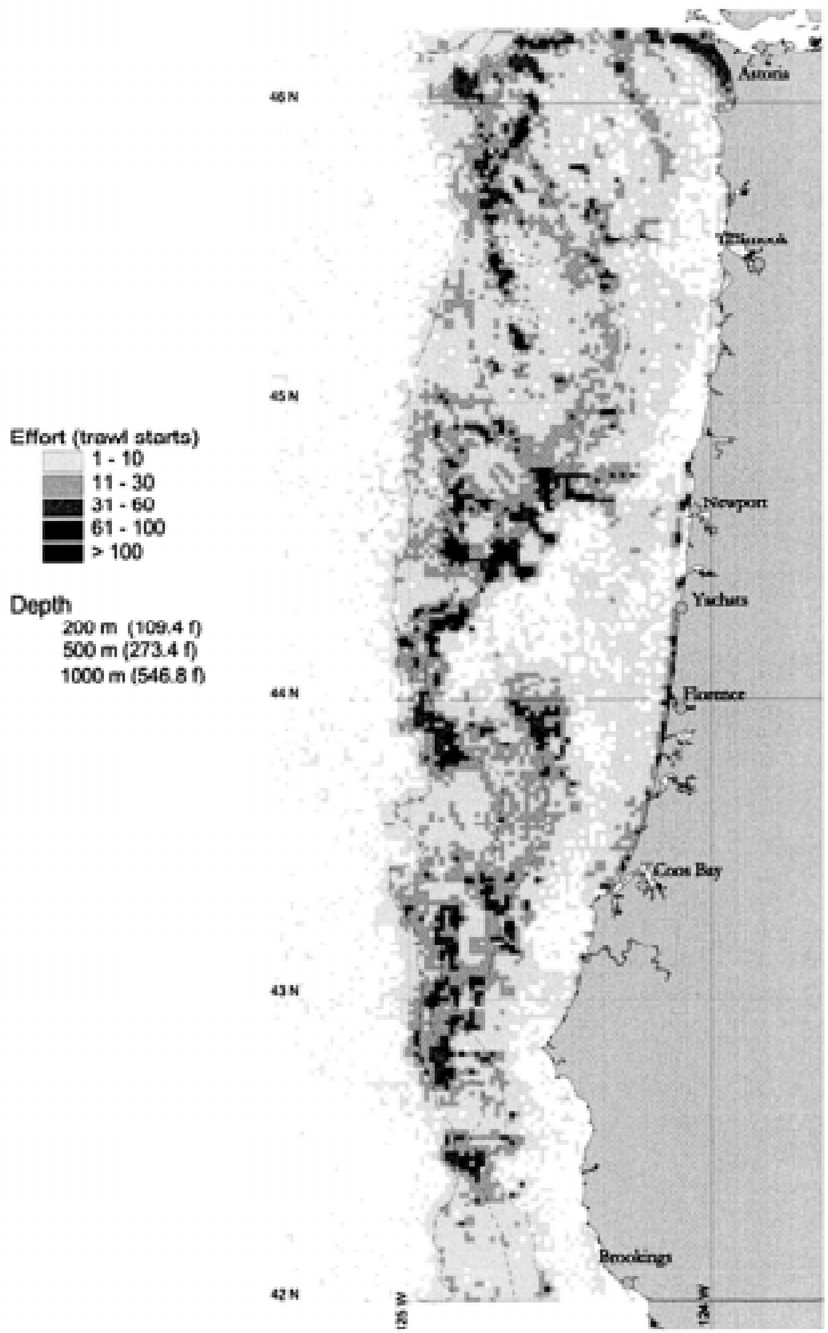
flecting declining stock sizes due to fishing and much-reduced harvest quotas implemented to prevent further declines. Although total marine fishery landings remain high due to the very large volume of Pacific whiting, the decline in other marine fisheries, especially several of the groundfish species, suggests that some parts of marine ecosystems are distorted and not functioning well.

Indicator 2: Bottom habitat degradation (trawl areas and intensity). Over the past two decades, concern has increased over the effects of fishing gear on marine bottom habitats. Although no studies have been conducted in Oregon waters, recent work off California (Engel and Kvitek, 1998; Freidlander et al., 1998) and studies from other regions suggest that mobile fishing gear (1) decreases structural diversity of the seafloor; (2) stirs up sediments, potentially altering biogeochemical cycles; and (3) reduces biodiversity while enhancing abundance of opportunistic species.

Although we do not have local data on the effects of fishing gear on bottom habitat, we do know how often different areas are fished. Examination of fisher log book data on bottom trawl starts on one square nautical mile grid cells for a ten-year period shows that fishing pressure is fairly evenly spread out along the coast (**Figure 3.2-4**) (Wakefield and Bailey, National Marine Fisheries Service, unpublished data, 1999). There are concentrations of bottom trawling near the 200 m to 500 m depth contours off Newport, Yachats, Florence, and south of Coos Bay, and few areas inside the 1000 meter contour that have not been trawled. Year-to-year analysis of these data show that trawl starts actually decreased about 15 percent from the early to late 1990s, and that the number of trawl starts in deep water (below 700 meters) increased dramatically in late 1980s, but has since leveled off. The number of trawl starts is now about equally divided among depth zones.

In examining the summaries of trawl start data, it is important to recognize that a map of the distribution of bottom trawl starts for specific blocks of time does not translate directly into a map of adverse impacts of mobile fishing gear on bottom habitats off Oregon. Although trawls do make contact with the bottom, we do not know to what extent this has a negative impact on the physical habitat or the biota. Further, distribution of trawl starts may not reflect impact on the bottom because some

Figure 3.2-4. Bottom trawl fishing effort off the Oregon coast, as indicated by number of trawl starts for 1-minute latitude cells for a ten-year period (1988-97).



Fishing Data: Oregon Department of Fish and Wildlife Trawl Logbooks
Bathymetry Data: General Bathymetric Chart of the Oceans (GEBCO)
Data Compilation and Cartography: Alison Bailey, NOAA, NMFS, Northwest Fisheries Science Center

habitats and areas are no doubt more sensitive to trawling than other areas. The fact that the same areas continue to be trawled and continue to produce fish suggests that trawling may not damage the habitat. The uncertainty in these data illustrates the critical need for more thorough investigation of the impacts of mobile fishing gear on different types of bottom habitat off Oregon.

Indicator 3: Marine mammals (pinniped population trends). Populations of harbor seals and the endangered Steller sea lions, both of which breed and pup along the Oregon coast, have risen dramatically in the past 25 years to what may be near historic abundance levels (Brown, 1997). Since passage of the Marine Mammal Protection Act in 1972, harbor seal numbers in Oregon have increased from about 2,500 to nearly 10,000. Populations of Steller sea lions, listed as a *threatened* species from California to Southeast Alaska, and as *endangered* west of the Gulf of Alaska, have declined significantly since the mid-1960s throughout most of its range. The exception is southern Oregon, where numbers have steadily increased from about 2,000 animals in the late 1970s to over 4,000 currently. Over the past dozen years, northern elephant seals have also begun to appear, bearing their young at Shell Island near Cape Arago, the most northerly known pupping site for this species. California sea lions do not breed north of San Francisco, but large numbers of male sea lions move northward into Oregon, Washington and British Columbia in the late summer following the breeding season. The four-fold increase of animals passing through Oregon reflects increased breeding population numbers in California.

In contrast to these successes is the story of the sea otter, a keystone species extirpated from the coast of Oregon in the 1800s. An attempt to reestablish sea otters in Oregon in the 1970s was unsuccessful.

Indicator 4: Kelp forests (location, area, and biomass). Rocky subtidal regions along the central and southern Oregon coast provide superb habitat for forests of bull kelp (*Nereocystis luetkeana*). Oregon's kelp forests serve an important role in the provision of habitat and food for diverse and productive communities. Among them are seabirds, shorebirds, marine mammals that rest and feed in the surface raft of floating kelp bulbs and fronds, mid-water communities of rockfish, perch, invertebrates, and epiphytes that inhabit the kelp forest canopy, and benthic communities composed of bottom fish, sea urchins, sea stars and understory algae. The ecological value of Oregon's kelp forests as a complex three-dimensional aquatic habitat for marine organisms extends far beyond the modest commercial value of harvestable kelp.

A sequential series of aerial surveys conducted at three offshore reefs indicate that the Orford Reef kelp forest is consistently larger than the beds located at Rogue Reef and Cape Blanco, and that annual variability in the overall size of the kelp canopy is considerable (**Table 3.2-2**). Detailed surveys of kelp canopies by ODFW at five offshore reefs (Cape Blanco, Orford Reef, Redfish Rocks, Humbug Mountain, and Rogue Reef) demonstrated that interannual differences in kelp biomass are dependent upon yearly changes in the spatial extent of kelp canopies and variation in the density of individual kelp plants. Consequently, estimates of the spatial extent (surface area) of kelp forests alone are not a good indicator of the annual biomass (weight) of the kelp plants (ODFW 1998).

Experimental commercial leases for kelp harvest have proved inconclusive about the effects of harvesting bull kelp. Significant questions remain regarding the ecological impacts of sustainable harvests and late-seasonal thinning on the quality of surface habitat, rates of recovery and growth, and the structural arrays of stipes and fronds that support kelp forest communities.

Indicator 5: Marine protected areas (number and area). The designation of protected areas is an important tool for preserving marine ecosystems, habitats, and biodiversity. Most protected areas in Oregon are small, do not exclude all uses and activities, and are not designed to protect ecosystems or biodiversity. Rather, they are special management areas, with some limitations designed to protect critical habitat and species. Protected areas, if large enough, can serve as buffers against management misjudgments in multiple-use areas, for example, by providing refugia for reproducing populations of exploited fish species. In some cases protected areas might even increase take levels of exploited species outside the protected area by safeguarding spawning areas and maintaining a natural size and age population distribution.

Many rocky intertidal areas along the coast are "protected" by virtue of their isolation and lack of access. Others are eas-

Table 3.2-2. Area estimates for three Oregon bull kelp forests in hectares (ha[1])

Kelp forest location	1990 ha	1996 ha	1997 ha	1998 ha	1999 ha
Cape Blanco	101	33	112	102	283
Orford Reef	313	66	159	145	670
Rogue Reef	78	67	29	52	304

[1] One hectare equals 2.47 acres

(ODFW, 1998; David Fox, pers. com., 2000)