Chapter 26

Mortality of Marbled Murrelets Due to Oil Pollution in North America

Harry R. Carter[1] **Katherine J. Kuletz**[2]

Abstract: Mortality of Marbled Murrelets (*Brachyramphus marmoratus*) due to oil pollution is one of the major threats to murrelet populations. Mortality from large spills and chronic oil pollution has been occurring for several decades but has been documented poorly throughout their range; it probably has contributed to declines in populations, in conjunction with loss of nesting habitat and mortality in gill nets. The 1989 *Exxon Valdez* oil spill in Alaska caused the largest single mortality of murrelets (about 8,400 birds) in the world and contributed to decline in murrelet populations in Prince William Sound. Due to inadequate baseline data, low recovery of oiled carcasses, and other factors, the full impacts of this extensive mortality have not been determined. Restoration activities have included acquisition of murrelet nesting areas in old-growth forests in southcentral Alaska. Similar acquisition of old-growth forests will occur as restoration for mortality from the 1986 *Apex Houston* oil spill in California. Future oil spills will continue to threaten the viability of small, declining populations, especially in California, Oregon and Washington where a single large spill could extirpate an entire population. Efforts must be expanded to: better document mortalities during large and small spills, develop better baseline data to assess impacts, identify old-growth forests for acquisition for restoration, and reduce oil pollution.

Large oil spills have killed millions of seabirds around the world in this century, as recently demonstrated during the 1989 *Exxon Valdez* spill in Alaska (Ford and others 1991a, Piatt and Lensink 1989, Piatt and others 1990a). In particular, oil pollution poses a significant threat to Marbled Murrelets (*Brachyramphus marmoratus*) in Alaska, British Columbia, Washington, and California (Carter and Morrison 1992, King and Sanger 1979, Marshall 1988a, Sealy and Carter 1984, Wahl and others 1981). Large numbers of Marbled Murrelets were killed during the *Exxon Valdez* spill, and this has increased concerns. Large oil spills result periodically from: oil tanker and barge mishaps (groundings, collisions, explosions, accidental spillages); similar mishaps by other large ocean-going vessels; offshore oil wells (well blow-outs, accidental spillages); unloading and loading cargo from onshore and offshore facilities; and onshore facility spills that enter the ocean. In addition, small oil spills occur frequently in many populated areas due to cleaning of tanks at sea, bilge pumping and smaller accidental spills. All types of boats and marine transportation vessels may be involved. Other forms of marine pollution that may affect seabirds are considered by Fry (this volume).

Impacts of large oil spills on seabirds in California, Oregon, and Washington have been well-documented during the last 25 years, and sporadically in earlier years. Widespread concern about the effects of oil spills on seabirds along the west coast developed after the 1969 Santa Barbara and 1971 San Francisco oil spills in California and smaller spills in Washington. These spills followed similar events in Europe such as the 1967 *Torrey Canyon* spill in the western English Channel (Bourne and others 1967). Since the 1970s, the documentation of oil spills and their impact on seabirds has been much improved.

Impact assessment is now formalized within Natural Resource Damage Assessment (NRDA) legislation. When possible, the numbers of birds affected are enumerated and impacts at the population level are determined. Impacts include: the direct deaths of birds found dead on shore; deaths of birds found alive on shore and taken to rehabilitation centers; deaths of birds at sea and on shore that are not directly enumerated; reductions in numbers of breeding birds; reductions in breeding range; reduced breeding success; and the sublethal effects of oiling for birds that survived initial oil contamination whether rehabilitated or not.

When the full impacts of oil pollution are considered, lethal and sublethal impacts may have profound effects on local populations, especially when oil mortality acts in concert with other anthropogenic and/or natural factors affecting populations (Piatt and others 1991, Swartzman and Carter 1991, Takekawa and others 1990). However, population impacts are often difficult to demonstrate because they usually require detailed pre-event baseline data, careful injury determination, and detailed follow-up data after the event.

In this paper, we review documentation of mortality of Marbled Murrelets due to oil pollution throughout their range in North America. In particular, we have focused on providing a summary of mortality and restoration efforts after the 1989 *Exxon Valdez* spill in Alaska and details of mortality for several smaller spills in California, Oregon, Washington, and British Columbia, where the species in now listed as threatened. Information for the three southern states was collated for the Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service, in press).

Exxon Valdez Oil Spill

The largest single event of Marbled Murrelet mortality from oil pollution in North America was the *Exxon Valdez* oil spill in Prince William Sound, Alaska. On 24 March

[1] Wildlife Biologist, National Biological Service, U.S. Department of the Interior, California Pacific Science Center, 6924 Tremont Road, Dixon, CA 95620

[2] Wildlife Biologist, U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 East Tudor Road, Anchorage, AK 99503

1989, the oil supertanker *Exxon Valdez* spilled 11 million gallons of crude oil, that eventually travelled 750 km to the southwest and covered approximately 30,000 km^2 of coastal and offshore waters in southcentral Alaska (see *fig. 1*; Piatt and others 1990a).

Immediate Mortality

Alcids had the highest rate of mortality, as compared to the population at risk. Of six species of small alcids, Marbled Murrelets suffered the highest mortality (Ford and others 1991a, Piatt and others 1990a). An estimated 75 percent of Marbled Murrelets in U.S. waters breed in Alaska (Ralph and others, this volume a). Other than southeast Alaska, the primary population areas are Prince William Sound, the southern Kenai Peninsula, and the Kodiak archipelago (Piatt and Ford 1993; Piatt and Naslund, this volume). Therefore, a large portion of the U.S. murrelet population was at risk from the *Exxon Valdez* spill.

Immediate impacts of the *Exxon Valdez* oil spill on seabirds were attempted through two main approaches: (1)

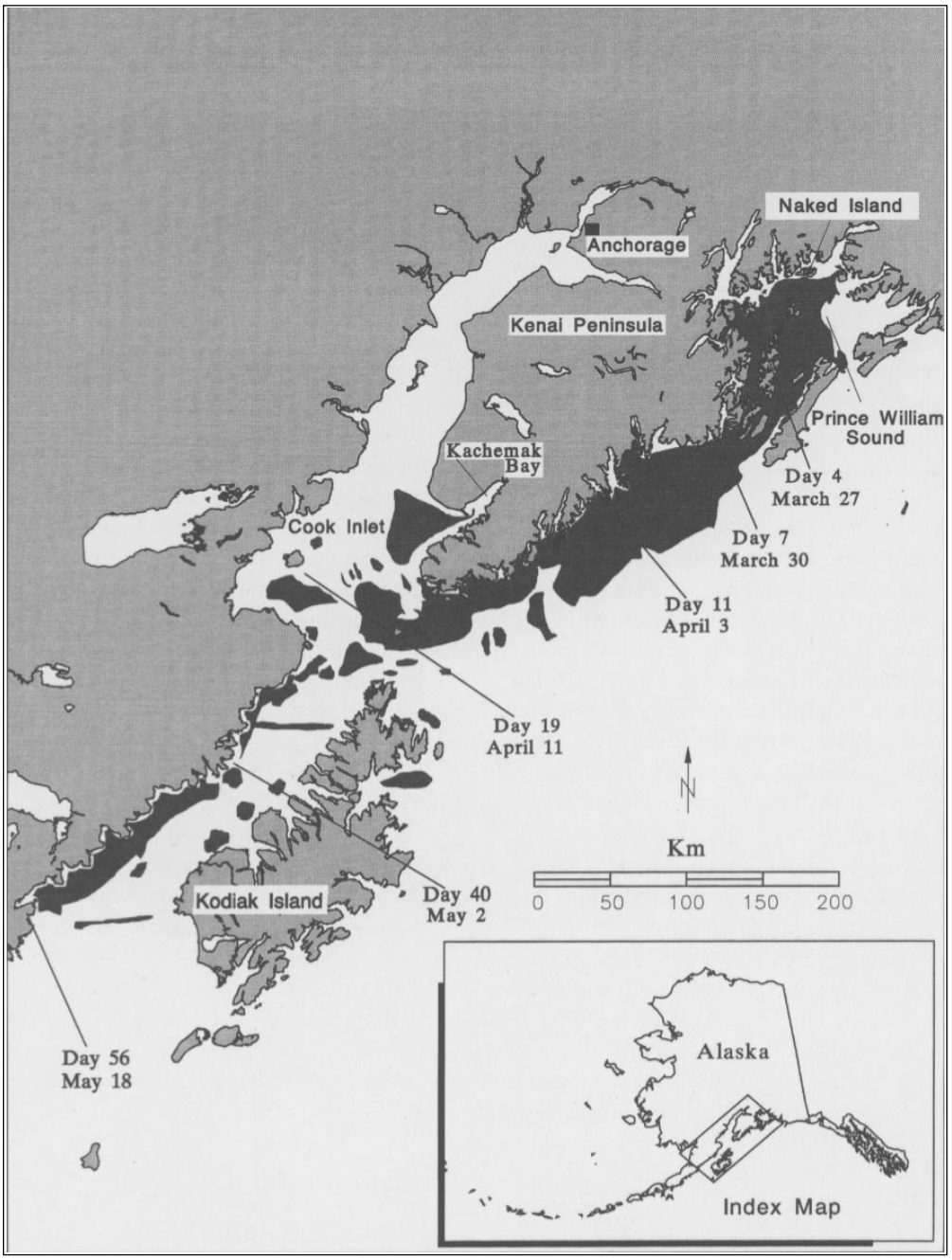

Figure 1—Extent of surface oiling (dark shading) from the *Exxon Valdez* oil spill as it spread from Prince William Sound in late March 1989 to the Alaska peninsula by late June 1989.

an estimate of the total numbers of seabirds killed was constructed, based on numbers of carcasses recovered from beaches and complex extrapolations to account for times and shoreline areas not covered, and the loss of carcasses at sea and on land (Ford and others 1991a); and (2) other NRDA studies were conducted to measure population impacts at breeding colonies and at sea for specific species and areas. All NRDA studies were initiated under the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Clean Water Act. Population estimates for Marbled Murrelets in Prince William Sound were obtained from NRDA Bird Study No. 2 (Klosiewski and Laing 1994). These population estimates were compared with those derived from similar surveys in 1972-1973 (Dwyer and others 1976) and 1984-1985 (Irons and others 1985). NRDA Bird Study No. 6 examined indices of changes in murrelet numbers and productivity at two locations in the spill zone and collected tissue samples for contaminant studies (Kuletz, in press; Oakley and others 1994).

Approximately 30,000 seabird carcasses were recovered in the spill zone throughout the spring and summer of 1989 through a large-scale effort coordinated by Exxon. Carcasses were processed and identified by U.S. Fish and Wildlife Service personnel. A variety of estimates suggest that at least 240,000 seabirds were killed (Ford and others 1991a; Piatt and Anderson, in press; Piatt and others 1990a). Murrelet carcasses were identified to species (i.e. Marbled, Kittlitz's or Ancient murrelets [*B. marmoratus*, *B. brevirostris*, *Synthliboramphus antiquus*]) whenever possible. However, many carcasses could only be classified as unidentified murrelets. Using U.S. Fish and Wildlife Service data files on identified carcass recoveries, recovery location and estimated carcass recovery rates for each region (Ford and others 1991a), the total mortality estimate was about 8,400 *Brachyramphus* murrelets (*table 1*). Most *Brachyramphus* murrelets were Marbled Murrelets. The estimate included only about 255 Kittlitz's Murrelets. Additional work is required to refine such estimates based on a reexamination of sample carcasses held in freezer vans after the spill (Ford and others 1991a). However, based on preliminary analyses, it is unlikely that estimates will change dramatically (Carter, unpubl. data; Ford and others 1991a; Page, pers. comm.).

The *Exxon Valdez* spill zone may support roughly half of the estimated 280,000 Marbled Murrelets in Alaska (Mendenhall 1992; Piatt and Ford 1993; Piatt and Naslund, this volume). If so, then approximately 6 percent of the murrelets in the spill zone were killed directly by oil. The carcass recovery rate for murrelets was probably lower than for other seabirds due to their small body size (Ford and others 1991a). Thus, the mortality estimate should be considered a minimum number.

Despite the high mortality of murrelets, U.S. Fish and Wildlife Service at-sea surveys of murrelet abundance in Prince William Sound were unable to demonstrate an effect of oiling on the marine population, although the total population had declines 67 percent since 1972. Murrelet populations were compared after the spill between oiled and unoiled areas, as well as to 1972 estimates (Klosiewski and Laing 1994). Kuletz (in press) suggested that significant oiling impacts were masked in this comparison. First, individual murrelets can forage over wide areas that may be up to 75 km apart (Burns and others 1994), making the assignment of birds to "oiled" or "unoiled" areas an uncertain exercise. Second, murrelets dispersed to widely scattered breeding sites up to a month after the initial oiling event. Part of the breeding population in Prince William Sound was exposed to oil prior to entering the Sound. Only about 25 percent of the summer population is present in the Sound in March (Klosiewski and Laing 1994). In nearshore southcentral Alaska, murrelet numbers increase throughout April, and do not reach summer peak numbers until May (Kuletz, unpubl. data; Vequist and Nishimoto 1990). The majority of murrelet carcasses were retrieved in April (Ford and others 1991a, Piatt and others 1990a) and most murrelets may have been killed outside Prince William Sound as they migrated northward and inshore in April. Large numbers are known to winter in the vicinity of Kodiak Island, southwest of the initial spill area in Prince

Table 1—Estimates of direct mortality of* Brachyramphus *murrelets from the* Exxon Valdez *oil spill in Alaska in 1989. Carcasses were identified as Marbled Murrelets (MAMU), Kittlitz's Murrelets (KIMU), or unidentified murrelet which includes Ancient Murrelets (see text)

Region	Estimated recovery rate	Number MAMU carcasses	Estimated MAMU mortality	Number KIMU carcasses	Estimated KIMU mortality	Number unidentified murrelet carcasses	Estimated unidentified murrelet mortality	Estimated[1] total mortality
Prince William Sound	0.35	289	826	23	66	21	60	952
Kenai Peninsula	0.14	113	807	23	164	73	521	1,492
Barren Islands	0.49	17	35	4	8	14	29	72
Kodiak Island	0.06	64	1,066	1	17	71	1,183	2,266
Alaska Peninsula	0.02	45	2,250	0	0	27	1,350	3,600
Total		528	4,984	51	255	206	3,143	8,382

[1]Excludes Ancient Murrelets, based on carcasses identified to species (see text).

William Sound (Forsell and Gould 1981). This scenario is supported by the relatively high proportion of carcasses estimated as killed outside Prince William Sound (*table 1*), compared to the relatively low numbers of murrelets which breed in other areas (Piatt and Ford 1993).

Other Impacts

A variety of other impacts to murrelets occurred as a result of the *Exxon Valdez* oil spill. Some murrelets were sublethally oiled and probably were affected physiologically after the immediate oiling event. Oakley and others (1994) found evidence of compounds indicative of oil ingestion in murrelets collected in 1989 in heavily-oiled areas, but not in lightly-oiled or unoiled areas of Prince William Sound. Murrelets also were affected in foraging areas by increased human activity, associated with clean-up and monitoring programs. In the summer of 1989 in Prince William Sound, Exxon mobilized over 600 marine vessels and 85 aircraft which logged 6,000 flight hours (Carpenter and others 1991). A reduced operation was conducted in 1990, followed by minimal operations in 1991 and 1992. In 1989, repeated surveys at Naked Island (in central Prince William Sound) and in Kachemak Bay (in lower Cook Inlet) showed a decrease in the number of murrelets with an increase in boat traffic over the course of the summer (Kuletz, in press). Similarly, land-based counts showed a similar relationship between murrelet numbers and boat and low-flying aircraft counts per hour. The *Exxon Valdez* was anchored at Naked Island until late June 1989. This area was a staging ground for clean-up and monitoring activities. Kuletz (in press) found significantly fewer murrelets there in 1989, compared to three pre-spill years. In 1990-1992, murrelet numbers returned to pre-spill levels.

The oil spill may have impacted on forage fish populations. Prey species for murrelets in south central Alaska include Pacific sand lance (*Ammodytes hexapterus*), capelin (*Mallotus villosus*), cod (*Gadidae* spp.) and juvenile Pacific herring (*Clupea harengus*) (Kuletz, unpubl. data; Sanger 1983, 1987). Seabird diet studies in Prince William Sound indicated that sand lance and herring were less available in 1989 and 1990 than in pre-spill years (Irons 1992; Oakley and Kuletz 1994; Piatt and Anderson, in press). Many prey species are intertidal spawners, and are more susceptible to oil pollution than pelagic spawners (Trasky and others 1977). At Naked Island, herring had high levels of sublethal damage and larval malformations after the spill; herring did not spawn there in 1991 (Hose and others 1993). Herring returns were drastically reduced between 1992-1994 and adult fish have had high rates of viral infections. On the other hand, there is evidence that the composition and abundance of forage fish populations throughout the Gulf of Alaska have changed markedly during the last 20 years (Piatt and Anderson, in press).

Marbled Murrelets may have experienced lower reproductive success at Naked Island after the spill, as evidenced by lower numbers of juveniles in relation to adults on the water (Kuletz, in press). In contrast, the adult:juvenile ratio at Kachemak Bay did not change after the spill. Kachemak Bay was further removed temporally and spatially from the spill epicenter. The potential for disruption of breeding activities in Prince William Sound was great due to the potential combination of direct mortality of adults, direct mortality of mates affecting surviving mates, displacement from foraging areas due to human activity, sub-lethal oil ingestion, and possible impacts on the prey base.

Restoration

Planning for restoration activities, mandated under CERCLA, began in late 1989. In October 1989, under a civil consent decree between Exxon and the state and federal governments, Exxon agreed to make ten annual payments totaling $900 million for injuries to natural resources, agency service costs, and for restoration and replacement of natural resources. A portion of these funds were used to lay the groundwork for restoration of the injured resources. Under a Memorandum of Agreement between state and federal governments, the restoration funds were to be used "...for the purposes of restoring, replacing, enhancing, or acquiring the equivalent of natural resources injured as a result of the Oil Spill...", and further, that the funds had to be spent on resources in Alaska if possible. Six appointed Trustees have overseen public meetings, authorization of projects, and implementation of restoration programs (Exxon Valdez Oil Spill Trustee Council [EVOSTC] 1994).

Public input has been an important part of the restoration process. Overwhelming public support was indicated for acquisition of land to protect natural resources and promote recovery. For aesthetic and recreational reasons, as well as to protect commercially-important salmon resources, the acquisition of forested lands has remained a high priority. Few other options could be agreed upon to restore injured resources within a landscape of the size and complexity of the *Exxon Valdez* oil spill zone. By 1994, 42 percent of the $100 million committed to annual work has been allocated to habitat protection (EVOSTC 1994). Marbled Murrelets were known to depend on old-growth forests, were impacted heavily by the spill, and have become a focal species for ranking lands for potential acquisition. Therefore, the Marbled Murrelet Restoration Project attempted to describe their nesting habitat in the spill zone (see Kuletz and others, in press; Kuletz and others, this volume; Marks and others, in press; Naslund and others, in press).

Although protection of nesting habitat in old-growth forests removes one future threat to murrelets, partial or full recovery may not be possible until other threats are addressed. For example, mortality in commercial gill-net fisheries (Carter and others, this volume) and apparently high predation levels also impact murrelet populations in the spill zone.

Summary

The *Exxon Valdez* oil spill made it abundantly clear that oil spill prevention, response preparation, and habitat protection are the best means to reduce the impact of oil pollution on

Marbled Murrelets in Alaska. Large oil spills cannot be effectively contained, and rehabilitation efforts can be costly and of limited value to affected populations. *Brachyramphus* murrelets comprised only 2.4 percent of the total number of birds brought to rehabilitation centers during the spill (Wood and Heaphy 1991). Murrelets did not respond well to rehabilitation efforts. Only 3 of 33 Marbled and 2 of 6 Kittlitz's murrelets survived to be released (Wood, pers. comm.), compared to 51 percent released of all 1,630 treated birds. Wood and Heaphy (1991) concluded that murrelets had a low tolerance for capture and rehabilitation. Necropsies revealed enlarged adrenal glands, indicating stress-induced mortality.

The *Exxon Valdez* oil spill affected regions of Alaska with some of the highest recorded murrelet densities in the world. Prince William Sound is the northernmost extension of the coniferous rainforest on the west coast of North America. There is no doubt that the spill has been a contributing factor to population decline in Prince William Sound over the past 20 years, along with other factors (Carter and others, this volume; Klosiewski and Laing 1994; Piatt and Naslund, this volume). The threat from future oil spills remains. Since 1989, several near catastrophes already have occurred in Prince William Sound. A spill similar to the *Exxon Valdez* during the peak breeding season has the potential to risk three to four times the number of murrelets that were present in Prince William Sound in late March 1989.

Large Oil Spills in California, Oregon, Washington, and British Columbia

Between the late 1800s and 1968, medium and large oil spills occurred frequently, but were rarely documented with respect to seabird mortality in California, Oregon, Washington, and British Columbia. In most cases, the source of the spilled oil was not determined. Few reports of murrelet mortality during this period are available. In spring 1929, 15 oiled murrelets were found dead on a 0.4 km section of beach at Crescent Beach, British Columbia, after a fuel oil spill that occurred weeks earlier and extended from Vancouver to at least Crescent Beach on the Canada-U.S. border (Racey 1930, Rodway and others 1992). In March 1937, 14 Marbled Murrelets (as well as five other unidentified murrelets) were found dead on beaches after the tanker *Frank H. Buck* oil spill near San Francisco, California (Aldrich 1938, Moffitt and Orr 1938). In September 1956, one Marbled Murrelet was found dead on beaches searched after a spill from the freighter *Seagate* on the outer coast of Washington, near Point Grenville (Richardson 1956). There is no way to quantify historical losses or fully assess the impact of these losses on murrelet populations based on available data. They serve to demonstrate that oil pollution has been affecting murrelet populations for many decades.

Since 1968, several large and medium oil spills have occurred for which seabird mortality was estimated. These spills are discussed below (see *figure 2* for general locations).

1969 Santa Barbara: In January 1969, a large spill (3-5 million gallons) of crude oil resulted from an offshore well blow-out off Santa Barbara, California. Oil spread throughout the Santa Barbara Channel area between January and August (Nash and others 1972, Steinhart and Steinhart 1972). No oiled murrelets were recorded dead on beaches but large numbers of other birds were reported (Straughan 1971). Murrelets occur only in small numbers in this area at all times of year.

1971 *Anacortes*: In April 1971, a large spill (204,600 gallons [gals]; 4,870 barrels [bbls]) of diesel oil resulted from an accident at a Texaco onshore facility while loading a barge near Anacortes, Washington (Chia 1971). Although at least 460 dead and live seabirds were recovered, mortality to marine birds was not properly assessed and no oiled murrelets were recorded.

1971 San Francisco: A large spill (810,000 gals; 19,300 bbls) of bunker oil occurred in the entrance to the Golden Gate near San Francisco when a Chevron oil tanker struck another vessel in January 1971. No murrelets were reported from this winter spill, but efforts were focused on rehabilitating live oiled birds recovered on beaches (Smail and others 1972). The lack of recovery of murrelets in January 1971 may also reflect a population decline in this area since the March 1937 *Frank H. Buck* oil spill (Carter and Erickson 1988). The latter spill occurred in the same area and at the same general time of year, and yet several murrelet carcasses were recovered in the earlier spill.

1978 *Toyota Maru*: In 1978, a fuel oil spill of 30,000-58,000 gals (715-1380 bbls) occurred from the vessel *Toyota Maru* just east of Portland along the Columbia River, Oregon (Nelson and others 1992). No documentation of impacts to birds was undertaken.

1983 *Blue Magpie*: A medium spill of 69,000 gals (1,643 bbls) from the vessel *Blue Magpie* occurred in Yaquina Bay, Oregon, in November 1983 (Bayer 1988, Burger and Fry 1993, Nelson and others 1992). At least two (and possibly four) oiled murrelets were recovered on beaches over a wide stretch of coast in Clatsop, Tillamook, and Lincoln counties.

1984 *Mobiloil*: In March 1984, a medium spill of about 200,000 gals (4,700 bbls) of mixed oils occurred from the tanker *Mobiloil* about 88 miles inland along the Columbia River, Oregon, near St. Helens (Burger and Fry 1993, Nelson and others 1992, Speich and Thompson 1987). The oil travelled to the ocean and extended north to Grays Harbor. A total of 450 birds were recovered although a complete damage assessment was not conducted. No oiled murrelets were reported. However, one dead oiled murrelet was found during monthly beached bird surveys on 20 June 1984 on Ocean Park Beach, Washington according to Lippert (Speich, pers. comm.). This beach was well within the spill zone and oiled birds were noted from March to August in this vicinity. This murrelet was probably killed by the *Mobiloil* spill and, if so, we suspect that more murrelets could have been affected.

1984 Whidbey Island: In December 1984, a spill (5,000 gals; 120 bbls) of fuel oil at the south end of Whidbey Island,

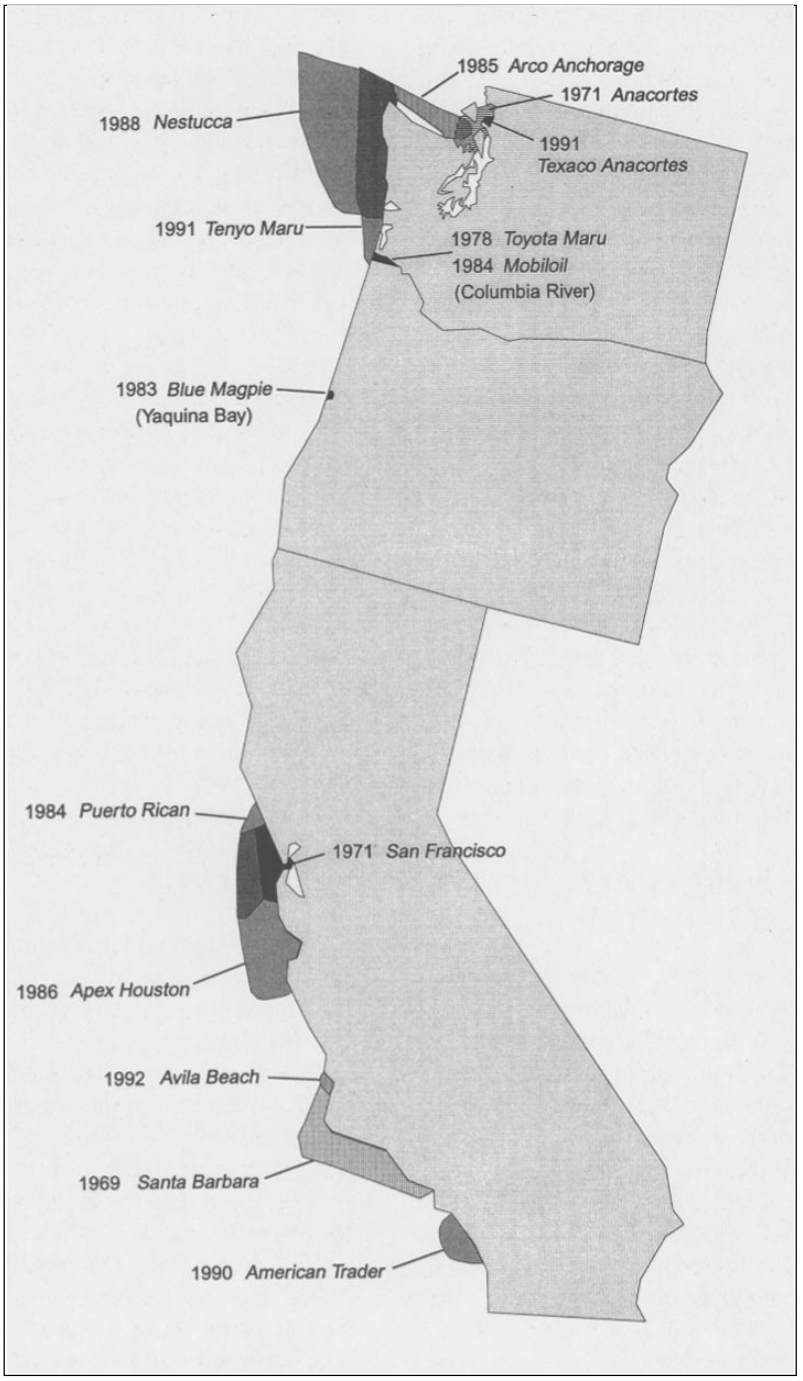

Figure 2—West Coast Oil Spills (1969-1993). The approximate locations of large and medium oil spills in Washington, Oregon and California where seabird mortality was assessed are indicated.

near Seattle, Washington (Speich and Thompson 1987). About 450 dead birds were recovered and about 650 live oiled birds were observed off shore. No oiled murrelets were recovered or observed.

1984 *Puerto Rican*: In November 1984, a large spill (1,470,000 gals; 35,000 bbls) of mixed oils occurred when the tanker *Puerto Rican* exploded off San Francisco (Herz and Kopec 1985). About 1,300 birds were recovered on beaches and a minimum of 4,800 birds were estimated to have been killed (Dobbin and others 1986, Ford and others 1987, Point Reyes Bird Observatory 1985). One dead oiled Marbled Murrelet was found on a beach.

1985 *Arco Anchorage*: In December 1985, the oil tanker *Arco Anchorage* spilled 240,000 gals (5,700 bbls) of crude oil off Port Angeles, Washington (Kittle and others 1987; Speich and others 1991; Speich, pers. comm.). Totals of 1,562 live and 355 dead oiled birds were recovered on shore after the spill. About 4,000 birds total were estimated to

have been killed. One dead oiled Marbled Murrelet was recovered. On 1 July 1986, 62 murrelets were counted in the Striped Peak Headland area near the spill location (Kittle and others 1987), indicating that local breeding birds probably were affected.

1986 *Apex Houston*: In February 1986, the tank barge *Apex Houston* spilled 26,100 gals (616 bbls) of crude oil between San Francisco and Monterey (Ford and others 1987, Page and Carter 1986, Page and others 1990). A total of 4,198 birds were recovered and about 10,600 birds were estimated to have been killed, based on carcass and live bird counts from searched and unsearched coastal areas, as well as birds lost at sea. A total of 11 Marbled Murrelets were estimated to have been killed: three were found dead on beaches, two live birds were turned into rehabilitation centers, and another six birds were estimated to have died and washed ashore in coastal areas not searched (Carter and Erickson 1988, 1992; Page and others 1990; Siskin and others 1991). This mortality probably was significant for the small, declining local breeding population in central California (Singer and Carter 1992). Acquisition of old-growth forest nesting habitat in central California with restoration funds obtained through recent litigation is indicated in the Consent Decree signed in 1994.

1988 *Barge MCN5*: In January 1988, this barge spilled 72,000 gals (1,700 bbls) of gasoline and oil near Anacortes, Washington (Burger and Fry 1993). No bird mortalities were reported.

1988 *Nestucca*: In December 1988, the *Nestucca* spilled 231,000 gals (5,500 bbls) of bunker oil off Grays Harbor, Washington, with oil extending as far north as Vancouver Island, British Columbia (Burger 1990, 1992; Ford and others 1991b). A total of 12,535 live and dead birds were recorded and an estimated 56,000 birds were killed. Only two Marbled Murrelets were recovered along the outer Washington coast (Ford and others 1991b) although about 50 murrelet deaths could be extrapolated from the sample of dead birds recovered on Vancouver Island beaches; 120-150 were estimated to have been killed there (Burger 1990, 1992; Rodway and others 1989, 1992). Oiled carcasses recovered on Vancouver Island may have included some local birds and some carcasses that were passively transported across the border from Washington.

1990 *American Trader*: In February 1990, the oil tanker *American Trader* ran onto its own anchor and spilled 400,000 gals (7,000 bbls) of crude oil off Huntingdon Beach, in southern California (Oceanor 1990). Hundreds of birds were recovered on shore. No murrelets were found, possibly because few occur along the southern California coast during winter.

1991 Texaco Anacortes: In February 1991, a small spill (200,000 gals; 4,760 bbls) of crude oil occurred from an onshore facility at Fidalgo Bay near Anacortes, Washington. No murrelets were found dead in the immediate vicinity of the facility (Momot, pers. comm.).

1991 *Tenyo Maru*: In July 1991, the *Tenyo Maru* fish packer struck another vessel off the Olympic Peninsula, Washington, spilling 99,000 gals (2,360 bbls) of bunker and diesel oil. About 45 Marbled Murrelet carcasses were recovered on beaches (Benkert, pers. comm.), representing the largest recovery of oiled murrelets after a spill, excepting the *Exxon Valdez* spill. Total estimates of 200-400 birds have been derived (Warheit, pers. comm.). This mortality represents a significant proportion of local breeding populations. These murrelets probably belonged to western Washington populations, which also have been heavily impacted by loss of old-growth forest nesting habitat (Hamer, this volume). This oil spill is in the process of litigation, so a full assessment of population impacts to murrelets is not currently available.

1992 *Avila Beach:* In August 1992, a spill of about 16,800 gals (400 bbls) of crude oil occurred while loading a tanker at Avila Beach in southcentral California. No murrelets were found during NRDA work (Kelly, pers. comm.), possibly because few birds occur along this part of the coast throughout the year.

A great variety of other medium and large spills have occurred off the Alaska, California, and Washington coasts since 1968 (especially prior to 1980) without adequate documentation of their impacts on seabirds. At least 7 significant spills (between 300-300,000 gals) have occurred on the west coast of Vancouver Island between 1972 and 1984 without documentation of mortalities (Burger 1992, Kay 1989).

Chronic Oil Pollution in California, Oregon, Washington, and British Columbia

Chronic oil pollution, which includes small oil spills, bilge dumping, seeps, etc., have occurred continuously throughout this century. Chronic oil pollution has been documented very poorly in California, Oregon, Washington, and British Columbia, making an assessment of impacts difficult. There are sporadic reports of oiled murrelets separate from known large and medium spills in the literature, especially in California. Streator (1947) noted “many dead on the beach, oil soaked” in Santa Cruz County. Munro (1957) noted single dead oiled murrelets on 21 December 1953, 31 January 1954, and 9 January 1957 at Morro Bay in San Luis Obispo county. One dead oiled murrelet was found at Las Varas Ranch Beach in Santa Barbara County on 21 September 1976 (Stenzel and others 1988). Two murrelets were found on 26 April 1986 on Hope Ranch Beach, Santa Barbara County (Carter and Erickson 1988).

The only direct means to assess potential impacts of chronic oiling is through beached bird surveys. In California, the Point Reyes Bird Observatory coordinated an extensive beached bird survey program throughout much of the state from 1971-1985 (Stenzel and others 1988). Only 23 dead Marbled Murrelets were identified on beaches throughout this period. Marbled Murrelets were probably under-represented because: (1) low sampling effort occurred in northern California where most murrelets occur; (2) counts usually were conducted monthly and small alcid carcasses may not have persisted long enough to be counted on beaches;

and (3) some observers may not have been able to identify Marbled Murrelet carcasses (especially decomposed carcasses) (Stenzel, pers. comm.). Only one of the 23 murrelets found during this program was determined to be oiled. However, the degree of oiling may be underestimated, due to the advanced state of decomposition of some carcasses (Stenzel, pers. comm.). In Washington, beached bird surveys were conducted between 1978-1979 for inland marine areas (Speich and Wahl 1986). Only one unoiled Marbled Murrelet was recovered dead on beaches out of a total 110 birds examined. Between January 1982 and December 1986, outer Washington coast areas (especially in the vicinity of Grays Harbor) also were surveyed by Lippert (Speich, pers. comm.). A total of five murrelets (two adults and three unknown age) were found. Only one oiled adult was found on Ocean Park Beach, Washington (see *1984 Mobiloil* above). Both of these beached bird programs were conducted between the early 1970s and mid 1980s when large and medium oil spills occurred less frequently (Burger and Fry 1993). Thus, the low occurrence of oiled murrelets on these surveys may reflect low incidence of oil pollution as well as low recovery of oiled and unoiled murrelet carcasses. Burger (1992) conducted beached bird surveys between 1987-1991 on the southwest coast of Vancouver Island, British Columbia. Marbled Murrelets were not reported specifically. Small alcids were lumped into one category (of which few were recovered in any case).

Summary and Recommendations

It is difficult to assess the impacts of oil spills and other marine pollution on Marbled Murrelets because of inadequate baseline data, and poor documentation of post-spill damages. For example, even though reasonable population estimates were available in Prince William Sound, 17 years separated pre-spill and post-spill surveys. Klosiewski and Laing (1994) determined that, given the low number of baseline survey years, their tests only had a 20-40 percent probability (based on Monte Carlo runs) of detecting a 50 percent decline in population size of Marbled Murrelets in Prince William Sound. In particular, low recovery rates of murrelets after pollution events must result in part from: (1) improper identification of murrelet carcasses that resemble other small alcids; (2) undercounting of carcasses on beaches due to small carcass size, incomplete coastal coverage, and burial in beach substrates; (3) high rates of carcass removal by predators on shore and at sea; and (4) carcass loss due to sinking at sea. Efforts are underway to improve the rate of recovery of murrelet carcasses during large oil spills, especially by the California Department of Fish and Game (Kelly, pers. comm.) and Washington Department of Fish and Wildlife (Warheit, pers. comm.).

However, seabird mortality from small spills is often not assessed. Greater efforts should be expended to investigate all spills for their impacts on Marbled Murrelets. In addition, greater coordination is required between wildlife care centers and government agencies for documenting live and dead murrelets sporadically found on shore in small numbers. In Washington, the *Adopt A Beach* program may recover such oiled carcasses during regular beach surveys although none have been found from 1988-1993 (Silver, pers. comm.). In California, a group such as the International Wildlife Rehabilitation Council could coordinate better documentation and reporting of oiled murrelets turned into wildlife care centers of various affiliations (e.g., Society for the Prevention of Cruelty to Animals, International Bird Rescue, etc.). In addition, the *Beach Watch* program may encounter oiled murrelets through regular beach surveys within the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries which encompass the central California population of Marbled Murrelets (Rolleto, pers. comm.). Birds found on beach surveys or interned in centers should be preserved for later examination or to have their identification confirmed. Oil samples from such birds also may link mortality to specific sources. Also, rehabilitation efforts for oiled murrelets must be improved by conducting physiological, wildlife health, and captive care research on oiled murrelets.

Better baseline data and monitoring (before, during and after the pollution event) is needed for at-sea population size and distribution during the non-breeding and breeding seasons. This task is immense, especially in Alaska and British Columbia, but is critical to documenting injury and devising restoration activities. As populations dwindle in size, it will be important to attempt to prevent all mortality possible, even if this process is costly and has only moderate success.

We feel that a detailed assessment of the threat of oil pollution to Marbled Murrelets throughout their range in North America is required by analyzing data on: (1) the location, size and frequency of oil spills; (2) the distribution and abundance of Marbled Murrelets at sea; (3) the routes of tanker and other shipping traffic along the coast; and (4) the amount of oil transported along the coast by various means (Burger 1992; USDI Fish and Wildlife Service, in press). Databases with some of the above spill and NRDA information are being developed from California to Alaska (Kelly, pers. comm.; Oman, pers. comm.). With these databases, future in-depth analyses should be conducted to indicate the overall threat of oil pollution to Marbled Murrelets over the long term and to devise methods to reduce oil mortality.

Oil pollution has had significant impacts on murrelet populations in Prince William Sound, central California, and western Washington. However, these effects have probably been felt only sporadically by local populations. If murrelet populations were in better health, oiling mortality might be naturally recoverable within several years to decades, depending on the size and nature of the mortality. However, when oiling mortality is considered as a cumulative effect with other anthropogenic factors and affects small, declining populations of murrelets, the relative effects of oil pollution will become greater and recovery may not be possible (Piatt

and others 1991, Singer and Carter 1992). Management efforts to reduce or stop oil spills should be undertaken. Industry and government efforts are underway to examine how tanker traffic could be routed away from sensitive coastal areas in California, Oregon, and Washington (Kelly, pers. comm.; Oman, pers. comm.). However, oil traffic into and out of major oil ports at Valdez (Alaska), Anacortes (Washington), San Francisco, and Los Angeles (California) will continue to threaten murrelet populations in adjacent areas throughout the 21st century and beyond.

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