FISHERY OCEANOGRAPHY--II

Salinity Front at Entrance to Washington's Strait of Juan de Fuca

Felix Favorite

Little is known about the reaction of fish to conditions in their natural environment because measuring, monitoring, and understanding these conditions require a cadre of oceanographers with training in several disciplines and much time. Fishery oceanographers have not made the impact upon fisheries that could, or indeed must, be made if we are to understand completely the causes of long- and short-term fluctuations in the components of the resources.

Where to Fish?

Once a net or other device has been retrieved, or a fishing operation completed, several things are apparent: the catch is either large or small, the fish are either the same or different species, and either marketable or unmarketable. Except for sorting and storing the catch, the men are ready to fish again. The question is: Where? If fish traces appear on the echo sounder, the problem is solved; if not, a search is begun on a grid, or at random. Standard oceanographic techniques of the past would help little at this point to decide in which direction to maneuver. It requires hours to take and process data from a Nansen bottle cast and ascertain the distribution of water properties with depth. Observations at 2 or more stations would be needed to determine a current pattern or other environmental features. And, of course, the analytical procedures are fairly technical. One cannot blame the fisherman for preferring to continue with his random or intuitive search.

Modern Technology Helps

However, modern technology is rapidly reducing the tedious and time-consuming analytical work by providing equipment that permits direct readings of water properties significant to fishing. One such piece is a surface temperature and salinity recording device. With this device, a probe is inserted in the engine intake or attached to the hull outer part, and a continuous record of temperature and salinity at the surface is recorded in the wheelhouse or other desire location. Continuously recording thermographs have been in use aboard some vessel for years, but the salinograph has been available only within the past decade. Instrumen with high accuracy are expensive and not i common use, even aboard oceanographic o fishery research vessels, but less expensiv models are sufficient for some purposes The necessity of measuring salinity--and als recording it continuously to detect significa environmental changes--was clearly show during recent cruises of two BCF researc vessels: 'Miller Freeman' off California an 'George B. Kelez' off Washington.

Pacific Salmon

One group of valuable fishes off the U.S west coast is the Pacific salmon (genus Oncorhynchus). By intricate and incomplete explained mechanisms, they are able to re turn to the fresh-water stream or lake whe they were spawned after 1 to 3 or more yea in the ocean. It long has been suggested, a it is a reasonable hypothesis, that the di charges of rivers along the coast serve guideposts. Until our high-seas studies b gan, it was generally believed that the salm never migrated far beyond the continent shelf, or from the influence of their nat streams.

As far south as San Francisco, local ru offs from river systems to which salmon mi grate can be detected as seaward plumes low salinity. These plumes carry with the specific chemical relations, odors, or oth identifying characteristics detectable b salmon. Such a plume was seen off San Fra cisco Bay during the Freeman cruise; its co figuration was grossly delineated from da obtained at closely spaced oceanographi stations, rather than from a continuous

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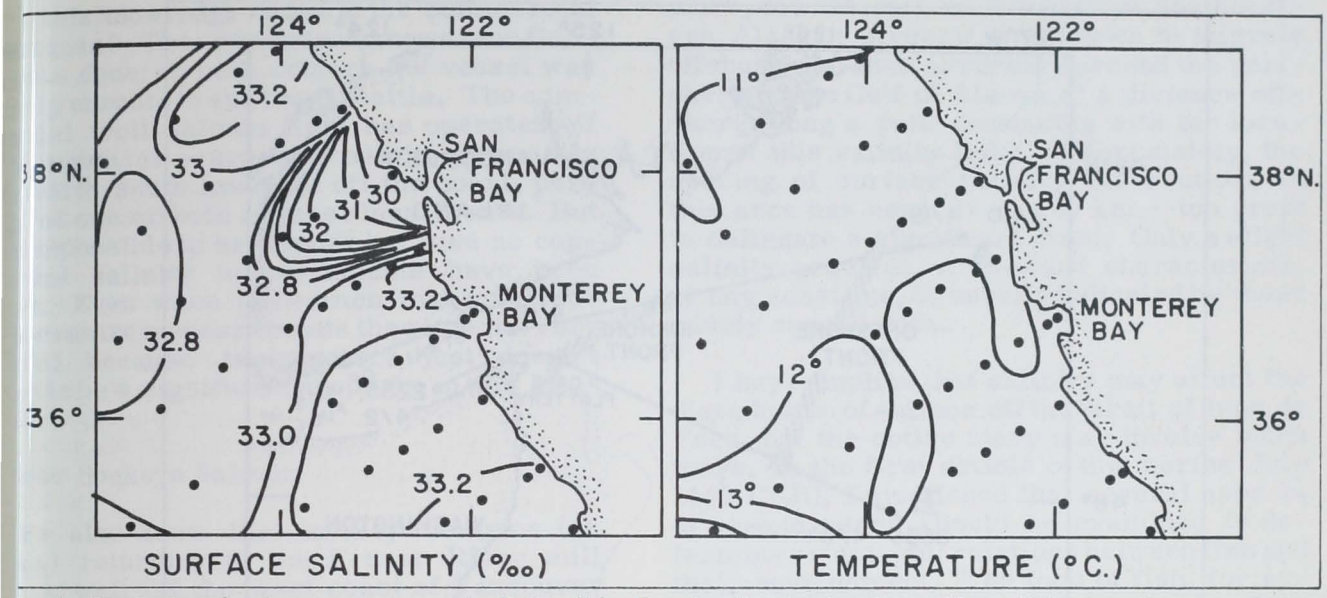


ig. 1 - Distribution of surface temperature and salinity off San Francisco Bay showing plume of low salinity extending seaward, undetectable in the temperature distribution, February 1969. Station locations are shown by dots.

recording device (fig. 1). The seaward gradient of salinity is fairly well defined because the stations are only about 20 km. (12.4 m.) apart. But stations along the coast are 60 km. apart and, obviously, it is impossible to ascertain whether or not a sharp front exists at the northern and southern edges of the plume. It is also obvious that surface temperatures provide no indication of the plume's presence.

The Columbia's Plume

The area offshore of the Columbia River is a much better example. Not only can the plume be seen from the air--extending into the ocean during late spring, straight as a superhighway--but the demarkation line between the surface lens of silt-laden runoff and the relatively clear blue-green coastal water is obvious even aboard ship, when the north and south edges of the plume are crossed many miles at sea. In fact, the plume's seaward extent, as determined by dilute surface water, can be traced at times over 500 km. offshore.

However, just north of the Columbia River, the runoffs from rivers in Washington and southern British Columbia flow seaward through the Strait of Juan de Fuca. Tidal and turbulent mixing from sills in the inland waters reduces the possibility of this fresh water forming a dilute surface lens, and thereby maintaining its identify in the ocean.

Even up to the present, observations in the Strait at 10 to 30 km. intervals, made largely by local research vessels, have indicated only a slight salinity gradient from the Strait's inner reaches into the ocean, and no indications of a sharp salinity front at the entrance. Nevertheless, during an April 1969 Kelez cruise (she is equipped with continuously recording temperature and salinity device), we discovered 2 salinity fronts: a marked one inshore, with an increase of 2 to 4 ‰ (parts per thousand) in 4 km., and a lesser one offshore with an increase of about 1 ‰ over the same distance (fig. 2). These fronts also were noted in about the same position on April 4, a day later, as the vessel returned to Seattle along the same track.

The device was operated again as the vessel departed Seattle on April 16. The inshore front was clearly present about 75 km. northwest of one observed April 3-4, but the offshore front was not so clearly defined. Both times, the temperature changes across the fronts were slight, almost negligible. However, the salinity changes were large, considering that there is little change in surface salinity from the offshore front across the Pacific Ocean at this latitude. Thus, it is at this location that an organism might first detect any indication of coastal water. We know also from drift-bottle experiments that the flow along the coast is northward at this time of year. A northward flow of dilute water discharged through the Strait would explain why the southern inshore front lies so close to Cape Flattery.

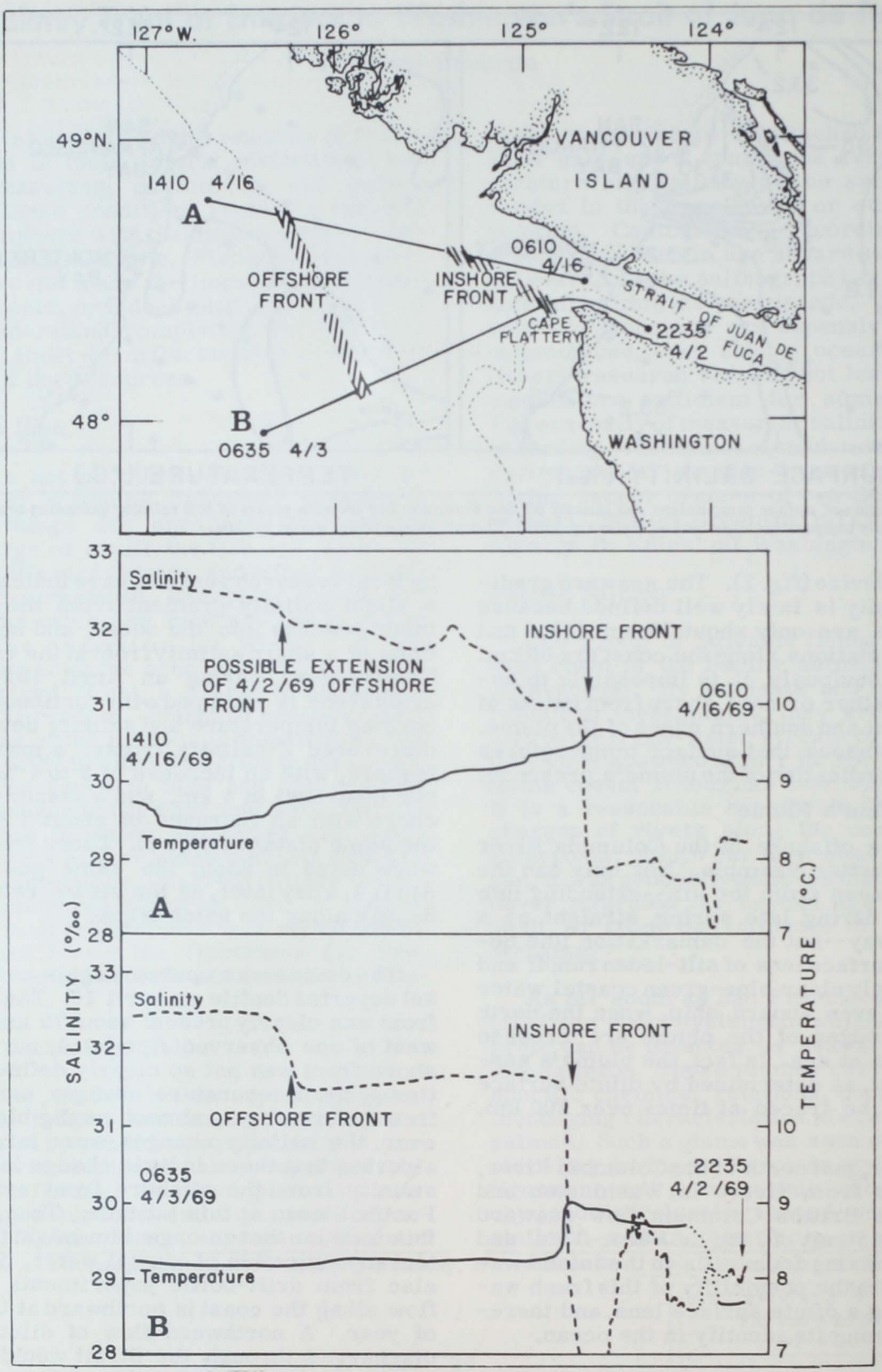


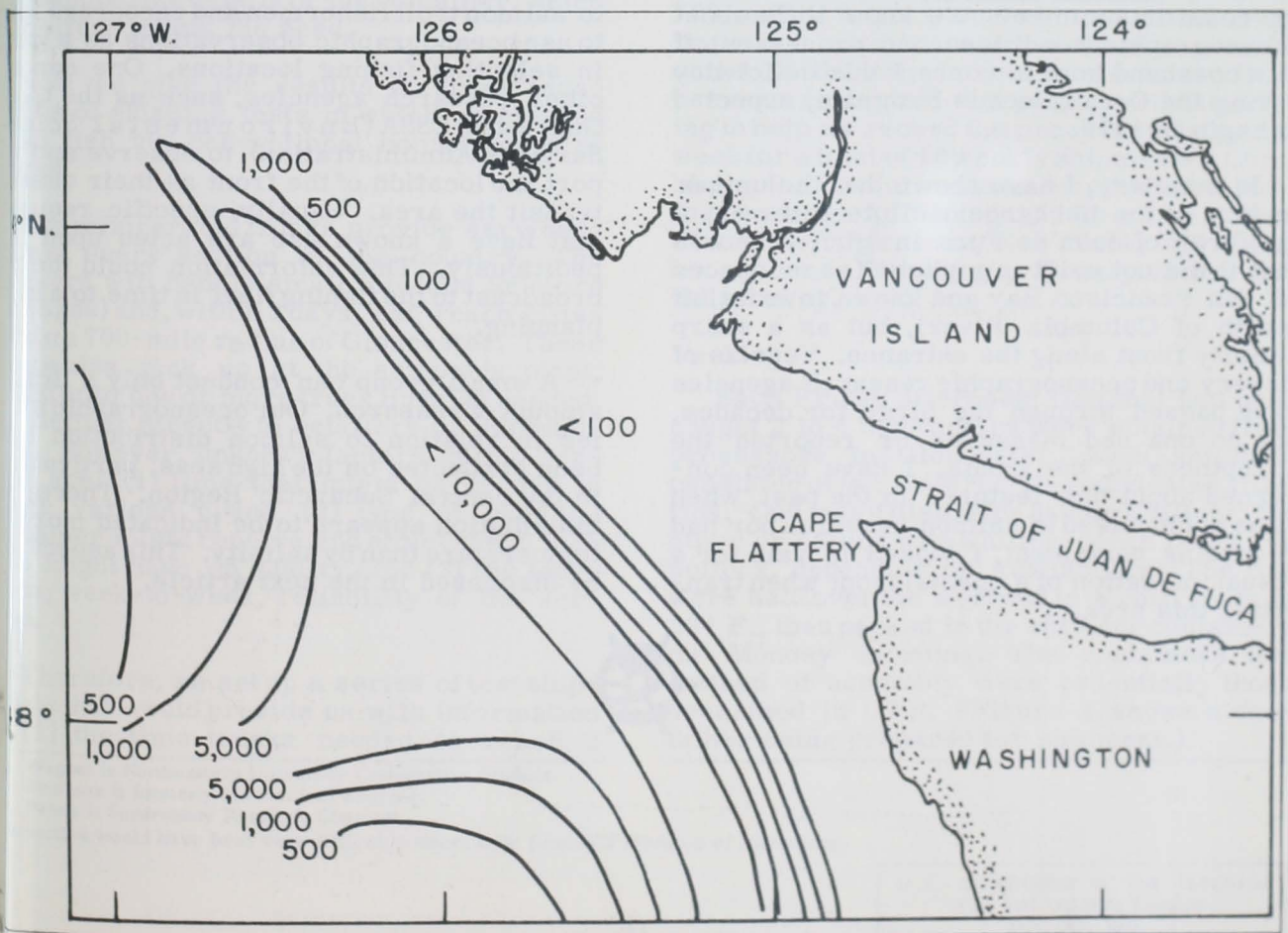
Fig. 2 - Continuous surface temperature and salinity traces seaward of the Strait of Juan de Fuca in April 1969 showing inshore and offshore salinity fronts at which temperature changes are slight. Temperature is indicated by solid line and salinity by dashed line. Dotted lines show traces originally recorded on a different time scale. Salinity trace for April 2 went off scale at 28 ‰ at about 3 a.m. on April 3.

this knowledge of use to the commercial ...erman? The answer is unknown--no fish... ...as done; on both cruises the vessel was ...ely enroute to and from Seattle. The com... ...cial troll salmon fleet has operated off ...hington for years; at times in spring it is ...north-south line well off the coast, per... ...at one or both of these local fronts. But ...mpossible to be certain because no con... ...ent salinity measurements have been ... Even when fishermen make surface ...erature measurements they are not very ...ful because temperature just doesn't ... to be a significant property in this situ...

...ser Sockeye Salmon

...e also know that sockeye salmon (O. ...a) returning to the Fraser River mill ...nd well off the west coast of Vancouver ...nd before they enter inshore waters--...metimes in such concentrations that they ...easily observed from a plane. Furthermore, downstream migrants from southeastern Alaskan streams are known to migrate offshore and then northward around the periphery of the Gulf of Alaska at a distance offshore along a path coinciding with the location of this salinity front. Unfortunately, the spacing of surface salinity observations in this area has been 30 to 100 km.--too great to delineate a significant front. Only a slight salinity gradient, a seaward characteristic of any coastline, is usually indicated by these widely spaced data.

I have implied that salinity may affect the distribution of salmon off the Strait of Juan de Fuca, but the entire story may involve much more. In the first article of this series (July 1969 CFR), I mentioned that several aspects of oceanography should be examined to determine meaningful relations between fish and their environment. The food of fish, for example, would be a logical thing to study. With this in mind, we discovered in spring 1963 that euphausiids, a shrimplike planktonic



3 - Distribution and abundance of euphausiids near the Strait of Juan de Fuca, spring 1963. Abundances determined by catches euphausiids during 30-minute oblique tows from 30 m. to the surface when a 3-foot Isaacs-Kidd midwater trawl was used.

animal on which salmon feed, were concentrated near the 183-m. (100-ftm.) curve off the Strait (fig. 3). We do not know if euphausiids cannot tolerate the dilute inshore water, if they have enough mobility to avoid areas of low salinity, if they are quickly consumed by larger animals such as fish or whales, or if their distribution in spring 1963 was unusual. Is it possible that salmon feed heavily here before they enter inshore waters and migrate up their natal streams to spawn?

Unanswered Questions

Other questions must be answered: What happens to these fronts when the northward coastal flow ceases in spring and the southward flow, characteristic of summer conditions, begins? What happens to them during the period of maximum runoff later in spring when the snow in the rainshed melts? What is the cause of the offshore front? What effect do the fronts have on the distribution of albacore (Thunnus alalunga) and other fish off the coast in summer? We know little about oceanographic conditions and processes off this coast and hope to correct this deficiency during the Ocean Decade Program, expected to begin in 1970.

In summary, I have shown that the unique feature of the discharge of dilute water out of the Strait of Juan de Fuca in April 1969 was that it did not exist as a plume (as evidenced off San Francisco Bay and known to exist off mouth of Columbia River), but as a sharp salinity front along the entrance. Vessels of fishery and oceanographic research agencies have passed through the Strait for decades, but no one had measured or reported the abruptness of the fronts. I have been concerned about this feature. In the past, when I was not involved in salmon research nor had recording equipment, I looked in vain for a visual indication of a coastal front when transiting this area.

Therefore, when one asks, "What cond tions in the ocean may affect the moveme of seaward and shoreward migrating sal on?"--and uses a proper instrument to mea ure critical water properties--interest results are obtained and further hypothes can be tested. This I suggest is fishe oceanography. Proper investigation of t front would require 2 vessels: a resear vessel moving along the front and maki oceanographic observations at the surf and at depth while searching with sonic vices for fish; and a vessel ready to fish short notice when interesting conditions encountered. It is important to observe e vironmental conditions--and to fish wh stocks are known to be in the area. To one without the other ignores half the ta Furthermore, this phenomenon is not nece sarily a physical or chemical oceanograph feature. The biological oceanographic impl cations also are interesting.

One should make this phenomenon kno to salmon troll fishermen and encourage the to use oceanographic observations as a gui in selecting fishing locations. One can a other research agencies, such as the Coa Guard and ESSA (Environmental Scien Services Administration), to observe and re port the location of the front as their vesse transit the area. Usually, specific reques that have a known use are acted upon e peditiously. This information could then broadcast to the fishing fleet in time to aid planning.

A small group can conduct only a limit amount of research. Our oceanographic stu ies in relation to salmon distribution ha been conducted on the high seas, particula in the central Subarctic Region. There, t distribution appears to be indicated more temperature than by salinity. This aspect wi be discussed in the next article.