murrelets (Pierce *et al.* in draft). Entanglement in other Washington drift net and set gill-net fisheries has also been documented (Speich and Wahl 1989; Craig and Cave 1993; BIA 1994; J. Grettenberger, USFWS, pers. comm. 1995). Observer programs in 1993 and 1994 in Puget Sound salmon purse seine fisheries indicated that entanglement rates of marbled murrelets were much lower with this gear type (Natural Resources Consultants 1995).

Adults are also subject to other sources of mortality. Marbled murrelets have been accidentally hooked on fishing lures, and could also become entangled in fishing line (Campbell 1967; Burger 1993). In general, increased mortality of adult seabirds and decreased reproductive efforts have been linked with El Niño episodes when food supplies are depressed (Graybill and Hodder 1985). However, marbled murrelets have evolved to survive El Niño events over the long term (USFWS 1995).

Management Considerations

Marbled murrelets are found in forests containing a variety of structures, which are in part the result of varied management practices. In many areas, management practices have resulted in fragmentation of the remaining older forests and creation of large areas of younger forests that have yet to develop habitat characteristics suitable for marbled murrelet nesting. Past and current forest management practices have also resulted in a forest age distribution skewed toward youngeraged stands at a landscape scale.

In many portions of the range of the marbled murrelet, forest management has historically concentrated on clearcut logging. After forests are clear-cut, the areas are traditionally replanted to a single or few tree species and maintained as even-aged stands for maximum wood-fiber production. Sitepreparation and management activities may further decrease species' diversity. These methods include prescribed burning and the use of herbicides or mechanical methods to control competing vegetation.

Historical logging practices in some portions of the species' range consisted of more selective timber harvest, leaving remnant patches of forests of varying ages with older forest characteristics. The uneven-aged management practices used in these areas usually resulted in more diverse forests that may provide some nesting habitat where a few trees containing suitable marbled murrelet nesting structure remain.

Current and historic marbled murrelet habitat loss is generally attributed to timber harvest and land conversion practices, although, in some areas, natural catastrophic disturbances such as forest fires have caused losses. Reduction of the remaining older forest has not been evenly distributed in western Washington, Oregon, and California. Timber harvest has been concentrated at the lower elevations and in the Coast Ranges (Thomas *et al.* 1990), generally overlapping the range of the marbled murrelet.

Habitat for marbled murrelets has been generally declining since the arrival of European settlers. Bolsinger and Waddell (1993) estimated that oldgrowth forest in Washington, Oregon, and California have declined by twothirds statewide during the last five decades. Information specific to the range of the marbled murrelet is not available. Historic forest conditions have been estimated for western Washington and Oregon by several authors. Marbled murrelet habitat represents a significant portion of area included in these estimates, therefore, trends in habitat are assumed to follow the same general pattern identified for the larger area.

Although the extent of mature and old-growth forest before the 1800s is difficult to quantify, western Washington and Oregon are estimated to have been covered by approximately 9.7 to 12.8 million hectares (24 to 32 million acres) of forest at the time of euroamerican settlement in the early to mid-1800s, of which about 5.6 to 7.9 million hectares (14 to 20 million acres) (60 to 70 percent) are estimated to have been old-growth (Society of American Foresters Task Force 1983; Spies and Franklin 1988; Morrison 1988; Norse 1988; Booth 1991; Ripple 1994). As of 1991, there were approximately 1.4 million hectares (3.4 million acres) of old-growth forest remaining in western Washington and Oregon, an 82 percent reduction from estimated prelogging levels (Booth 1991).

Estimates for a similar time period in northwestern California are not as precise, but suggest there were between 526,000 and 1.3 million hectares (1.3 and 3.2 million acres) of old-growth Douglas-fir/mixed conifer forest and approximately 890,000 hectares (2.2 million acres) of old-growth coastal redwood forest (Society of American Foresters Task Force 1983; Laudenslayer 1985; Fox 1988; California Department of Forestry and Fire Protection 1988; Morrison 1988). Currently there are approximately 28,000 hectares (70,000 acres) of old-growth coastal redwood forest remaining in California (Larsen 1991).

Some of the forests that were affected by past natural disturbances, such as forest fires and windthrow, currently provide suitable nesting habitat for marbled murrelets because they retain scattered individual or clumps of large trees which provide structure for nesting. This is particularly true in coastal Oregon where extensive fires occurred historically. Marbled murrelet nests have been found in remnant oldgrowth trees in mature forests in Oregon.

Forests providing suitable nesting habitat and nest trees generally require 200 to 250 years to develop characteristics that supply adequate nest platforms for marbled murrelets. This time period may be shorter in redwood forests and in areas where significant remnants of the previous stand remain. Intensively managed forests in Washington, Oregon, and California have been managed on average cutting rotations of 70 to 120 years (USDI 1984; USDA 1988). Cutting rotations of 40 to 50 years are common for some private lands. Timber harvest strategies on Federal lands and some private lands have emphasized dispersed clear-cut patches and even-aged management. Forest lands that are intensively managed for wood fiber production are generally prevented from developing the characteristics required for marbled murrelet nesting. Suitable nesting habitat that remains under these harvest patterns is highly fragmented.

Previous Management Efforts

In May 1991, the U.S. House of Representatives' Committees of Agriculture and Merchant Marine and Fisheries commissioned the Scientific Panel on Late-Successional Forest Ecosystems (Scientific Panel) to provide an array of alternatives for the management of Late-Successional forests on Federal lands in the range of the northern spotted owl (Strix occidentalis caurina). Information about the known inland locations of marbled murrelets and marbled murrelet habitat was included in the base information used by the Scientific Panel and was specifically considered in developing the alternatives. The proposed reserve system developed by the Scientific Panel is often referred to as Late-Successional/Old-Growth areas (LSOGs).

Since the listing of the marbled murrelet population of Washington, Oregon, and California as threatened, several different approaches to management of the species or its habitat have been developed through various Federal efforts.