

tively low salinity, and the North Pacific central water, with relatively high salinity, is well defined by a salinity gradient which usually lies just south of the islands during late autumn and early winter. During February or March it begins a northward movement, passing the islands in spring and reaching its northern position just north of the islands in July or August. The movement of the boundary is reflected in changes of surface salinity which are monitored by regular sampling near Koko Head, Oahu. It has been found that when the California Current Extension bathed the islands in summer skipjack landings were above average, whereas when North Pacific central water prevailed landings were below average. From these findings and additional information on water temperatures, we are able to predict whether skipjack landings will be above or below average for the season.

Other factors

We have found that some of the differences in tuna abundance are related to the topography of the ocean bottom. Fishermen have known for years that tuna will congregate at times near islands or reefs. Later it was discovered that they also like to gather around seamounts, which do not reach the surface. The regular navigational charts were not adequate to locate these features on the fishing grounds, so the Bureau developed its own set of charts. These are in great demand by tuna fishermen.

Tuna also gather around floating objects in the sea. This characteristic also has possibilities for aiding the fishing fleet. We are studying phenomenon from a floating raft with underwater viewing ports. Preliminary results have been spectacular. In a relatively short period the raft accumulates a following of oceanic fishes, from small forage fish to large dolphins, tunas, and sharks.

Although we can explain causes for local variations in abundance and distribution of fish stocks on the basis of changing ocean conditions, we have had to look farther and farther over the horizon, as much as many thousands of miles away, to try to explain why the ocean changes.

The answers lie in understanding interactions between global atmospheric and ocean circulation. Scientific studies recently carried out by the Inter-American Tropical Tuna Commission have shown that strength and position of the Azores high pressure cell over the Atlantic Ocean affects precipitation and winds in the eastern tropical Pacific Ocean, which in turn affect ocean circulation and distribution of tunas in the eastern Pacific. The strength and position of the Azores high also affects upwelling and increases biological productivity off the coast of Africa, with profound effects, no doubt, upon fisheries there also.

Another study by the Tuna Commission suggests that the severe 1957-58 "El Nino"—a flow of warm surface water into coastal Peru where normally cold water is found—was related to meteorological and oceanographic processes thousands of miles to the westward in the Pacific Ocean. It is known also that the severe Tehuantepec storms that roar into the Pacific in the winter through the Isthmus of Tehuantepec, Mexico, affect the biological productivity of ocean waters and movements of tuna in the eastern tropical Pacific. Events that push cold air southward over the United States into the Gulf of Mexico, producing Tehuantepec winds frequently have their origin in the North Central Pacific or even over northeast Asia. The same atmospheric conditions over northeast Asia that may ultimately produce Tehuantepec conditions also cause winter monsoons in the northern Indian Ocean. Northeast winds bring dry continental air over the Indian Ocean, causing surface water flow to the westward. Low rainfall and high evaporation cause a rise in salinity. The process reverses in the summer monsoon from May to September. Undoubtedly, but in a way still little understood, the monsoons have a profound effect on abundance and availability of Indian Ocean resources.

We are convinced that we must pay more attention to global atmospheric and oceanic circulation. In this respect we are now studying possible application of earth orbiting satellites, which will give us this global look, to assist in marine resource development. Problems in marine resource development and management will intensify in the future, and we must use the best of the newly developing technologies to solve these complex problems.

WATER USE+REUSE=FORMULA FOR PROGRESS

This Nation and the world are beginning to realize that natural resources must be used and used again many times to sustain our increasing rate of population growth and industrial and economic development.