

EXECUTIVE SUMMARY

Merton C. Ingham¹ and Douglas R. McLain²

During the winters of 1976-77 and 1977-78 a strong and persistent ridge of upper air circulation occurred over the west coast of North America from California to Alaska. This ridge brought southerly winds and mild temperatures to much of the coast. In Alaska the mild temperatures broke the period of abnormal cold of the early 1970's and allowed a remarkable recovery of salmon stocks.

During the 15-month period January 1978-March 1979, the upper air circulation over the northeastern Pacific Ocean shifted from the west coast ridge pattern of the previous two years and appeared to be returning to a more normal pattern. The west coast ridge reoccurred during the early part of the winter of 1978-79, but by the end of the winter it had shifted westward and weakened.

The pattern of anomaly of sea-surface temperature (SST) over the northeastern North Pacific shifted in association with the shifting pattern of atmospheric circulation. Whereas anomalies of SST had been generally negative in the central North Pacific and zero or positive near the west coast in 1977 and early 1978, in late 1978 and early 1979 the pattern shifted to one of positive anomalies in a large region between Hawaii and Alaska with negative anomalies all along the west coast. Whether this shift is truly indicative of a change from the pattern of the previous two years or not remains to be seen, because in summer

1979, after the end of the 15-month analysis period, the pattern of SST anomalies had reverted to the prevailing pattern of cold in the central North Pacific and warm along the eastern shore of the ocean.

The wind-driven surface ocean transport during January 1978-March 1979 was abnormal in several biologically important ways. During late 1977 and early 1978 strong northeastward transport occurred in the Gulf of Alaska and along the British Columbia coast. The resulting onshore transport resulted in an intrusion of southern, pelagic fauna into the area, and caused a large percentage of adult Fraser River sockeye salmon to return to the river through Queen Charlotte Sound rather than via the Strait of Juan de Fuca.

Off California, winter onshore transport was much stronger than normal during January-March 1978 and, to a lesser extent, again in December 1978-January 1979 and in March 1979. These strong onshore transports resulted in downwelling and thus extremely low computed indices of upwelling. The onshore transport held larvae of pelagic spawners such as anchovy and Pacific mackerel near shore and apparently resulted in better than normal recruitment. Associated with the onshore transports were stronger than normal northward flows of the California Counter Current or Davidson Current. Southern fauna such as trigger fish and billfish were caught in

¹Atlantic Environmental Group, National Marine Fisheries Service, NOAA, Narragansett, RI 02882.

²Pacific Environmental Group, National Marine Fisheries Service, NOAA, Monterey, CA 93940.

late summer 1978 off California; possibly their presence there was in response to increased northward currents.

In the Eastern Tropical Pacific, "anti-El Niño" conditions persisted throughout 1978 and early 1979, with strong upwelling and below normal sea-surface temperatures along the Equator. An index of the Southern Oscillation remained below normal, indicating generally weak trade winds and a low probability of El Niño conditions occurring in the near future.

In the Atlantic and Gulf coastal areas, 1978-79 was the third consecutive severely cold winter. These were the result of a deep and persistent atmospheric trough downstream from the west coast ridge. Three such cold winters in succession had never occurred before in the period of instrumental record in the United States. February air temperatures were lowest in 1978 south of Cape Hatteras on the Atlantic coast and in the northern Gulf of Mexico. In 1979 the greatest anomalies were found north of Norfolk, VA, on the Atlantic coast and in the northeastern Gulf of Mexico.

River runoff into Chesapeake Bay reached near or record high values in January and March in both 1978 and 1979, and also in May 1978. Flow into Long Island Sound reached record highs in January of both years, but remained near the long-term average values in other months. The Mississippi River flow reached relatively high, but not record, levels in March-May 1979, in contrast with the previous spring, when they were only about half as large.

Unusually large wind-driven transports occurred toward the south-southwest in December 1978 and toward the southwest in February 1979 in the southern New England area. These transports, the consequence of persistent west-northwest and northwest winds, occurred during the spawning periods of cod and haddock on Georges

Bank. The drift of eggs and larvae in the plankton community in those months should have been strongly influenced by the anomalous transports. Off North Carolina there was a pronounced westward component in the wind-driven transport only in one month (February) of the 1979 winter spawning period of Atlantic menhaden. The component was less than half as large as that recorded in February 1978.

Sea-surface temperatures in the first three months of 1979 in the northwestern North Atlantic were up to 0.8°C (February) colder than the 1948-67 means for the area. The pattern was neither as intensive nor as extensive as that of January-March 1978. The pattern was similar in the Boothbay Harbor sea surface temperature data: anomalously cold in January-April 1979, but not as much as the comparable period in 1978. In the South Atlantic Bight, the anomaly pattern in the January-March periods of 1978 and 1979 were very similar, with February showing the largest negative anomalies, -1.24°C in 1978 and -1.36°C in 1979. Similar patterns were found in the Gulf of Mexico, once again showing the early months of 1978 to be colder than in 1979.

Apparently related to the variations in circulation and water masses was an absence of Gulf Stream warm core eddies near the continental shelf edge in the Georges Bank area during January-March 1978 and 1979. During these periods the Shelf Water/Slope Water front moved far seaward (up to 150 km) of its usual position near the edge of the Continental Shelf. The hiatus in eddy activity in 1978 was followed by an 8-month period (April-November) during which there was always an eddy or two adjacent to the bank, involving a total of six eddies. This period of eddy activity included the peak spawning months for several commercial species on the bank, but the amounts of eggs and larvae lost from the bank are unknown.

Bottom water on the shelf off southern New England (71°W) reached about the same minimum temperatures ($<2^{\circ}\text{C}$) in February-March of both years, 1978 and 1979. In 1978 the unusually cold temperatures persisted in the mid-shelf cold cell into the summer period, remaining 1° - 2°C lower than those measured during the previous four years. The offshore extension of the Shelf Water/Slope Water front was manifested in the bottom water also, reaching bottom depths of about 150 m in 1978 and 1979.

Off New Jersey the minimum bottom water temperatures in early 1978 were about 2°C warmer than 1977, but still were about 3°C colder than normal. By June, however, the cold cell bottom temperatures had warmed to about 4°C , about the same as in June 1977. In February 1979 bottom water temperatures were much like the minimum values of 1978, about 2°C in shallower water, but

warmed 2° - 4°C during the unusually mild March weather in the area. Seaward excursions of the Shelf Water/Slope Water front occurred in February-July and December 1978 and in March 1979. There was an absence of Gulf Stream warm core eddies off the middle Atlantic shelf during March-June 1978 and January-March 1979.

The Eastern Gulf Loop Current underwent a major northward extension (to about 30°N) into the Gulf of Mexico in spring and early summer of 1978. The timing of the extension fit the average pattern of variation, but the magnitude exceeded the average by about 3° latitude. The extension of Loop Current water onto the shelf is believed to have impacted on fisheries, yielding poorer harvests of brown shrimp, better catches of menhaden, and a red-tide bloom off the west Florida coast.