposal directions for proper disposal of this rinse water.

STORAGE AND DISPOSAL

Store unused SEVIN 80S in original container only, in cool, dry area out of reach of children and animals. Do not store in areas where temperatures frequently exceed 100°F. Do not contaminate water, food or feed by storage or disposal. Open burning is prohibited.

Pesticide Disposal:
Pesticide spray mixture or rinse water that cannot be used according to label instructions must be disposed of according to applicable Federal, State, or local procedures.

Container Disposal:
Completely empty bag by shaking and tapping sides and bottom to loosen clinging particles. Empty residue into application equipment. Then dispose of bag in a sanitary landfill or by incineration if allowed by State and local authorities.

INSECT CONTROL

Apply when insects or their damage appears. To maintain control repeat at 7 to 14 day intervals or as necessary unless a shorter interval is specified below. Where a dosage range is indicated, use lower rate on young plants and early instars and higher rate on mature plants, advanced instars and adults. Thorough and uniform spray coverage is essential for effective control.
SEVIN 80S does not control spider mites. If spider mites are a problem, use a registered miticide.
Regional differences have been noted in the susceptibility of certain strains of fall armyworm to SEVIN 80S. If your experience indicates inadequate control, use an alternative pesticide.

FORAGE, FIELD AND VEGETABLE CROPS

Use at least 1 gallon of finished spray per acre for aerial application and at least 3 gallons of finished spray per acre for concentrate ground application. To prepare small volumes of spray, use 1¼ tablespoonfuls of SEVIN 80S per gallon of water where rates of 1¼ pounds per acre or 1½ pounds per 100 gallons are indicated in the tables below.

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
All Forage, Field and Vegetable Crops	Grasshoppers	2/3 to 1 1/8	See specific Forage, Field or Vegetable Crop	Use 2/3 to 1 1/4 pounds for nymphs on small plants or sparse vegetation in wasteland, rangeland, ditch banks and borders. Use 1 1/4 to 1 1/8 pounds for adult grasshoppers or applications to dense vegetation.
Alfalfa* Clovers	Blister beetles Mexican bean beetle	2/3 to 1 1/4	0	Observe plant response precautions.
	Alfalfa caterpillar Bean leaf beetle Cucumber beetles Green cloverworm Japanese beetle Leafhoppers Three cornered alfalfa hopper Thrips Velvetbean caterpillar	1 1/4		
	Alfalfa weevil larvae Armyworm Clover head weevil Corn earworm Cutworms Egyptian alfalfa weevil larvae Essex skipper European alfalfa beetle Fall armyworm Lygus bugs Webworms Yellow-striped armyworm	1 1/4 to 1 1/8		For alfalfa weevil larvae, if pretreatment damage is extensive cut alfalfa and treat the stubble. Use higher rate on areas east of the Rocky Mountains. On dense growth use 25 to 40 gallons per acre with ground equipment to ensure adequate coverage.
For application to Alfalfa via Center Pivot Irrigation Systems refer to "Directions for Use Through Center Pivot Irrigation Systems."				
Asparagus	Asparagus beetle	1 1/3 to 2 2/3	1	
	Apache cicada Asparagus beetle	2/3 to 1 1/3	Post harvest application only	Treat stems or brush-growth. Do not treat more than once every 14 days.

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Beans (including blackeyed peas, cowpeas, crowder or southern peas, dry beans, green beans, lima beans, navy beans and snap beans)	Blister beetles, Mexican bean beetle	2/3 to 1¼	0	Observe plant response precautions.
	Alfalfa caterpillar, Bean leaf beetle, Cucumber beetles, Flea Beetles, Green cloverworm, Japanese beetle, Leafhoppers, Three cornered alfalfa hopper, Thrips, Velvetbean caterpillar, Western bean cutworm	1¼		
	Armyworm, Corn earworm, Cutworms, European corn borer, Fall armyworm, Silnk bugs, Tarnished plant bug, Webworms	1¼ to 1⅞		
	Cowpea curculio	2½		
	Corn earworm, Limabean pod borer, Lygus bugs, Silnk bugs	2½		CALIFORNIA ONLY
Cabbage, Broccoli, Brussels Sprouts, Cauliflower, Kohlrabi	Flea beetles, Harlequin bug, Leafhoppers	2/3 to 1¼	3	
	Armyworm, Corn earworm, Fall armyworm, Imported cabbageworm	1¼ to 2½		
Chinese cabbage, Collards, Hanover salad, Horseradish, Kale, Mustard greens, Radishes, Rutabagas, Turnips	Flea beetles, Harlequin bug, Leafhoppers	2/3 to 1¼	3 (Horseradish, radishes, rutabagas and turnip roots) 14 (Chinese cabbage, collards, Hanover salad, kale, mustard greens, and turnip tops)	
	Aster leafhopper	1¼ to 1⅞		
	Armyworm, Corn earworm, Fall armyworm, Imported cabbageworm, Silnk bugs, Tarnished plant bug	1¼ to 2½		

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Sweet potato	Sweet potato weevil	9 Tbsps /gal.	0	NOT FOR USE IN CALIFORNIA PREPLANT DIP Just prior to planting, dip sweet potato cuttings in a suspension of SEVIN 80S (9 Tbsps /gal. of water)
	Corn earworm, Cucumber beetles, Flea beetles, Sweet potato hornworm, Tortoise beetles	1" to 2"		Apply as a foliar needed
	Sweet potato weevil	1" to 2"		FOLIAR APPLICATION Full coverage of plants is essential. Use lower rate on young plants and higher rate on mature plants

CROP	INSECT	POUNDS OF SEVIN 80S 100 GAL.	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Tobacco	Tobacco flea beetle	2½ Tbs-gal or 1¼ lbs/50 gal and apply 6 gal/100 sq yards	0	IN PLANT BEDS To prevent plant injury avoid excessive applications
	Green June beetle grubs	2/3 lb/100 gallons		Apply only to areas that larvae have uprooted by sprinkling as a drench with 50 to 100 gallons per 100 square yards.
	Budworms, Fall armyworm, Flea beetles, Hornworms, Japanese beetle, June beetles, Suckfly	1¼ to 2½		IN FIELDS Use lower rate on young plants (up to knee height). Use at least 10 gallons of prepared spray per acre. Begin treatments when worms are small If late season applications are necessary, allow three days before priming or cutting

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Wheat	Cereal leaf beetle	1"	0 (forage) 21 (grain)	NOT FOR USE IN CALIFORNIA Do not make more than two applications after grain heads emerge from boot Application is effective against eggs, larvae and adults
	Armyworm, Fall armyworm	1" to 1"		

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Cotton cont.	Boll weevil, Bollworms, Cotton leaperforator, Fall armyworm, Leafrollers, Leafhoppers, Tarnished plant bug, Yellowstriped armyworm (cotton cutworm)	1¼ to 2½	0	Treat on a 5 to 7 day schedule for as long as control is necessary. Mid and late season insect control. May be applied after bolls open
	Lygus bugs	1¼ to 2½		For light to moderate populations in Western irrigated cotton
	Pink bollworm	1⅞ to 3		Aphid populations will be suppressed by repeated applications of this insecticide
	Silnk bugs, Saltmarsh caterpillar	2½		
Cucumber, Melons, Pumpkins, Squash	Pickleworm, Melonworm	2/3 to 1¼	0	Observe plant response precautions Avoid excessive applications
	Cucumber beetles, Flea beetles, Leafhoppers, Squash bugs	1¼		
Dandelion, Endive (Escarole), Lettuce, Salsify	Flea Beetles, Harlequin bug, Leafhoppers	2/3 to 1¼	3 (head lettuce & salsify roots) 14 (dandelion, endive (escarole) leaf lettuce & salsify tops)	Observe plant response precautions Treat on a 5 to 7 day schedule after heads begin to form
	Aster leafhopper, Lygus bugs, Spittlebugs	1¼ to 1⅞		
	Armyworm, Corn earworm, Fall armyworm, Imported cabbage worm, Silnk bugs, Tarnished plant bug	1¼ to 2½		
Forage Grasses, Pasture, Rangeland	Armyworm, Black grass bugs, Chinch bugs, Essex skipper, Fall armyworm, Range caterpillars, Range crane fly, Striped grass looper, Thrips	1¼ to 1⅞	0	To control thrips in grasses grown for seed use high spray pressure to improve penetration into boot
	White grubs (green June beetle)	1⅞ to 2½		

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Potato* Tomato Eggplant Pepper	Colorado potato beetle, Flea beetles, Leafhoppers	2/3 to 1¼	0	
	European corn borer, Fall armyworm, Lace bugs, Silnk bugs, Tarnished plant bug, Tomato fruit worm, Tomato hornworm, Tomato pinworm	1½ to 2½		
	Cutworms	2½		
*—"For application to Potatoes via Center Pivot Irrigation Systems, refer to "Directions for Use Through Center Pivot Irrigation Systems."				
Rice			14	CAUTION! May kill shrimp and crabs. Do not use in areas where these are important resources DO NOT APPLY PROPANIL HERBICIDES WITHIN 14 DAYS BEFORE OR AFTER SEVIN SPRAYABLE APPLICATION OR PLANT INJURY WILL RESULT
	Armyworm, Chinch bugs, Fall armyworm, Silnk bugs	1¼ to 1⅞		MISSISSIPPI DELTA & TEXAS
	Armyworm, Leafhoppers, Tadpole shrimp	2½		CALIFORNIA ONLY For optimum tadpole shrimp control apply to water when pest first appears
Sorghums (milo, grain sorghum, sweet sorghum and hybrids)	Armyworm, Chinch bugs, Corn earworm, Fall armyworm, Silnk bugs, Webworms	1¼ to 2½	21 (grain) 0 (forage)	Direct spray into feeding heads for optimum insect control Treat for sorghum midge when 25 to 30 percent of heads have emerged from boot and are in bloom. Repeat application every 5 days later if adults are still active. A third application may be necessary in late planted sorghum or if midge are abundant For chinch bugs use high gallonage ground application directed at base of plants
	Sorghum midge, Southwestern corn borer	1⅛		
	Cutworms	2½		

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Soybeans	Bean leaf beetle, Mexican bean beetle, Cucumber beetles, Velvetbean caterpillar, Green cloverworm	2/3	0	DO NOT APPLY A COMBINATION OF SEVIN SPRAYABLE AND 2,4-DB HERBICIDES TO SOYBEANS. Use lower rates for light to moderate populations and smaller instars. Use the higher rates for heavy populations and larger instars.
	Corn earworm	2/3 to 1 1¼ to 1⅝		
	Blister beetles, Grape colaspis, Mexican bean beetle	2/3 to 1¼		
	Alfalfa caterpillar, Bean leaf beetle, Cucumber beetles, Green cloverworm, Japanese beetle, Leafhoppers, three cornered alfalfa hopper, Thrips, Velvetbean caterpillar	1¼		
	Armyworm, Cutworms, Fall armyworm, Slink bugs, Webworms	1¼ to 1⅝		
	Painted lady (thistle caterpillar), Saltmarsh caterpillar, Yellowstriped armyworm	2½ to 3		
Sugar beets	Armyworm, Beet leaf beetle, Fall armyworm, Flea beetles, Leafhoppers, Webworms	1¼ to 1⅝	14	
	Cutworms	1⅝		
Sunflower	Cutworms	1	80	NOT FOR USE IN CALIFORNIA. Do not allow animals to graze on treated crops.
	Armyworm, Fall armyworm	1 to 2*		
	Sunflower Weevil, Sunflower beetle	1* to 2*		

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Garden beet, Spinach, Swiss chard	Flea beetles, Leafhoppers, Harlequin bug	2/3 to 1¼	3 (garden beet roots) 14 (garden beet tops, spinach, Swiss chard)	Treat on a 5 to 7 day schedule
	Aster leafhopper	1¼ to 1⅝		
	Armyworm, Corn earworm, Fall armyworm, Slink bugs, Tarnished plant bug	1¼ to 2½		
Okra	Corn earworm, Slink bugs	1¼ to 2½	0	Treat on a 5 to 7 day schedule
Peanuts	Blister beetles, Mexican bean beetle	2/3 to 1¼	0	Observe plant response precautions
	Alfalfa caterpillar, Bean leaf beetle, Cucumber Beetles, Green cloverworm, Japanese beetle, Leafhoppers, Red-necked peanut worm, Three cornered alfalfa hopper, Thrips, Velvetbean caterpillar	1¼		
	Armyworm, Corn earworm, Fall armyworm, Slink bugs, Webworms	1¼ to 1⅝		
	Whitefringed beetle adults, Cutworms	2½		
Peas	Colorado potato beetle, Leafhoppers	1¼	0	
	Armyworm	1¼ to 1⅝		
	Alfalfa caterpillar, Cutworms, Pea leaf weevil, Pea weevil, Yellowstriped armyworm	1⅝		

TREE FRUIT AND NUT CROPS

For dilute sprays apply the specified dosage per 100 gallons of water. For concentrate and aerial sprays increase the concentration of SEVIN 80S in the spray mixture to apply an amount per acre equivalent to that in a dilute spray. The optimum spray gallonage will depend on tree size, density and stage of growth. Typical spray gallonages per acre range from 200-300 gallons for dilute sprays, 30-100 gallons for concentrate sprays and 10-25 gallons for aerial sprays. Do not exceed maximum label rate per acre per application.

CROP	POUNDS OF SEVIN 80S 100 GAL.	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
APPLE THINNING			Apply 1 full coverage dilute spray between 10 and 25 days after full bloom. If factors such as tree age, variety, previous crop, pruning, bloom and degree of set limit excessive fruit thinning with SEVIN 80S, exercise caution to avoid possible yield reduction.
Apples only	½ to ⅔	1	For easily thinned varieties including Cortland, Gravenstein, Jonathan, McIntosh, Orleans, Rome Beauty, Puritan, Red Delicious, Winesap, Yellow Newtown.
	⅔ to 1½	1	For difficult to thin varieties including Baldwin, Bird Davis, Duchess, Early McIntosh, Golden Delicious, Lady Apple, Northern Spy, Rhode Island Greening, Stayman Red, Turley, Wealthy, Yellow Transparent and York Imperial.

CROP	INSECT	POUNDS OF SEVIN 80S/ 100 GAL.	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Almond	Peach twig borer, San Jose scale, Fruitfree leafroller	1¼	28	Apply as "popcorn" or petal fall stages when the May brood of the peach twig borer begins to hatch or thereafter as needed.
	Navel orangeworm			Time early and mid season applications to correspond to moth flight peaks. Make a late season application at initiation of hull split or up to 10% hull split. Do not apply more than 6¼ pounds per acre.
Apples, Pears	Apple aphid, Apple rust mite, Apple sucker, Bagworms, California pearslug (pear sawfly), Codling moth, Eyespotted bud moth, Green fruitworm, Lecanium scales, Lesser appleworm, Lygus bugs, Orange tortrix, Oystershell scale, Pear leaf blister mite, Pear psylla, Pear rust mite, San Jose scale, Tentiform leafminers, Woolly apple aphid	1 to 1¼	1	WEST OF THE ROCKY MOUNTAINS. To avoid undesired apple thinning, delay use until at least 30 days after full bloom. For psylla control apply when eggs hatch or young nymphs are present.
	Apple mealybug, Apple aphid, Codling moth, White apple leafhopper	2/3		EAST OF THE ROCKY MOUNTAINS. To avoid undesired apple thinning, delay use until at least 30 days after full bloom. For optimum scale control apply when crawlers are present.
	Apple maggot, Apple rust mite, Bagworms, Eastern tent caterpillar, European apple sawfly, Eyespotted bud moth, Forbes scale, Fruitfree leafroller, Green fruitworm, Japanese beetle, Lecanium scales, Lesser appleworm, Oystershell scale, Pear psylla, Pear leaf blister mite, Pear rust mite, Periodical cicada, Plum curculio, Red-banded leafroller, Rosy apple aphid, San Jose scale, Tarnished plant bug, Tentiform leafminers, Woolly apple aphid, Yellowheaded fireworm	1¼	1	

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Carrots, Celery, Parsnips, Parsley	Flea Beetles, Leafhoppers	2/3 to 1¼	0 (carrots) 3 (parsnips) 14 (celery & parsley)	Treat on a 5 to 7 day schedule. NOT FOR USE ON CELERY IN CALIFORNIA
	Aster leafhopper, Lygus bugs, Spittlebugs	1¼ to 1⅝		
	Armyworm, Corn earworm, Fall armyworm, Slink bugs, Tarnished plant bug	1¼ to 2½		
Corn* (field, sweet, pop)	Armyworm, Chinch bugs, Corn earworm, Corn rootworm adults, European corn borer, Fall armyworm, Flea beetles, Japanese beetle, Sap beetles, Southwestern corn borer, Leafhoppers	1¼ to 2½	0	OBSERVE BEE CAUTION. For insects attacking silks and ears apply at 1 to 6 day intervals, starting when first silks appear and continuing until silks begin to dry. For larvae in whorl and foliage feeders, apply as necessary. For chinch bugs use high gallonage ground application directed at the base of plants. Optimum timing and good coverage are essential for effective control.
	Western bean cutworm	2½		Treat when infestation averages 15% and at 90% to 100% tassel emergence. Treatment after 100% silk emergence will reduce effectiveness.
	Cutworms	2½ to 8		Apply in a 12 inch band, using ¼ pound (4 ounces) per 1000 linear feet of row, in at least 15 gallons of water per acre. For broadcast application use up to 8 pounds in at least 20 gallons (ground) or 5 gallons (air) of water per acre.
* For application to Corn via Center Pivot Irrigation Systems, refer to "Directions for Use Through Center Pivot Irrigation Systems."				
Cotton	Cotton fleahopper, Cotton leafworm, Flea beetles, Stalked blister beetle, Thrips	2/3 to 1¼	0	Early season insect control.

CROP	INSECT	POUNDS OF SEVIN 80S/ 100 GAL.	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Chestnuts	Chestnut weevil	2½ to 3¾	0	Make 4 applications at weekly intervals beginning in late July for adult chestnut weevil control. Last application should be made prior to shuck split. NOT FOR USE IN CALIFORNIA.
Citrus Fruits (such as grapefruit, lemons, limes, oranges, tangelos, tangerines, citrus citron, kumquats and hybrids)	Avocado leafroller California orangedog Citrus cutworm Citrus root weevil Fruitree leafroller Orange tortrix Western tussock moth West Indian sugarcane borer (adults)	1¼	5	Do not apply more than 25 pounds of SEVIN 80S per acre per application Do not apply less than 10 gallons of dilute spray mixture per mature tree. May be mixed with petroleum oils commonly used on citrus.
	Black scale Brown soft scale California red scale Citricola scale Citrus snow scale Yellow scale	1 to 1¼		
Filbert	Filbert aphid Filbert leafroller Filbertworm	1¼	0	Apply when leafroller eggs are hatching. Repeat on first appearance of adult filbert moths and again 3 to 4 weeks later.
Olives	Olive scale	1 to 1¼	0	For optimum scale control add 1½ gallons of summer oil and apply mixture when crawlers are present. Do not exceed 2 applications per year. Do not apply more than 183¾ pounds of SEVIN 80S per acre per application
Peaches Apricots Nectarines	Apple pandemis Codling moth Cucumber beetles European earwig Fruitree leafroller Japanese beetle June beetles Lecanium scales Lesser peachtree borer Olive scale Orange tortrix Oriental fruit moth Peach twig borer Periodical cicada Plum curculio Redbanded leafroller San Jose scale Tarnished plant bug Tussock moths Variegated leafroller	1¼	1 (Peaches) 3 (Apricots & Nectarines)	Do not apply more than 7½ pounds of SEVIN 80S per acre per application to apricots Spray limbs and trunk thoroughly, weekly during moth flight For optimum scale control apply when crawlers are present. Spray limbs and trunk thoroughly, weekly during moth flight

CROP	INSECT	POUNDS OF SEVIN 80S/ 100 GAL.	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Pecans	Black margined aphid Fall webworm Hickory shuckworm Lesser webworm Pecan leaf phylloxera Pecan nut casebearer Pecan spittlebug Pecan stem phylloxera Pecan weevil Twig girdler Walnut caterpillar	1¼ to 3	0	Do not apply more than 9 pounds of SEVIN 80S per acre per application.
Pistachios	Navel orangeworm	¾ to 2	14	Apply dilute volumes of 150 to 300 gallons of mixed spray per acre for full coverage at onset of hull split.
Plums Prunes Cherries	Black cherry aphid Brown soft scale Cherry fruitworm Cherry maggot European earwig Eyespotted bud moth Forbes scale Fruitree leafroller Green fruitworm Japanese beetle Lecanium scales Lesser peach tree borer Mealy plum aphid Oystershell scale Peach twig borer Plum curculio Prune leafhopper Redbanded leafroller Rose chafer San Jose scale Variegated leafroller	1¼	Do not apply more than 7½ pounds of SEVIN 80S per acre per application. For optimum scale control apply when crawlers are present For lesser peachtree borer control, spray limbs and tree trunks thoroughly, weekly during moth flight	
	Codling moth Eastern tent caterpillar Orange tortrix Tussock moth	1		
Walnut	Calico scale European fruit lecanium Filbertworm Fruitree leafroller Frosted scale	⅔	0	Apply 6¾ pounds of SEVIN 80S spray per acre for mature trees
	Codling moth	⅔		For codling moth apply first spray when average cross sectional diameters of developing nuts are ½ to ¾ inch. Repeat during middle or late June as needed
	European earwig	2½		Spray tree trunks to point of run-off.

SMALL FRUIT CROPS

Recommended dosages refer to pounds of SEVIN 80S per acre. The optimum spray gallonage will depend on plant size, density and stage of growth. Typical spray gallonages per acre range from 100-300 gallons for dilute sprays, 30-100 gallons for concentrate sprays and 10-25 gallons for aerial sprays. Do not exceed maximum label rate per acre per application.

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Blackberries Raspberries Dewberries (including boysenberries and loganberries)	European raspberry aphid Japanese beetle Leafhoppers Leafrollers Rose chafer Snowy tree cricket	1¼ to 2½	7	
	Omnivorous leafroller Raspberry sawfly	2½		CALIFORNIA ONLY
Blueberries	Blueberry maggot Cherry fruitworm Cranberry fruitworm European fruit lecanium Japanese beetle	⅛	0	Apply 3 weeks before harvest and repeat as necessary
Cranberries	Cutworms Cranberry fireworms Cranberry fruitworms Japanese beetle Leafhoppers Rose chafer	⅛ to 3⅓	1	CAUTION! May kill shrimp and crabs. Do not use in areas where these are important resources Apply at late bloom and as needed at 7 to 10 day intervals
Grapes	European fruit lecanium Grape leaffolder Grape leafhopper Western grapeleaf skeletonizer Western yellow-striped armyworm	1¼ to 2½	0	Apply before first brood leaffolder larvae emerge from rolls
	Cutworms Eight spotted forester Grape berry moth Japanese beetle June beetles Orange tortrix Omnivorous leafroller Redhumped leafrollin Saltmarsh caterpillar	2½	0	
Strawberries	Flea beetles Meadow spittlebug Omnivorous leaftier (strawberry fruitworm) Strawberry leafroller Strawberry weevil	1½ to 2½	1	SEVIN may injure Early Dawn and Sunrise varieties on the Delmarva Peninsula

TREES AND ORNAMENTALS

For dilute-spray ground applications to trees (including shade trees, shelter belts, forests, plantations, parks and recreational areas), ornamentals, woody plants and shrubs, apply the specified dosage per 100 gallons of water. For concentrate-spray ground applications, apply the specified dosage per acre in sufficient spray volume to provide thorough coverage. To prepare small volumes of spray, use 1¼ tablespoonfuls of SEVIN 80S per gallon of water where rates of 1½ pounds are indicated.

For aerial applications to forest trees (including shade trees, shelter belts, plantations, parks, and recreational areas) and commercially grown ornamentals, woody plants and shrubs, apply the specified dosage per acre in sufficient spray volume to provide thorough coverage. Avoid direct application to lakes, streams and ponds.

CROP	INSECT	POUNDS OF SEVIN 80S	SPECIFIC DIRECTIONS
GROUND APPLICATION: Trees (including shade trees, shelter belts, forests, plantations, parks and recreational areas). Ornamentals (including roses, flowers and other herbaceous plants). Woody Plants and Shrubs. AERIAL APPLICATION: Forest Trees	Ants Apple aphid Armyworm Azalea leafminer Bagworms Birch leafminer Blister beetle Boxelder bug Boxwood leafminer Brown tail moth Cankerworms Catalpa sphinx Chiggers Cooley spruce gall aphid Cutworms Cypress tip moth Hackberry nipplegall maker Holly bud moth Holly leafminer Honeylocust plant bug Japanese beetle Jeffrey pine needleminer June beetles Lace bugs Leafhoppers Leafrollers Locust borer Maple leafcutter Mealy bugs Mimosa webworm Psyllids Puss caterpillar Redhumped oakworm Rose aphid Rose chafer Rosesiug Saddled prominent Sawflies (exposed) Scale insects Sowbugs Spiny elm caterpillar Springtails Spruce budworm	1¼	Observe plant response precautions Apply dilute sprays to obtain thorough coverage of upper and lower leaf surfaces. To control scale insects, treat trunks, stems and twigs in addition to plant foliage. For optimum worm control, treat when in early instars. Addition of a sticker may improve residual control Applications for control of maple leafcutter on sugar maple should be made when larvae are in 2nd instar, after mining, and as cases are being formed

CROP	INSECT	POUNDS OF SEVIN 80S	SPECIFIC DIRECTIONS
(including shade trees, shelter belts, forests, plantations, parks and recreational areas) and Commercially Grown Ornamentals (including roses, flowers and other herbaceous plants). Woody Plants and Shrubs	Douglas fir tussock moth Eastern spruce gall aphid Elm leaf aphid Elm leaf beetle Elm spanworm Eriophyid mites European pine shoot moth Fall armyworm Flea beetles Fuller rose beetle Gall midges Gall wasps Green striped mapleworm Grasshoppers Gypsy moth Nantucket pine tip moth Oak leafminers Oak leaf skeletonizer Oakworm complex Oleander caterpillar Olive ash borer Orange striped oakworm Orange tortrix Periodical cicada Pine sawfly Pine spittlebug Pitch pine tip moth Plant bugs Polistes hornworm Spruce needleminer Subtropical pine tip moth Tent caterpillars Thorn bug Thrips (exposed) Ticks Walnut caterpillar Webworms Western hemlock looper Western spruce budworm Willow leaf beetles Yellow poplar weevil		
	Ips engraver beetles Mountain pine beetle Roundheaded pine beetle Western pine beetle	25	Effective as a preventive treatment only. Repeat annually as required to prevent beetle attacks. Apply 1 gallon of spray per 50 square feet of bark in late May to early July, or prior to beetle attack. Treat tree trunks from ground level up, until trunk diameter is less than 5 inches.
	Elm bark beetle		Apply approximately 20-40 gallons of spray mixture for each 50 feet of elm tree for thorough coverage of all bark surfaces on trunk, limbs, and twigs

MOSQUITO CONTROL

For dilute-spray ground applications to trees (including shade trees, shelter belts, forests, plantations, parks and recreational areas), ornamentals, woody plants and shrubs, apply the specified dosage per 100 gallons of water. For concentrate-spray ground applications, apply the specified dosage per acre in sufficient spray volume to provide thorough coverage. To prepare small volumes of spray, use 1 ¼ tablespoonful of SEVIN 80S per gallon of water, where rates of 1¼ pounds are indicated.

For aerial applications to forest trees (including shade trees, shelter belts, plantations, parks and recreational areas) and commercially grown ornamentals, woody plants and shrubs, apply the specified dosage per acre in sufficient spray volume to provide thorough coverage. Avoid direct application to lakes, streams and ponds.

CROP	POUNDS OF SEVIN 80S/	SPECIFIC DIRECTIONS
Pastures, Rangelands, Parks, Recreational Areas, Logging Camps, Military Posts and Adjacent Forested lands or Wastelands		ADULT MOSQUITOES
	⅓ to 1¼ (⅓ to 1¼ tablespoonful per gallon)	CAUTION! May kill shrimp and crabs. Do not use in areas where these are important resources OBSERVE BEE CAUTION Treat shrubbery and areas where adult mosquitoes congregate. Treat when adult mosquitoes are active in early morning or late evening. Repeat at 7 to 10 day intervals. Use ⅓ to ⅔ pound per 100 gallons in mistblowers, ⅔ to 1¼ pounds per acre in aerial sprays and 1¼ pounds per acre in low pressure ground sprayers.
	3 1¼	For residual control in subtropical regions apply 4 gallons of prepared spray per 2000 square feet of surface area. Repeat in 3 to 6 months or when necessary

PEST CONTROL IN AND AROUND BUILDINGS LIMITED TO PEST CONTROL OPERATORS ONLY

INSECT	POUNDS OF SEVIN 80S/ 100 GAL.	SPECIFIC DIRECTIONS
Ants Cockroaches	25 (25 tablespoonfuls/ gallon)	For use in and around buildings such as homes, apartments, warehouses, barns, and municipal and recreational areas Apply as a coarse wet spray or with a paint brush, and thoroughly treat cracks and crevices, baseboards, corners, walls, door sills, and window frames, quarters of household pets, ant trails, outside perimeter of dwellings and other areas where insects tend to congregate Do not use as a space spray. Repeat when necessary but not more often than twice per week. Do not use in food areas of food handling establishments, restaurants, or other areas where food is commercially prepared or processed. Do not use in serving areas while food is exposed. Avoid application to surfaces where visible spray residues are objectionable
Brown dog tick Earwigs Fleas Millipedes Silverfish Spiders	12½ (12½ tablespoonfuls/ gallon)	

LAWNS AND RECREATIONAL AREAS

CROP	INSECT			SPECIFIC DIRECTIONS
Lawns and Recreational Areas (including turf, golf courses and parks)	Ants Armyworm Bluegrass billbug Centipedes Chiggers Cutworms Earwigs Essex skipper European chafer	Fall armyworm Ferry skipper Fleas Grasshoppers June beetles Leafhoppers Lucerne moth Millipedes Mosquitoes	Sod webworm (lawn moths) Sowbugs Springtails Ticks Yellowstriped armyworm	Use 1¼ pounds of SEVIN 80S in 150 to 200 gallons of spray mixture per 5000 square feet of established lawn, recreational area, roadway or path border. For best results, mow lawn and apply after watering or rain. Insure good penetration of turf. Garden hose or pressure applicators may be used. Repeat 2 to 3 weeks later if necessary.
	Chinch bugs	White grubs		Use 1¾ pounds of SEVIN 80S in 150 to 200 gallons of spray per 5000 square feet

POULTRY INSECT CONTROL

POULTRY	INSECT	SPECIFIC DIRECTIONS
Chickens, Ducks, Geese, Gamebirds, Pigeons, and Turkeys	Chicken mite Fleas Lice Northern Fowl mite	For use as a direct spray on birds by: 1 Misting with Electric Fog Machine: Mix ⅜ pound (6 ounces) of SEVIN 80S in 1 gallon of spray. Use 1½ gallons per 1000 hens in cages, on litter or on slatted floor. Repeat in 4 weeks if necessary. or 2 Spraying with knapsack or cylinder type compressed air sprayers: Mix 1/4 pound (4 ounces) of SEVIN 80S in 5 gallons of spray. Use 1 gallon per 100 hens in cages, on litter or on slatted floor. Repeat in 4 weeks if necessary Direct mist spraying for chicken mite and fleas is a supplement to spraying roosts and buildings for control of these pests Do not apply to poultry and game birds within 7 days of slaughter

POULTRY QUARTERS	INSECT	SPECIFIC DIRECTIONS
Roosts and Buildings	Bedbugs Chicken mite Fleas Fowl tick Lesser mealworms Lice Northern fowl mite	Spray roosts and buildings with conventional power spray or knapsack equipment. For chicken mite, fleas and bedbugs, use 5 pounds of SEVIN 80S per 100 gallons of water. For fowl ticks, use 20 pounds of SEVIN 80S per 100 gallons of water. For lesser mealworms, use 62½ pounds per 100 gallons. Spray 1 to 2 gallons per 1000 square feet of wall, bedding, litter or roost surface. Force spray into cracks. Repeat as needed. Avoid contamination of nests, eggs and feeding and watering troughs. Ventilate while spraying. Do not treat premises within 7 days of slaughter

CENTER PIVOT IRRIGATION APPLICATIONS FOR ALFALFA, CORN AND POTATO

GENERAL PRECAUTIONS FOR APPLICATIONS THROUGH CENTER PIVOT IRRIGATION SYSTEMS

MAINTAIN CONTINUOUS AGITATION IN MIX TANK DURING MIXING AND APPLICATION TO ASSURE A UNIFORM SUSPENSION.

GREATER ACCURACY IN CALIBRATION AND DISTRIBUTION WILL BE ACHIEVED BY INJECTING A LARGER VOLUME OF A MORE DILUTE SOLUTION PER UNIT TIME.

APPLICATION OF MORE THAN LABEL RECOMMENDED QUANTITIES OF IRRIGATION WATER PER ACRE MAY RESULT IN DECREASED PRODUCT PERFORMANCE.

APPLY SEVIN 80S ONLY THROUGH SYSTEMS CONTAINING ANTI-SIPHON AND CHECK VALVES WHICH WILL PREVENT WATER SOURCE CONTAMINATION AND OVERFLOW OF THE MIX TANK, AND CONTAINING INTERLOCKING CONTROLS BETWEEN THE METERING DEVICE AND THE WATER PUMP TO INSURE SIMULTANEOUS SHUT-OFF.

DO NOT APPLY WHEN WIND SPEED FAVORS DRIFT. WHEN SYSTEM CONNECTIONS OR FITTINGS LEAK, WHEN NOZZLES DO NOT PROVIDE UNIFORM DISTRIBUTION OR WHEN LINES CONTAINING THE PRODUCT MUST BE DISMANTLED AND DRAINED.

WHERE SPRINKLER DISTRIBUTION PATTERNS DO NOT OVERLAP SUFFICIENTLY, UNACCEPTABLE INSECT CONTROL MAY RESULT. WHERE SPRINKLER DISTRIBUTION PATTERNS OVERLAP EXESSIVELY, PLANT INJURY MAY RESULT ON SENSITIVE CROPS.

ALLOW SUFFICIENT TIME FOR PESTICIDE TO BE FLUSHED THROUGH ALL LINES AND ALL NOZZLES BEFORE TURNING OFF IRRIGATION WATER.

DIRECTIONS FOR USE THROUGH CENTER PIVOT IRRIGATION SYSTEMS

Spray Preparation: Remove scale, pesticide residues, and other foreign matter from the chemical tank and entire injector system. Flush with clean water.

Application Instructions:
Prepare a suspension of SEVIN 80S Carbaryl Insecticide in a mix tank. Fill tank with ¼ or ½ the desired amount of water. Start mechanical or hydraulic agitation. Slowly add the required amount of SEVIN 80S, and then the remaining volume of water. Suspension concentrations of 1¼ to 2½ pounds of SEVIN 80S per 1 to 4 gallons of water are recommended.

Set sprinkler to deliver 0.1 to 0.3 inches of water per acre. Start sprinkler and then uniformly inject the suspension of SEVIN 80S into the irrigation water line so as to deliver the desired rate per acre. The suspension of SEVIN 80S should be injected with a positive displacement pump into the main line ahead of a right angle turn to insure adequate mixing.

Note: When treatment with SEVIN 80S has been completed, further field irrigation over the treated area should be avoided for 24 to 48 hours to prevent washing the chemical off the crop.

FOR INSECT CONTROL THROUGH CENTER PIVOT IRRIGATION SYSTEMS

Recommended dosages refer to pounds of SEVIN 80S per acre. Consult the Directors for Use and General Precautions Through Center Pivot Irrigation Systems before application.

CROP	INSECT	POUNDS OF SEVIN 80S/ ACRE	PRE-HARVEST INTERVAL (DAYS)	SPECIFIC DIRECTIONS
Alfalfa	Alfalfa caterpillar	1¼ to 2½	0	Observe plant response precautions.
	Grasshoppers	2½		
	Leafhoppers	1½ to 2½		
Corn (field, sweet, pop)	Corn earworm	2½	0	OBSERVE BEE CAUTION. Apply when first silks appear. If local populations warrant, a second application should be made 5 to 7 days after the first. Optimum timing is essential for effective control.
	European corn borer Southwestern corn borer			Apply as necessary. Optimum timing is essential for effective control.
	Western bean cutworm			Make 2 applications. First application should be made at 60% egg hatch. Second application should be made at 98% egg hatch. Optimum timing is essential for effective control.
	Corn rootworm beetles Grasshoppers			Treat as necessary.
Potato	Colorado potato beetles European corn borer Flea beetle	2½	0	Treat as necessary.

Appendix C. Sevin Product Bulletin

PRODUCT BULLETIN

UNION CARBIDE

UNION CARBIDE AGRICULTURAL PRODUCTS COMPANY, INC.
T. W. ALEXANDER DRIVE
P.O. BOX 12014
RESEARCH TRIANGLE PARK, NC 27709

SEVIN® 80S Carbaryl Insecticide
For Use in Washington
EPA No. 264-316

FOR DISTRIBUTION AND USE ONLY IN THE STATE OF WASHINGTON

DIRECTIONS FOR USE:

It is a violation of federal law to use this product in a manner inconsistent with its labeling. This labeling must be in the possession of the user at the time of pesticide application.

Oyster beds: For control of ghost shrimp and mud shrimp. Treatment is allowed only on ground with no oysters or oysters less than one year old on it. A 200 foot buffer zone is required between the treatment area and the nearest marketable shellfish if treatment is by aerial spray, and a 50 foot buffer zone is required if treatment is by ground spray.

Treatment must be timed seasonally to avoid major concentrations of Dungeness crabs. Treatment is not allowed until the ground becomes bare at ebb tide, and must be completed one-half hour after low tide to prevent direct contamination of the water. A 200 foot buffer zone must be maintained between the treatment area and all sloughs and water channels. Treatment must be made at a rate of 10 pounds of carbaryl active ingredient per acre by ground or air equipment. Rates of less that 10 pounds of carbaryl active ingredient may be made only on the specific recommendation of a Washington State Department of Fisheries Biologist. Constant agitation must be maintained to prevent settling.

A special permit must be obtained from the Washington State Department of Fisheries prior to the application. All permits must be screened by the Department of Fisheries with a physical inspection prior to issuance to determine that treatment would be worthwhile and effective, that the ground is bare of oysters, or the oysters are less than one year of age, that the ground is properly staked and flagged, and to protect adjacent shellfish and water areas. Permits must be reviewed by the State of Washington Departments of Agriculture and Social and Health Services. The actual treatment must be conducted under the direct supervision of a staff member of the Washington Department of Fisheries.

The staff member of the Washington Department of Fisheries who is supervising the treatment of ground may suspend or cancel the treatment operations at any time when the conditions for use are violated or environmental conditions change immediately prior to or during treatment.

Special Crab Caution: This product may kill Dungeness crab if they are present on the oyster bed.

CAUTION: Treatment over newly seeded oysters may cause significant mortality to the oysters and should only to be used when risk of this loss is acceptable. Treated oysters may not be harvested for food for two years following treatment.

OBSERVE ALL APPLICABLE DIRECTIONS, RESTRICTIONS & PRECAUTIONS ON THE REGISTERED LABEL.

EPA SLN NO. WA-760021

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Appendix D. Environmental Protection Agency Registration Action Under Section 24(c).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 6 1981

Washington Department of
Agriculture
Grain and Chemical Division
Olympia, WA 98504

Attention: Mr. Glenn E. Smerdon

Gentlemen:

Subject: Registration Action Under Section 24(c)
EPA SLN No. WA-760021

We have re-examined the use of carbaryl for the control of ghost shrimp and mud shrimp on commercial oyster beds and have decided that if the state is willing to adhere to the following restrictions and recommendations we will not consider the registration invalid.

1. That the treatment will be limited only to areas of significant need. To that end, every tract will be carefully examined to ensure that a need exists.

2. Applications are to be limited to areas of 200 feet or more from channels and sloughs (water) and treatment will be done only at low tide when the ground is bare so that the pesticide will not be placed directly into the water. Aerial applications will not be made at wind speeds greater than 10 mph.

3. Application will be permitted only during time (July and August) of reduced abundance of crabs in the general area, since crabs are the primary shellfish species that could be adversely affected.

4. Spraying over commercial oyster crops is not permitted. The treatment will be made during absence of oysters requiring a minimum of 5 days prior to seeding of any oysters on the bed following treatment. After carbaryl application and oyster seeding, a minimum of 3 years will be required before harvesting the oysters.

5. Treatments are to be limited to a maximum of 300 acres per year in Willapa Bay.

6. Treatments in excess of 50 acres are to be applied at intervals.

7. No more than two treatments of carbaryl per given area (or section) are to be made in consecutive years and a three year no-treatment interval prior to retreatment.

8. A monitoring program to observe changes in the planktonic and benthic populations in the use area will continue throughout the 24(c) registration.

9. A tolerance(s) or an exemption(s) from tolerance will be required on all commercially harvested edible marine species. Information concerning this requirement can be obtained by contacting me at (703) 557-7024.

10. Other molluscs capable of co-habitating with the burrowing shrimp should be investigated as possible commercial alternatives to the oyster species in current production.

11. All spraying will be conducted under the immediate supervision of the Department of Fisheries' employees who are empowered to halt the operations should unforeseen crab abundance or potential wind drift produce circumstances unsuitable for the treatment.

The Agency believes that if the above requirements are met, the effects of carbaryl on the environment and non-target species will be kept to a minimal and acceptable level. If these requirements are not adhered to then we may see the need to invalidate the registration.

Respond to this letter by stating in writing your intentions to follow each of these use restrictions, tolerance requirements, and monitoring requirements.

Sincerely,

Jay S. Ellenberger
Product Manager (12)
Insecticide-Rodenticide Branch
Registration Division (TS-767C)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 05 1976

Washington Department of Agriculture
Attention: Mr. Glenn E. Smerdon
Grain and Chemical Division
Olympia, Washington 98504

Gentlemen:

Subject: Registration Action under section 24(c)
EPA SLN NO. WA-760021

D 2

This will acknowledge receipt of your notification of June 8, 1976, to this Agency of a registration, pursuant to section 24(c) of the Federal Insecticide, Fungicide, and Rodenticide Act, as follows:

Product: Sevin 80 Sprayable

EPA Reg. No. 1016-43

24(c) Registrant: Union Carbide Corporation

This acknowledgement is not to be construed as an EPA approval of this registration.

The Department of Fisheries plays an essential role which should continue to be emphasized.

The use appears acceptable if the State is willing to continue to restrict treatment to limited acreage. We have several recommendations relative to this registration, as follows:

1. Treatments should be limited to a total of 400 acres per year.

2. Treatments in excess of 50 acres should be applied in intervals, rather than one application (perhaps on a weekly basis).

3. Treatments must not exceed 10 pounds active ingredient per acre, and should be conducted only during the low tides of July and August.

4. Allow three (3) years prior to re-treatment.

5. A 200-foot buffer zone must be maintained between tideland treated and water, and between treated area and the following: pools, sloughs, channels and oyster beds.

Criteria should be established for the following:

1. Pre-treatment criteria to determine degree of infestation or ghost shrimp activity necessary to initiate control program.

2. Criteria to ascertain what is considered a "major concentration of dungeness crab", so as to determine when treatments should be postponed or prohibited.

We suggest, but do not require, the addition of the statement, "This labeling must be in the possession of the user at the time of pesticide application". The regulations do specify that possession of the labeling is a requirement.

Sincerely yours,

Charles L. Smith
Special Registrations Officer
Registration Division (WH-567)

APPENDIX E
Benthic Invertebrate and Finfish Species Inventory

- CTENOPHORA
  - Nuda
    - *Beroe sp.* ?
- NEMERTEA
  - Enopia
    - Heteronemertea
      - *Amphiporus sp.* 1 (imparispinosis?)
      - *Amphiporus sp.* 2
      - *Paranemertes sp.*
- ACANTHOCEPHALON
  - Found in fish stomachs (starry flounder)
  - Found attached to *Corophim stimpsoni*
- ANNELIDA
  - Oligochaeta
    - Tubificidae
      - *Peloscolex gabriellae*
    - Enchytraeida
      - *Enchytraeus sp.* 1
      - *Enchytraeus sp.* 2
    - Naididae
      - *Naididae sp.* 1
  - Polychaeta
    - Arenicolidae
      - *Abarenicola pacifica*
    - Ampharetidae
      - *Amphicteis mucronata*
      - *Anobothrus gracilis*
    - Capitellidae
      - *Capitella capitata*
      - *Capitellid '6'*
      - *Heteromastus filiformis*
      - *Mediomastus californiensis*
      - *Notomastus tenuis*
    - Cirratulidae
      - *Cirratulus sp.*
    - Goniadidae
      - *Glycinde armigera*
    - Nephtyidae
      - *Nephtys caecoides*
      - *Nephtys ferruginea*
    - Nereidae
      - *Nereis brandti*
      - *Nereis sp.*
      - *Nereis vexillosa*
      - *Nereis virens*
    - Orbiniidae
      - *Haploscoloplos sp.*
      - *Scolopolos armiger*
    - Ophelidae
      - *Armandia bioculata*
      - *Ophelia assimilis*
    - Phyllodocidae
      - *Eteone longa*
    - Polynoidae
      - *Harmothoe imbricata*
      - *Hesperonoe complanata*
    - Sabellidae
      - *Fabricia sabella*
      - *Manayunkia sp.*
    - Sigalionidae
      - *Pholoe minuta*
    - Spionidae
      - *Polydora ligni*
      - *Pseudopolydora kempi japonica*
      - *Pygospio elegans*
      - *Pygospio sp.*
      - *Rhyncospio arenicola*
      - *Spio filicornis*
      - *Spiophanes sp.*
      - *Streblospio benedicti*
    - Syllidae
      - *Brania brevipharyngea*
      - *Sphaerosyllis pirifera*
      - *Syllis sp.*
      - *Trypanosyllis sp.*
      - *Unidentified Syllidae*
- MOLLUSCA
  - Pelecypoda
    - Eulamellibranchia
      - Cardiidae
        - *Clinocardium nuttallii*
      - Mactridae
        - *Tresus capax*
      - Myidae
        - *Mya arenaria*
        - *Cryptomya californica*
      - Ostreidae
        - *Crassostrea gigas*
      - Solenidae
        - *Siliqua patula*
      - Tellinidae
        - *Macoma inconspicua*
        - *Macoma nasuta*
        - *Tellina nuculoides* (salmonea)
      - Veneridae
        - *Protothaca staminea*
        - *Tapes japonica*
        - *Saxidomas giganteus*
    - Filibranchia
      - Mytellidae
        - *Modiolus rectus*
        - *Mytilus californianus*
        - *Mytilus edulis*
  - Gastropoda
    - Nacticidae
      - *Polinices draconis*
    - Nassariidae
      - *Nassarius perpingus*
- ECHINODERMATA
  - Asteroidea
    - *Pisaster ochraceus*
- ARTHROPODA
  - Crustacea
    - Ostracoda
      - Unidentified *ostracod*
    - Copepoda
      - *Clausidium vancouverensis*
      - *Diaptemous sp.*
    - Cirripedia
      - Thoracica
        - *Balanus glandula*
        - *Lepas anatifera*
      - Rhizocephala
        - Unidentified genus: Parasictic on *Corophium*
        - Unidentified genus: Parasictic on *Callianassa*
        - May be *Ellobiopsid*
    - Malacostraca
      - Pericarida
        - Mysidaces
          - *Archaeomysis grevnitzskii*
          - *Mysis oculata?*
          - *Neomysis mercedis*
      - Cumacea
        - *Eudorella sp.*
        - *Eurodorella sp.*
        - *Diastylis sp.*
        - *Lamprops*, *Hemilamprops*, or *Mesoprops sp.*
        - *Leptocuma sp.*
          - Tanaidaces
            - *Leptochelia savignyi*
            - *Pancolus californiensis*

- Isopoda
  - Valvifera
    - *Idotea (Idotea) fewkesi*
    - *Idotea (Idotea) refescens*
    - *Idotea (Penidotea) resecata*
    - *Idotea (Penidotea) wosnesenskii*
    - *Saduria entomon*
  - Flabellifera
    - *Aegidae sp.*
    - *Cirolana kincaidi*
    - *Gnorismosphaeroma oregonensis*
  - Epicaridea
    - *Argeia pugettensis*
    - *Bopyrus sp.*
  - Oniscoidea
    - *Lygidia palsaii*
- Amphipoda
  - Gammaridea
    - *Allorchestes angusta*
    - *Amphithoe sp.*
    - *Anisogammarus confervicolus*
    - *Ceradocus spinicaudus*
    - *Corophium acherusicum*
    - *Corophium oaklandense*
    - *Corophium spinicorne*
    - *Corophium stimpsoni* (later identified as *C. salmonis*)
    - *Dogielinotus loquax*
    - *Eohaustorius sp.*
    - *Hyale ancepts*
    - *Mandibulophoxus gilesi*
    - *Orchestia transkiana*
    - *Orchestoidea pugettensis*
    - *Orchomene pacifica*
    - *Paraphous milleri*
    - *Photis brevipes*
    - *Pontogeneia inermis*
  - Caprellidea
    - *Caprella borealis*
    - *Caprella californica*
    - *Caprella incisa*
- Eucarida
  - Decapoda
    - Natantia
      - Caridea
      - Crangonidae
        - *Crangon alba*
        - *Crangon franciscorum*
        - *Crangon nigricauda*
- Reptantia
  - Astacura
    - Thallasinoidea
      - Callianassidae
        - *Callianassa californiensis*
        - *Upogebia pugettensis*
  - Brachyura
    - Brachygnatha
      - Brachyrhyncha
        - *Cancer magister*
        - *Cancer oregonensis*
        - *Cancer productus*
        - *Hemigrapsus nudus*
        - *Hemigrapsusregonensis*

- Insecta
  - Collembola
    - Arthropleona
      - *Anurida Maritima*
  - Diptera
    - *Aphrosylus sp.*
    - *Saunderia sp.*

- HEMICHORDATA
  - Enteropneusta
    - Unidentified genus

SOURCE: Albright and Rammen 1976.

Invertebrates and finfish found on commercial oyster beds in Willapa Bay.

Species/Group	Common name	Lifestyle
PLANTS		
Algae		
Ulva sp.	sea lettuce	encrusting
Rooted plants		
Zostera marina	eelgrass	rooted
INVERTEBRATA		
Cnidaria		
Anemone sp.	-	encrusting
Nemertea		
Nemertean worms	ribbon worms	infauna
Nematoda		
Nematode worms	hair worms	infauna
Mollusca		
Gastropoda	snails	epifauna
Crepidula adunca	slipper snail	epifauna
Nucella lamellosa	purple whelk	epifauna
Bivalvia	clams, mussels, oysters	
Clinocardium nuttallii	cockle	infauna
Crassostrea gigas	Pacific oyster	epifauna
Cryptomya californica	clam	infauna
Macoma balthica	clam	infauna
Macoma nasuta	bent nose clam	infauna
Modiolus demissus	ribbed mussel	encrusting
Mytilus edulis	blue mussel	encrusting
Ostrea lurida	native oyster	encrusting
Pododesmus macroschisma	rock oyster	encrusting
Tapes japonica	Manila clam	infauna
Annelida	segmented worms	
Polychaeta		
Arenicola cristata	lug worm	infauna
Harmothoe imbricata	scale worm	infauna
Nephtys caecoides		infauna
Nereis vexillosa		infauna
Nothria iridescens		infauna
Pectinaria granulata		infauna
Pherusa sp.		infauna
Arthropoda		
Crustacea		
Cirripedia	barnacles	
Balanus sp.	acorn barnacle	encrusting
Isopoda		
Gnorimosphaeroma lutea		epifauna
Amphipoda		
Ampithoe valida		infauna
Corophium aschericum		infauna
Corophium insidiosum		infauna
Eohaustorius washingtonianus		infauna
Tanaidacea		
Leptochelia dubia	tanaid	infauna
Decapoda		
Callianassa californiensis	ghost shrimp	infauna
Cancer magister	Dungeness crab	epifauna
Hemigrapsus oregonensis	shore crab	epifauna
Upogebia pugettensis	mud shrimp	infauna
Insecta		
Collembola	springtail	epifauna
Diptera larva	midge larva	epifauna
Bryozoa (Ectoprocta)		
Schizoporella unifornis	moss animal	encrusting
CHORDATA		
Urochordata	tunicates	
Chelyosoma productum	tunicate	encrusting
Pisces	fish	
Ophiodon elongatus	lingcod	epifauna
Pholis ornata	saddleback gunnel	epifauna

SPECIES COMPOSITION OF FISHES IN GRAYS HARBOR

Petromyzontidae - lampreys
*Pacific lamprey - Lampetra tridentata

Squalidae - dogfish sharks
Spiny dogfish - Squalus acanthias

Rajidae - skates
Big skate - Raja binoculata

Acipenseridae - sturgeons
White sturgeon - Acipenser transmontanus
Green sturgeon - Acipenser medirostris

Clupeidae - herrings
American shad - Alosa sapidissima
Pacific herring - Clupea harengus pallasi
Pacific sardine - Sardinops sagax

Engraulidae - anchovies
Northern anchovy - Engraulis mordax

Salmonidae - salmon, trout, and char
Chum salmon - Oncorhynchus keta
Coho salmon - Oncorhynchus kisutch
Chinook salmon - Oncorhynchus tshawytscha
Cutthroat trout - Salmo clarki
Steelhead trout - Salmo gairdneri
Dolly Varden - Salvelinus malma

Osmeridae - smelts
Surf smelt - Hypomesus pretiosus
Longfin smelt - Spirinchus thaleichthys
*Eulachon - Thaleichthys pacificus

Cyprinidae - minnows
*Peamouth - Mylocheilus caurinus
Northern squawfish - Ptychocheilus oregonensis

Gadidae - codfishes
Pacific tomcod - Microgadus proximus

Atherinidae - silversides
Topsmelt - Atherinops affinis affinis

Gasterosteidae - sticklebacks
Threespined stickleback - Gasterosteus aculeatus

Syngnathidae - pipefishes
Bay pipefish - Syngnathus griseolineatus

Embiotocidae - surfperches
Redtail surfperch - Amphistichus rhodoterus
Shiner perch - Cymatogaster aggregate
Striped seaperch - Embiotoca lateralis
Walleye surfperch - Hyperprosopon argenteum
Silver surfperch - Hyperprosopon ellipticum
White seaperch - Phanerodon furcatus
Pile perch - Rhacochilus vacca

Pholidae - gunnels
Saddleback gunnel - Pholis ornata

Ammodytidae - sand lances
Pacific sand lance - Ammodytes hexapterus

Gobiidae - gobies
Arrow goby - Clevelandia ios

Hexagrammidae - greenlings
Kelp greenling - Hexagrammos decagrammus
Mask greenling - Hexagrammos octogrammus
Lingcod - Ophiodon elongatus

*Scorpaenidae - rockfishes
Black rockfish - Sebastodes melanops

Cottidae - sculpins
*Prickly sculpin - Cottus asper
Pacific staghorn sculpin - Leptocottus armatus
Padded sculpin - Artedius fenestralis
Buffalo sculpin - Enophrys bison
Cabezon - Scorpaenichthys marmoratus

Stickaeidae - pricklebacks
Snake prickleback - Lumpenus sagitta

Agonidae - poachers
Sturgeon poacher - Agonus acipenserinus
Wartysea poacher - Occa verrucosa

Cyclopteridae - lumpfishes and snailfishes
Blacktail snail fish - Careproctus melanurus

Bothidae - lefteyed flounders
Pacific sanddab - Citharichthys sordidus

Pleuronectidae - righteyed flounders
English sole - Parophrys vetulus
Starry flounder - Platichthys stellatus
Sand sole - Psettichthys melanosticus

Appendix F. Birds of Willapa Bay and Grays Harbor

Explanation of Symbols

Breeding: * - (after species name) Known to breed regularly within Willapa Bay or Grays Harbor.

References: - Wahl, R. and R. Paulson. 1981. A Guide to Bird Finding in Washington. Whatcom Museum Press, Bellingham, WA.
- Willapa Bay National Wildlife Refuge Checklist and Widrig, R. 1980. The Birds and Plants of Long Beach Peninsula.

Habitats: SW - open salt water
SS - sandy shore
FW - fresh water (including marsh and shore)

Abundance: (in columns under Habitats and Seasons)
A - abundant
C - common; often seen or heard in appropriate habitats
U - uncommon; usually present but not seen or heard on every visit to appropriate habitats
R - rare; present in appropriate habitats only in small numbers and seldom seen or heard

Seasons: S - Spring F - Fall
S - Summer W - Winter

	Habitats			Seasons			
	SW	SS	FW	S	S	F	W
GAVIIDAE							
Common Loon	C		U	C	C	C	C
Arctic Loon	C		R	C	U	C	U
Red-throated Loon	C			C	U	R	C
PODICIPEDIDAE							
Red-necked Grebe	C		U	U		U	U
Horned Grebe	C		U	C	R	C	C
Western Grebe	C		C	A	U	A	A
Pied-billed Grebe	U		C	U	U	U	U
PROCELLARIIDAE							
Sooty shearwater	C			U	C	A	
PELECANIDAE							
Brown Pelican	R				R	U	
PHALACROCORACIDAE							
Double-crested Cormorant	C		U	C	C	C	C
Brandt's Cormorant	C			C	C	C	C
Pelagic Cormorant	C			C	C	C	C
ARDEIDAE							
Great Blue Heron		C	C	C	C	C	C
Great Common Egret	U			R		R	
American Bittern			C	R	R	U	R
ANATIDAE							
Whistling Swan			C			C	C
Trumpeter Swan						C	C
Canada Goose	U		C	A	C	A	C
Brant	C			C		U	C
White-fronted Goose	U		R	U		U	R
Snow Goose				R		R	R
Mallard	C		C	C	C	C	C
Gadwall	U		C	C	R	C	C
Pintail	C		C	C	U		C
Green-winged Teal	C		C	C	U	C	U
Cinnamon Teal	R		C	R		R	R
European Widgeon	R		R	R		R	R
American Widgeon	C		C	C	R		C
Shoveler	C		C	U	R	U	C
Redhead	R		C			R	U
Ring-necked Duck	R		C	U		C	U
Canvasback	C		C	C		C	C
Greater Scaup	C		C	C	U	C	C
Lesser Scaup	C		C	U	R	U	U
Common Goldeneye	C		C	U		U	C
Barrow's Goldeneye	C		C	R		R	R
Bufflehead	C		C	C	R	C	A
Oldsquaw	U		R	U	R	R	U
White-winged Scoter	C		R	C	U	A	A
Surf Scoter	C		R	C	U	C	A
Common Scoter	U			U	R	U	U
Ruddy Duck	U		C	U	R	U	U
Hooded Merganser	R		U	U	R	U	U
Common Merganser	U		U	U	U	U	C
Red-breasted Merganser	C		R	C	U	C	C
ACCIPITRIDAE							
Sharp-shinned Hawk				U		U	C
Cooper's Hawk				U	U	U	C
Red-tailed Hawk				U	U	C	C
Bald Eagle		C		U	U	U	U
Marsh Hawk			C	U	U	C	C
PANDIONIDAE							
Osprey		U	U		U		
FALCONIDAE							
Peregrine Falcon		R		U		U	R
Merlin Pigeon Hawk				U		U	U
American Kestrel				U		U	R
GRUIDAE							
Sandhill Crane			U			R	

	Habitats			Seasons			
	SW	SS	FW	S	S	F	W
RALLIDAE							
Virginia Rail			C	U	U	U	U
American Coot	C	C		U	R	U	U
HAEMATOPODIDAE							
Black Oystercatcher					R		R
CHARADRIIDAE							
Semipalmated Plover		C	R	C	C	C	R
Snowy Plover		U		U	U	U	R
Killdeer		U	C	U	U	C	U
American Golden Plover		U	R	R	R	U	R
Black-bellied Plover		C	U	C	C	C	C
Surfbird				U	R	U	R
Ruddy Turnstone		U	R	U		U	R
Black Turnstone		U		U		U	C
SCOLOPACIDAE							
Common Snipe		U	C	C	R	C	U
Long-billed Curlew		R	R	U	U	U	R
Whimbrel		C	R	C	C	C	
Spotted Sandpiper		C	C	U	R	U	
Wandering Tattler				U	U	U	
Willet		R	R	R	R	U	R
Greater Yellowlegs		C	C	C	U	C	U
Lesser Yellowlegs		U	C	C	U	C	C
Red Knot		C	R	C	U	U	
Sharp-tailed Sandpiper		R		R		U	
Pectoral Sandpiper		C	C			C	
Baird's Sandpiper		U	C	R	R	U	
Dunlin		C	R		U		
Short-billed Dowitcher		C	R	U		U	
Long-billed Dowitcher		C	C		U		
Western Sandpiper		C	C		C		
Buff-breasted Sandpiper		R			R	R	
Marbled Godwit		R	R	R		U	
Sanderling		C	U	C	U	C	
Least Sandpiper		C	C		U		
PHALAROPODIDAE							
Red Phalarope	U	R		R		R	
Wilson's Phalarope		U	C	R			
Northern Phalarope	C	U	C	U		U	
STERCORARIIDAE							
Parasitic Jaeger	C				R	U	U

	Habitats			Seasons			
	SW	SS	FW	S	S	F	W
LARIDAE							
Glaucous Gull	R	R	R	U	U		U
Glaucous-winged Gull	C	C	U	C	U	C	C
Western Gull	C	C		C	U	C	C
Herring Gull	C	C	U	C	U	C	
Thayer's Gull	C	C		U		U	U
California Gull	C	C	C	U	C	C	U
Ring-billed Gull	U	U	C	C	U	C	C
Mew Gull	C	C	U	C	R	C	C
Bonaparte's Gull	C	C	C	C		C	U
Heermann's Gull	C	C		U	U	C	C
Black-legged Kittiwake	C			U		C	U
Common Tern	C	C		R	U	C	
Arctic Tern	U	R		R		U	
Caspian Tern	U	U	U	U		U	
ALCIDAE							
Common Murre	C			C	U	C	
Pigeon Guillemot	C			C	U	C	
Marbled Murrelet	C			R			R
Rhinoceros Auklet	C			R			R
STRIGIDAE							
Gread Horned Owl				C	C	C	C
Short-eared Owl				U	U	U	U
ALCEDINIDAE							
Belted Kingfisher		C	C	C	C	C	C
CORVIDAE							
Common Raven			C	R	R	R	R
Crow - Common and Northwestern		C	C	C	C	C	C

Appendix G. Executive Summary (Draft) "The 1984 Use of the Insecticide SEVIN to Control Burrowing Shrimp in Willapa Bay and Grays Harbor, Washington.

EXECUTIVE SUMMARY
(Draft)

THE 1984 SITUATION

Ghost and mud shrimp are considered as pest by the Washington state commercial oyster growers. The shrimp burrow extensive networks of tunnels in the oyster beds. This burrowing softens the bottom and releases sediments. Oysters cultured on infested beds may sink into the bottom or be buried by the sediments and die. Burrowing shrimp on the oyster beds have been controlled by applications of the insecticide SEVIN since 1963. These treatments are regulated by the Washington Departments of Fisheries.

Use of SEVIN is Willapa Bay and Grays Harbor has been a subject of concern. Because of potential environmental impacts. An environmental impact statement (EIS) was prepared on treatments, and the draft EIS issued shortly before the 1984 treatments.

An El Nino event during 1982 and 1983 caused substantial biological changes off the Washington coast, in Willapa Bay and in Grays Harbor. These changes included decreased oyster production and increased populations of burrowing shrimp. As a result, the coastal oyster growers received permission to treat acreage in excess of previous limits and to spray over seed oysters on a one-time emergency basis.

During the 1984 treatments, WDF obtained additional information on the effects of the insecticide. This research included methods to improve assessment of crab losses and further reduce mortalities. Other studies examined effects on benthic communities and the fate of SEVIN in estuarine water. This progress report presents the results of the 1984 SEVIN treatments and the associated studies.

DUNGENESS CRAB MORTALITY

Preliminary observations of the oyster beds showed unusually large populations of young-of-the-year (YOY) Dungeness crab associated with areas proposed for treatment. Subsequent examination before spraying indicated that these crab had moved from intertidal oyster beds into nearby subtidal habitats, as has been seen in previous years. However, initial SEVIN treatments resulted in unexpectedly large mortalities of YOY crab. In past years the crab mortalities had primarily been 1 and 2 year old crab. As a result, WDF modified the spraying schedules to reduce crab losses and shifted all available personnel to manage the treatment and minimize mortalities. Consequently, several planned experiments were not conducted.

After completion of the treatments, it was found that approximately 77 percent of all dead crab were YOY. According to available data, these observed losses represented 0.002 to 0.02 percent of the estimated juvenile crab population in Willapa Bay. Prior to treatment, WDF established a maximum allowable crab loss of 9,000 juvenile crab (1 to 3 years old) in Willapa Bay. The total observed mortality was 89 percent of this ceiling.

Crab loss estimates were highly variable, apparently because of habitat patchiness. Available information indicates that when heavy algae cover is present, spraying over seeded beds may contribute to higher losses of YOY crab.

CHUMMING EXPERIMENTS

Observations during previous SEVIN treatments found most crab mortalities adjacent to river channels or sloughs. WDF and the oyster growers predicted that placing bait or "chum" in the sloughs adjacent to the treated tracts may divert foraging crabs from the sprayed ground and reduce mortalities.

An initial experiment was conducted to assess the effectiveness of chumming. Preliminary results indicated a significant reduction in mortalities WDF had planned a more vigorous study of the effectiveness of chumming but was forced by high crab mortalities to act on the preliminary indications of success and chum all feasible areas. These observations need confirmation and further study remains a high priority for the 1985 treatments.

BENTHIC COMMUNITY IMPACTS

One of the major concerns about SEVIN USE is its effect on the community of bottom dwelling (benthic) invertebrates on the intertidal oyster beds. Potential impacts on crab, finfish, and birds could occur if substantial reductions in populations of the small crustacea (such as amphipods, tanaids and copepods) result from SEVIN use. All of these are important food items for other organisms and commercial fish species.

In order to document short-term effects of spraying on benthic communities, quantitative sampling was conducted in 1984 on a tract scheduled for SEVIN treatment. Preliminary results of this sampling indicate limited effects from spraying, primarily initial, short-term reductions of these communities on the tracts. Additional studies are being conducted to better assess these impacts and their significance.

WATER AND SEDIMENT QUALITY

One of the more important concerns over the use of any pesticide is its persistence in the environment after treatment. Studies were conducted in 1983 and 1984 on the uptake and persistence of SEVIN in sediments and water

associated with treated oyster beds. SEVIN concentrations in sediment dropped quickly after spraying but were highly variable. After 24 hours, SEVIN was present in concentration 3 to 9 percent of the initial level.

Water samples from treated beds showed that SEVIN and its decomposition product, 1-naphthol, disappeared from the water column almost completely in less than an hour. When these results are compared to other experiments, it is apparent that the sediment and water temperature are important in determining the environmental degredation rate of SEVIN.