Getting To Know OSCURS, REFM's Ocean Surface Current Simulator

by W. James Ingraham, Jr.

The quest for knowledge about ocean currents in the North Pacific Ocean and Bering Sea has continued for centuries, with important discoveries made in the 1900s. Early this century, knowledge came from drift bottle experiments, flotsam recoveries from beaches, and reported multiple sightings of drifting derelict ships, which led to the mapping of the dominant horizontal patterns of permanent ocean currents that form the Subtropic, Subarctic, and Bering Sea Gyres. More knowledge about the ocean-wide geostrophic currents in the Subarctic Region came in the mid-1950s when the first cross-ocean baseline Nansen bottle cast data were collected. As a result of these salinity-temperature-depth profile data, indirect calculations of surface flow provided the first seasonal and annual long-term mean geostrophic current charts for the Subarctic Region from 1955 to 1959. By the mid-1970s, improved technology and navigational systems brought direct current measurements via satellite-tracked drifting buoys. Drifter trajectories showed that surface currents caused by winds can be considerably different from the calculated geostrophic currents and thus were very important in the calculation of surface flow.

In the late 1970s computer modeling scientists at the Alaska Fisheries Science Center's (AFSC) Resource Ecology and Fisheries Management (REFM) Division began developing a numerial model to investigate how ocean currents might have influenced various fish populations in the North Pacific Ocean and Bering Sea. Atmospheric sea level pressure measurements recorded daily since 1946 at the U.S. Navy Fleet Numerical Meteorology and Oceanography Center were used as proxy data to calculate wind and changes in sea surface currents. This early numerial model set the stage for others to expand on surface current modeling research and led to the development of the Ocean Surface Current Simulations (OSCURS) model and its use in ocean current variability research and fishery applications at the AFSC.

A TOOL FOR RETROSPECTIVE ANALYSES

The OSCURS numerical model is a research tool that allows oceanographers and fisheries scientists to perform retrospective analyses of daily ocean surface currents anywhere in a 90-km ocean-wide grid from Baja California to China and from 10°N to the Bering Strait from 1901 to the present. The movement of ocean waters is an integrated response to atmospheric forcing and reflects changes in wind climatology on the ocean. This basic water flow is calibrated by comparing model trajectories with trajectories measured with satellite-tracked drifters. The OCSURS model is used to measure the movement of surface currents over time, as well as the movement of what was in or on the water. Ocean surface currents affect organisms suspended in the water column such as fish eggs, small larvae, and plankton, and may affect their survival by determining their location after a few months of drift. Even swimming or migrating fish or mammals may have their destinations significantly offset by currents or annual variability of currents.

Given a start location and date anytime during 1901-present, the OSCURS model converts the selected daily sea level pressure grid (Fig. 1) to east-west wind velocity (u,v-wind) components and then u,v-current grids using empirical functions. Adding the long-term mean u,v-geostrophic currents then produces the total velocity field from which the day's 24-hour water movement is calculated, using the velocity interpolated within the grid at the start point. Continuing this procedure from the end point of the previous day, daily, to the end date forms a trajectory progressing from the start point (latitude, longitude, date).

The key to OSCURS's usefulness is in determination of the time and location for the application. Trajectories can be computed for up to a year or more in several modes: 1) one trajectory from one starting point, 2) several trajectories from one starting point (as in a diffusion model), 3) trajectories from a line of starting points, or 4) trajectories from a grid of starting points. Such calculations can be repeated monthly, seasonally, or annually to provide time-series data on sea surface currents for use in fisheries analyses. As an added feature, when 5-day sea level pressure forecast grids are available, 5-day drift into the future may be estimated.

A NUMERICAL MODEL

The heart of OSCURS involves calculating the movement of the oceans's near-surface mixed layer which varies seasonally from the surface to a depth of about 10-30 m in summer and 50-100 m in winter. This mixed layer is stirred constantly by the wind and moves with the momentum of a slab as it quickly is mixed to its downward density limit at the thermocline or halocline. Although mixed layer depth data are not presently an input for the model, OSCURS computes the daily horizontal u,v-velocity fields of this mixed layer with experimentally established empirical functions to get the vertically averaged flow (here called an ocean surface current). The database consists of 20x44-grid-point subsets from the U.S. Navy's 63x63-point 360-km northern hemisphere grid of daily sea level pressures from 1946 to the present (Fig. 1). A recent improvement to OSCURS has been the addition to the database of time-interpolated daily sea level pressure grids from 1901 to 1945 calculated from National Center for Atmospheric Research monthly mean pressure fields. This addded data extends OSCURS' original analysis capability of 1946-97 to include nearly a century of data. In OSCURS each daily sea level pressure grid is interpolated to a finer 90-km 92x180-point grid for subsequent computations. At each grid point, geostrophic u,v-wind is computed from the pressure gradient, rotated about 15° to 20° toward lower pressure, and diminished about 20%. Then ocean u,v-currents are computed at these same grid points, where current speed (cm/sec) equals 4.8 times the square root of the wind speed (m/sec), and the angle of deflection to the right of the wind increases from 22° to 30° as the wind speed increases. Total currents, therefore, are the sum of these wind-induced ocean currents plus the long-term mean geostrophic currents (0/2,000 decibars) which were computed separately on the same grid from the long-term mean ocean temperature and salinity fields (0-2,000 m). Because OSCURS is intended for broad-scale use, it is sufficient to include in the calculations only the two main forcing components of surface flow: wind and pressure gradient. Other minor components of flow such as mesoscale eddies and tides which are not included comprise the error mode that is tuned out in the overall model calibrations which compare model tracks to measured drift in the ocean. Tuning was accomplished by adjusting the current speed coefficient and/or angle of deflection to the right of the wind.

TUNED TO OCEAN CURRENT MEASUREMENTS

Several different functions for current speed and angle to the right of the wind were tested in OSCURS, and the resulting trajectories compared with data derived from satellite-tracked drifters drogued at 20 m and tracked from August to December 1979 in the Gulf of Alaska. The best agreement (Fig. 2) was found using the functions described above. In Figure 2, notice 1) how the model trajectory filled in for the 30 days of missing location data (straight line of small dots) along the satellite-tracked drifter track and 2) the especially good daily agreement in

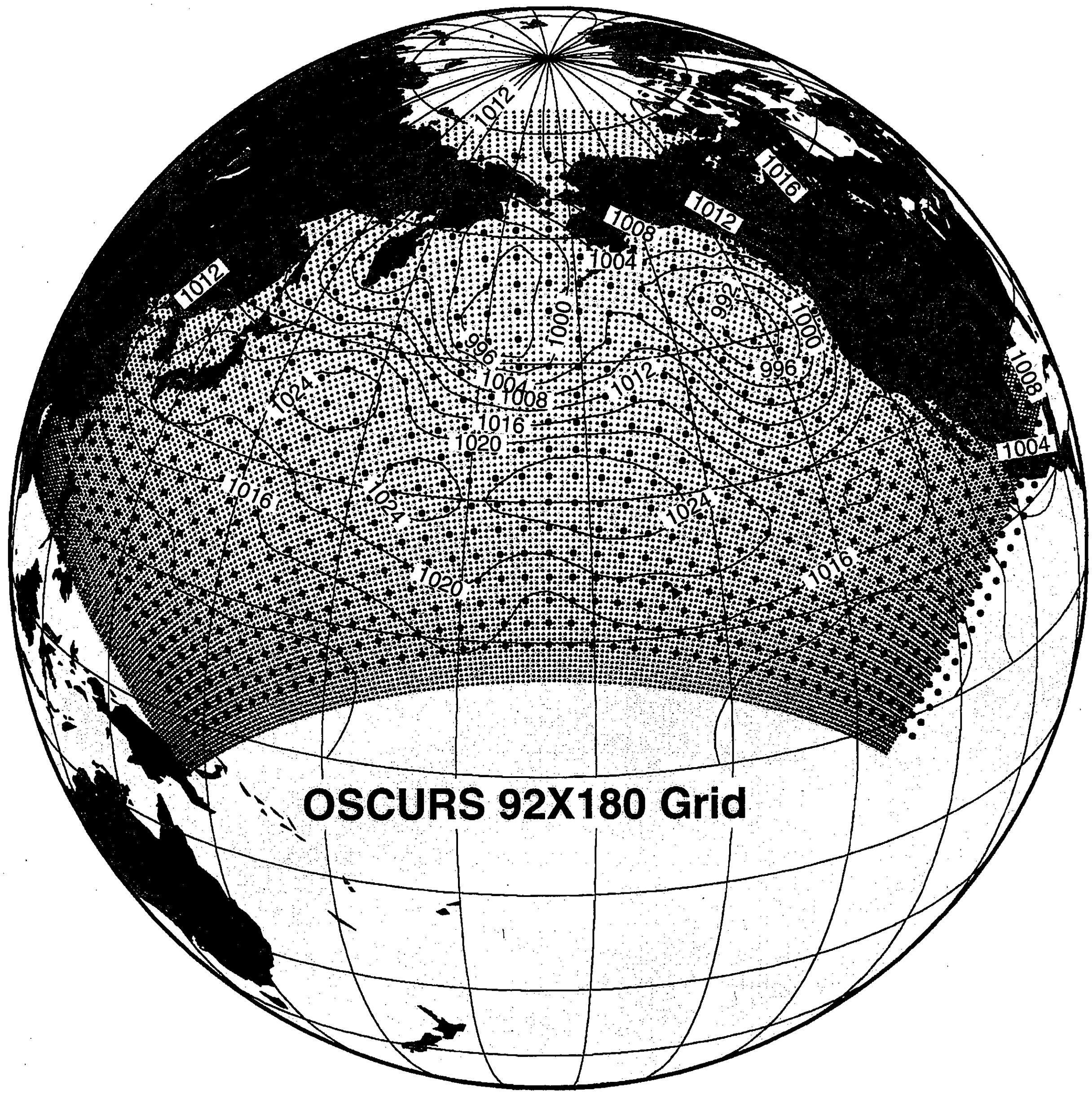

Figure 1. OSCURS Grid. Larger dots are the 20x44 grid of daily sea level pressure from the U.S. Navy Fleet Numerical Meteorology and Oceanography Center with contours every 4 millibars for 5/27/90; small dots are the OSCURS 92x180 computational grid points.

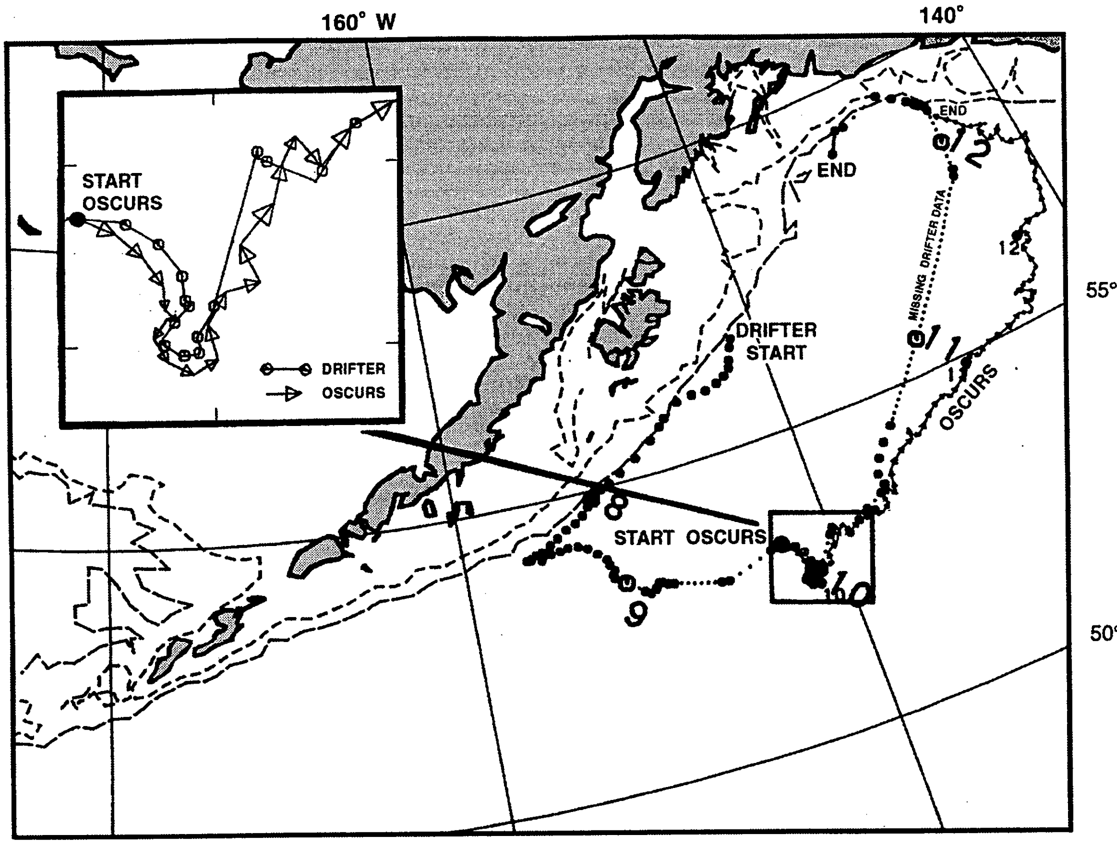

Figure 2. OSCURS vs Drifter. Comparison of OSCURS model trajectories with satellite-tracked drifter drogued at 20 m released during August 1979. Small circles indicate the daily locations of the satellite-tracked drifter; large numbers indicated the first of that month; the small arrows starting offshore indicate the daily positions calculated with OSCURS.

the loop created during the wind event caused by the slow passage of a low pressure area (see zoom insert). Tuning to the best visual agreement was accomplished by multiplying the wind current speeds and geostrophic current speeds by 1.2. This was the initial calibration of OSCURS.

Studies at the University of British Columbia (UBC) Oceanography Department comparing OSCURS' trajectories across the North Pacific and trajectories measured by the World Ocean Circulation Experiment (WOCE) and trajectories generated by the U.S. Navy Research Laboratory's (NRL) high resolution model have had mixed results. However, the cases where the models lacked agreement were primarily due to the passive WOCE drifters becoming trapped in mesoscale eddies, which neither OSCURS nor the NRL model reproduce. The UBC Fisheries Centre used OSCURS velocity fields in their salmon migration model, NerkaSim, because the OSCURS trajectories were closest to observed drift. OSCURS achieves even a greater accuracy when it is used for its primary purpose: determining year-to-year variability.

96 YEARS OF WATER MOVEMENT

It is well known that oceanic subarctic water (north of 42°N) is more productive than oceanic subtropic water (south of 42°N) and that both move eastward in parallel paths toward the North American continent as part of long-term mean ocean circulation. The relative amount of each water mass reaching the coast varies from year to year as atmospheric patterns shift. This variance is important to coastal fisheries because the condition of the water affects its basic food production capacity which is eventually passed to the fish. The driving force for these changes is associated with the Aleutian Low, a permanent atmospheric feature of the Subarctic Region in winter, which varies in intensity and eastward extent year to year. Surface water is forced onshore by the winds, but swings north or south as the winds and the currents vary in strength, direction, and location. The abundance of salmon, for example, a near surface swimmer, has been particularly affected by regime shifts, and OSCURS suggests substantial changes may occur about every 20 years. With OSCURS we are able to simulate the variability in surface water quantitatively, year by year, for the first time.

Ocean Weather Station P (PAPA; 50°N, 145°W) was chosen as the single starting position for simulated drifters because of its location within the eastern edge of the Aleutian Low and the numerous oceanographic observations made there since the mid-1950s characterizing the subarctic water mass. A plot of all-winter (December-January-February) drift tracks shows that the annual trajectory end points of the PAPA-drift distribute in two groupings, north and south (Fig. 3). In year-by-year simulations, the latitudes and longitudes of trajectory end points ranged 1,700 km between 45°- 60°N and 130°-155°W. The north and south groupings of trajectories appeared in both the first (Fig. 3 A) and second (Fig. 3 B) halves of this century. These oscillations are a continuous natural process that coincide with the warmer-drier or colder-wetter climate oscillations in the Pacific Northwest. The annual trajectories shown in Figure 3 appear to jump back and forth irregularly in time, alternating between north and south extreme modes, staying near either extreme for a few years, with a few occurring in the middle, near the theoretical average trajectory.

To better see the patterns in annual and decadal variability, the time-series of annual values of the latitudes at each trajectory end point was plotted (Fig. 4). The fine line which connects the annual values exhibits short-term variability, but smoothing the end point latitudes with an equally weighted 5-year running average (dark line) revealed four peaks averaging 20 years apart (1926, 1940, 1962, 1985) and four troughs 19 years apart (1909, 1932, 1950, 1967). Recently, the 5-year average has begun turning southward and is nearing its long-term mean latitude (54.4°N), indicating the onset of the next oscillation (south mode). This pattern has value as a forecasting tool on a 5-year average scale because it shows decadal variability as well as strong evidence of an impending shift in ocean circulation.

Indication that these oscillations were present prior to the 20th century is found in western juniper tree-ring data from eastern Oregon. The tree-ring data showed oscillations similar to those generated by OSCURS and appear to be a reasonable proxy for the latitude end point data mentionned above. Based on counting the troughs in the plot of the 5-year running average tree-ring widths, 34 oscillations with a spectral period of 17 years have occurred since the time of Columbus. Adding the longest interval between troughs (31 years) to the last trajectory trough (1967), indicates that the next trajectory trough should occur about 1998. The present 30-year interval is, therefore, nearly the longest in half a millennium. Salmon catches off Alaska and the U.S. west coast have varied according to the major regime shifts of the mid-1940s and the mid-1970s, which are reflected in the north-south changes in the latitude data. From 1976 to the present, salmon catches off Alaska have remained high relative to those off Washington-Oregon-California. The opposite is true for the period from the mid-1940s to the mid-1970s. The data above suggest a regime shift is due again and accordingly a change in regional salmon catches.

CURRENTS DEFLECT MIGRATING SALMON

Catch allocation of Pacific salmon between Alaska, Canada, and the U.S. west coast states is complicated by the annual effects of local currents during the fishes' spring onshore migration from winter feeding grounds in the central Gulf of Alaska to their natal streams. The majority of Pacific salmon in the central Gulf of Alaska head toward the west coast of North America each May-June-July in a rapid, well directed, and well-timed migration. Location and timing of their landfall and subsequent coastal migration routes are very important for management to know in order to determine season openings and closings and catch allocation. OSCURS was used initially in cooperative research between the UBC and the REFM Division to test the hypothesis that the

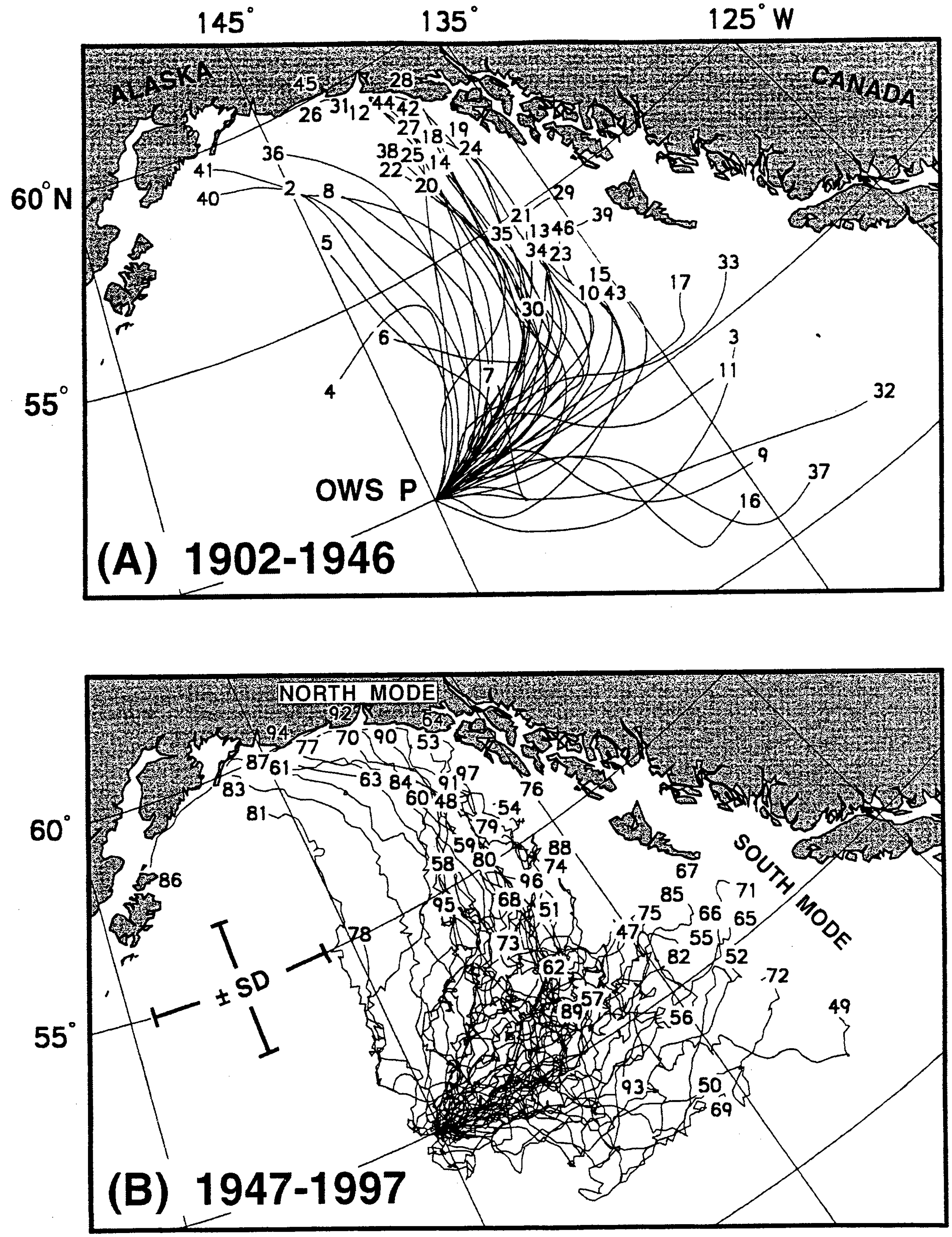

Figure 3. A Century of Drift. Ninety-day sea surface drift trajectories (Dec. 1- Feb. 28) simulated with OSCURS: A) 1902-1946, based on monthly average sea level atmospheric pressure; and B) 1947-1997, based on daily sea level atmospheric pressures. Numbers indicate year and location of trajectory end point.

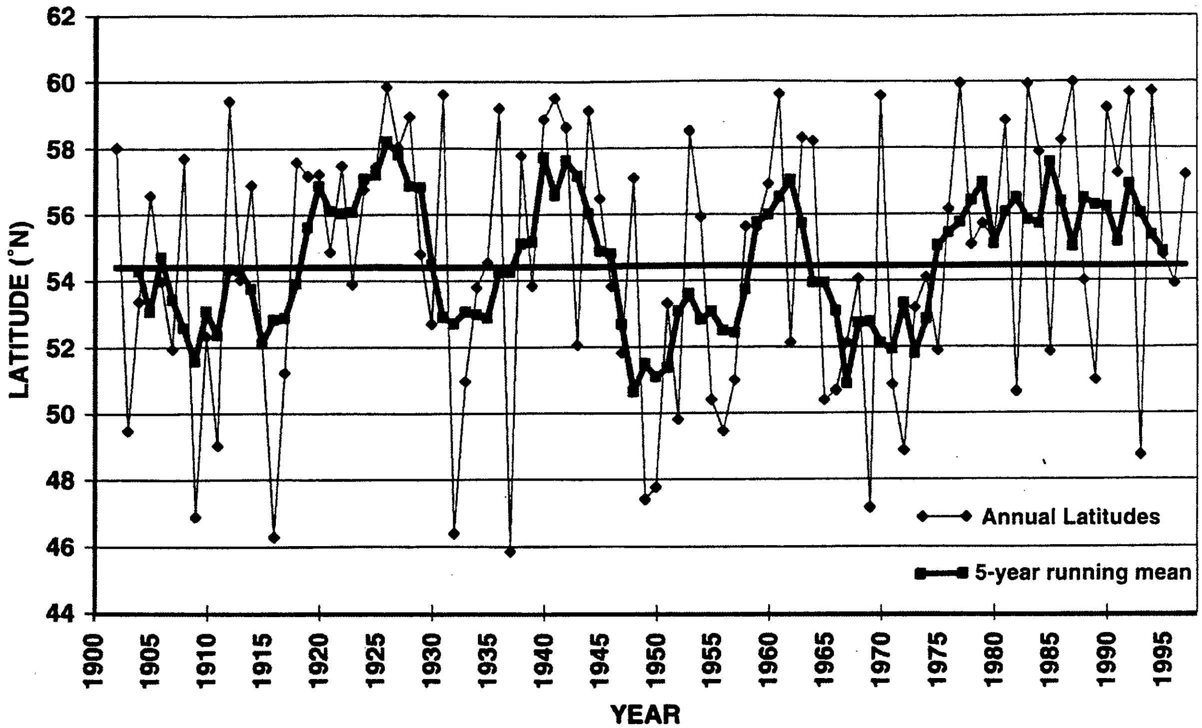

Figure 4. Trajectories Oscillate Decadally. Latitude of annual trajectory end points from Figure 3. Light lines connect diamonds of annual values 1902-97; dark line is equally weighted 5-year running average; and dark horizontal line is the mean latitude of 54.4°N.

interannual variability of the surface circulation in the northeast Pacific Ocean affects the latitude of landfall and migration speed of adult sockeye salmon returning to the Fraser River, British Columbia. Insight about the Northern Diversion Rate (NDR), which describes the percentage of the run going north around Vancouver Island (Canadian waters) or south through Juan de Fuca Strait (U.S./Canadian waters) enroute to the Fraser River and its many tributaries is of particular importance in international treaty negotiations between the United States and Canada.

Because the exact start points of the Fraser River sockeye salmon migration home are unknown, they were entered into OSCURS as 174 smart drifters which were each moved around passively by the daily varying currents and also given an active, fixed swimming speed and compass heading from an array of 174 points which covered most of the Gulf of Alaska. Multiple simulations were performed with different behavior scenarios involving different but constant swimming speeds, compass orientations, and migration start dates (1 May and 1 June). One part of the array shown in Figure 5 is a line of start points 1 degree of latitude apart along 150°W. To test the effect of interannual variability of currents during May and June, the OSCURS model was run for the relatively weak circulation year of 1982 and the relatively strong circulation year of 1983. Results indicated the latitude of landfall in 1983, compared to that in 1982, was generally farther to the north, which is consistent with the stronger circulation in 1983. The difference in latitude of landfall between 1983 and 1982 increased for slower swimming speeds, more southward orientations, and earlier migration start dates. The differences in the latitude of landfall were greater farther south and had a mean landfall distance of 292 km for the southern areas. These results were consistent with the hypothesis that the interannual variability of the surface circulation in the northeast Pacific Ocean does significantly affect the latitude and timing of landfall in the spring migration of adult sockeye returning to the Fraser River, British Columbia. Thus, the effects of

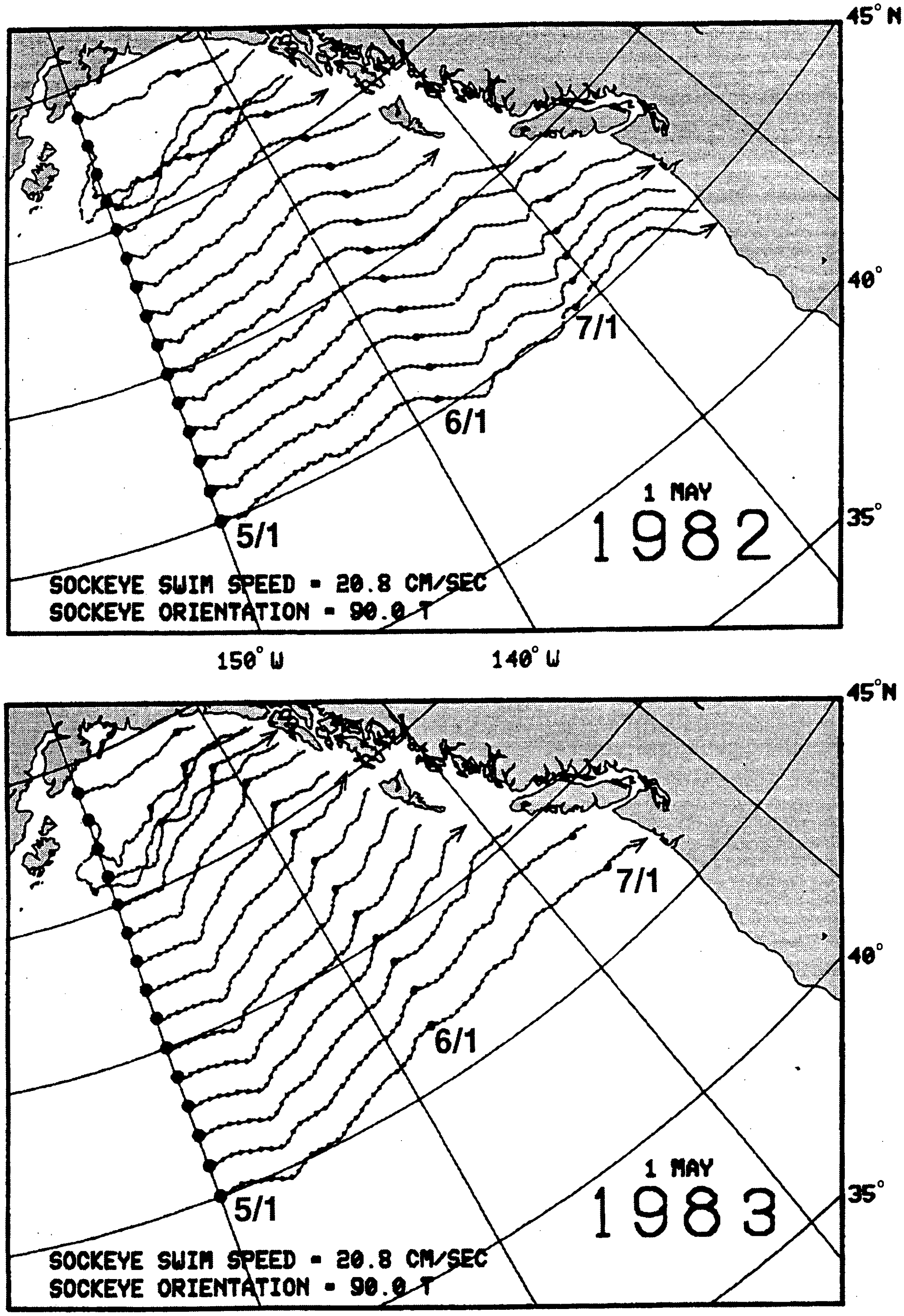

Figure 5. Currents Deflect Migrating Salmon. OSCURS simulated sockeye salmon starting their migration from 150°W on May 1 for 1982 and 1983 with a swimming speed of 20.8 cm/sec, an eastward compass orientation of 90°T. The large dots indicate the start locations. The small arrows along the paths are the daily locations of the sockeye ending when they intersect the coastline. The mid-sized dots along the paths are the locations at the first of the indicated months. Landfall was generally farther north in 1983.

Northeast Pacific Ocean currents should be included in sockeye migration models.

SALMON SHOW MODEL BEHAVIOR

In a collaborative project between the REFM Division and UBC to evaluate alternative regression models for predicting stock-specific marine production, a regression-based prediction of run-timing for Frazer River salmon was developed in which the independent variables were sea surface temperature and the landward component of the monthly OSCURS' current vector in the southeastern portion of the Alaska Gyre. For 1995, 1996, and 1997 the model gave more accurate predictions of the early Stuart Lake sockeye population run-timing peak than the temperature-based model did that the Pacific Biological Station had been using. On the last day of May, June, and July the daily pressure fields were downloaded and the model was run to update the latest months current index which was promptly sent to Canada for the model update to estimate the timing of the peak concentration of sockeye salmon passing Vancouver Island on their way to the Fraser River.

The UBC Fisheries Centre has used OSCURS exclusively in the advection aspect of their bioenergetics and migration model, NerkaSim. Through NerkaSim, which now appears on World Wide Web site "http://www.eos.ubc.ca/salmon/nerkasim," users can produce visual displays of the biophysical environment, simulate salmon migration, growth and survival processes, and produce space/time maps of key bioenergetic variables. NerkaSim links libraries of data on ocean currents, temperatures, zooplankton and fish stomach contents/fullness with subroutines that calculate vectors of fish movement, bioenergetic costs of migration, and growth potential. The area covered is the northeast Pacific Ocean and the eastern Bering Sea from 30° to 60°N and 120° to 170°W. Libraries are updateable to include specific areas of interest. The ability of NerkaSim to integrate the effects of spatial environmental patterns with time-based migration rules is a unique development within the field of ecological modeling; it serves as a platform to explore hypotheses concerning migration, growth, and survival processes.

Some interesting results of the collaborative modelling efforts show that 1) the salmon growth rate potential appears to be maximized near the center of the Alaska Gyre, 2) sockeye have the capability of reaching the Fraser River from anywhere in the northeast Pacific Ocean, 3) the NDR is affected by the location of the fish at the time they begin homeward migration from the Gulf of Alaska, 4) oceanic circulation can affect latitude of landfall but there is no strong relationship between the effects of circulation and the NDR, and 5) on the average, Fraser River sockeye make 1.5 loops of the Gulf of Alaska during their 2.5 years of oceanic life, but the pattern of movement of each year class is different and highly dependent on the patterns of ocean circulation that it encounters during its oceanic life.

LARVAL DRIFT TO SAFER NURSERY AREAS

The OSCURS model also has been used to investigate the spatial distribution of the early life history stages of walleye pollock, the most abundant and one of the most commercially important species in the Bering Sea. Fish eggs and small larvae remain suspended in and drift with the near surface water for atleast the first few months of life before they become active swimmers that are more independent of the ocean currents. Such is the case with the early life history stages of walleye pollock. Juvenile pollock comingle in the same areas adult pollock and are important prey for the larger pollock, marine mammals, and birds. Resource surveys by the AFSC have shown that juvenile walleye pollock stay on the mid-shelf after being transported there early in life. The larger separation between the young fish on the mid-shelf and the adults near the edge and outer shelf in years with large year classes has been suggested as a possible mechanism for greater survival because the young are more likely to avoid cannibalism by adults. Prevailing wind and current changes during and after spawning affect the final spatial distribution of juvenile pollock and may be favorable to their survival. OSCURS was used to investigate this theory by quantifying the 90-day water drift in the Bering Sea from 1970 to 1996 for the period immediately after pollock spawn.

Spawning typically ocurrs in late winter in the southeast corner of the Bering Sea, and the average currents transport the eggs and larvae slowly northward

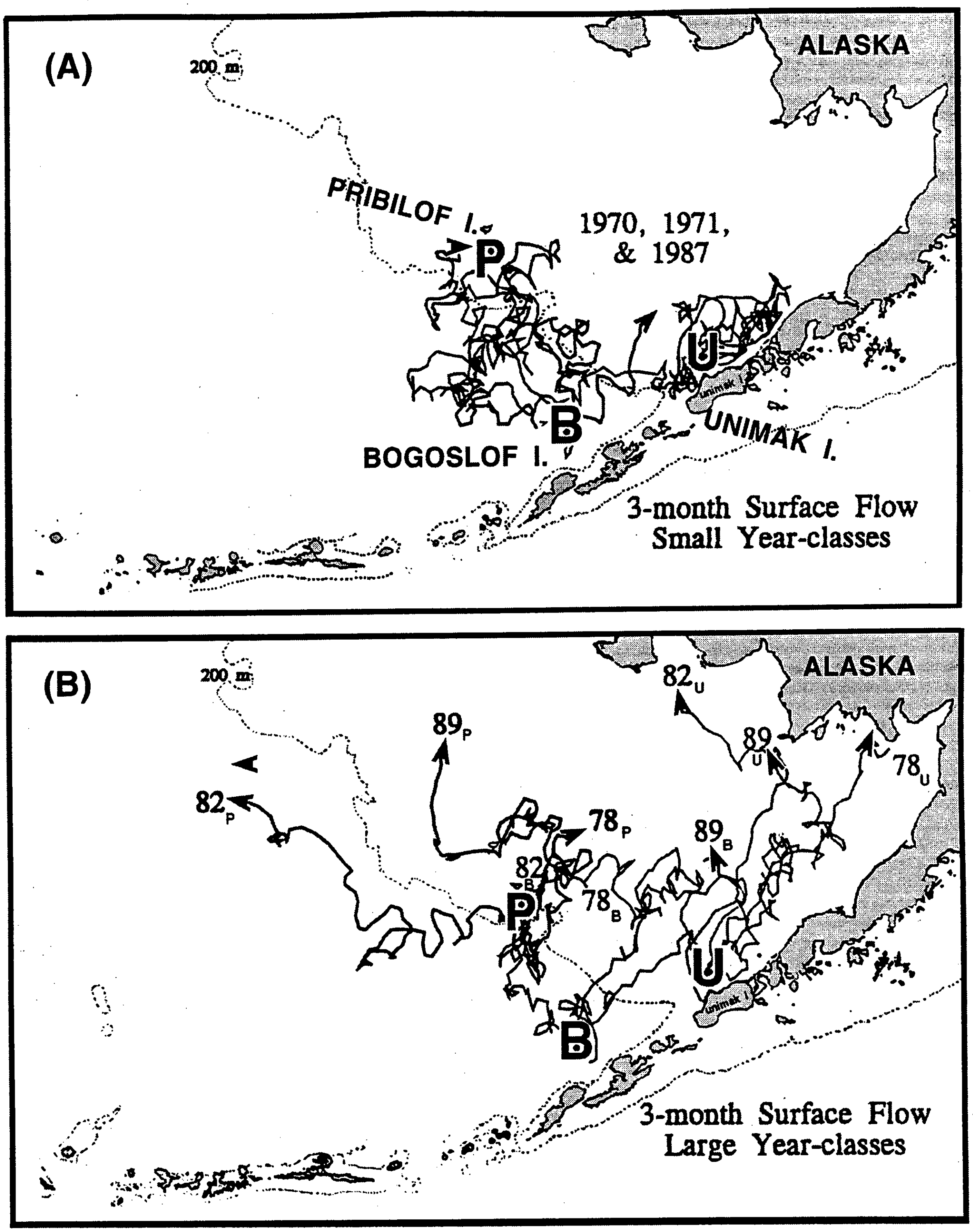

Figure 6. Pollock Spawn Drift. Ninety-day OSCURS trajectories of water movement estimate the transport of pollock eggs and larvae during the first 3 months of life for three spawning areas: 1) from Unimak Island (U) 1 March - 31 May; 2) from Bogoslof Island (B) 1 April - 30 June; and 3) from Pribilof Islands (P) 15 April -15 July. A) Trajectories which initiated poor year classes in 1970, 1971, and 1987; B) trajectories which initiated good year classes in 1978, 1982, and 1989.

along the outer shelf and slope. Reflecting what is generally known about the timing and location of pollock spawning, OSCURS trajectories were started each year on 15 April 1970-96 at three locations; 1) just north of Unimak Island (**U**) on March 1; 2) near Bogoslof Island (**B**) on April 1; and 3) near the Pribilof Islands (**P**) (Fig. 6). OSCURS trajectories showed that during spawning years which resulted in small year classes (1970, 1971, and 1987) there was little net northward and northeastward transport from any of the three spawning locations (Fig. 6 A), thus leaving the juveniles in the same area as the adults. On the other hand, during spawning years which resulted in large year classes (1978, 1982, and 1989) there was strong northeastward transport onto the shelf from the Unimak area, strong northeastward and northward water movement from the Bogoslof area, and stronger northward or northwestward water movement from the Pribilof Islands (Fig. 6 B).

ACCIDENTAL DEBRIS TRACKER

Although the dispersion of animals in the water is the primary interest of OSCURS modelers, unique opportunities have presented themselves since 1990 to analyze accidental but fortuitous at-sea events beyond the scale of normal oceanographic science. Investigation of these events has been used to fine-tune the OSCURS model. Historically, oceanographers throw only a few hundred drift bottles at a given time and spot in the ocean hoping for more than the expected 1-2 % recovery rate. The spill of 80,000 Nike shoes at one spot in mid-ocean in 1990, followed by other spills of 29,000 plastic bathtub toys, and 1,100 logs in 1992 and 1996, respectively, brought a new feature to OSCURS to simulate the drift and diffusion trajectories of great numbers of the same or similar floating objects from one spot in the ocean.

SHOES: FOOTPRINTS ON THE SEA

On 27 May 1990 a storm caused the container vessel *Hansa Carrier* to lose overboard five cargo containers with 80,000 Nike shoes south of the Alaska Peninsula near 48°N, 161°W. Reports from beachcombers revealed that the first 200 shoes started arriving at the northern Washington coast around Thanksgiving 1990, about 6 months after the spill. Beachcomber finds in January-February 1991 off Vancouver Island and in March 1991 in Queen Charlotte Sound showed that the aggregate mass of shoes next floated northward with the winter Davidson Current. The normal spring wind transition from southerly winds of winter to northerly winds of summer off the Pacific northwest coast must have occurred at the end of March 1991, because the next batch of recoveries was reported to the south off Oregon in April and May, indicating that a sharp reversal of currents had moved the flotilla to the south. It took a tuning coefficient multiplier of 1.3 (shoes traveling 30% faster than the current) in the speed equation to make the model trajectories match the recoveries of 1991.

TOYS FLOAT 'ROUND THE PACIFIC

OSCURS also was used to investigate the dispersion of 29,000 children's bathtub toys released from a cargo container that drifted eastward from a mid-ocean spill at 44°N, 178°E on 10 January 1992 to the North American west coast. Unlike the shoes, the toys arrived farther north and then drifted northward and westward, counterclockwise, around the Subarctic Gyre (perhaps, in response to El Nino conditions). In Sitka, Alaska, the *Sitka Sentinal* newspaper reported that several hundred blue turtles, yellow ducks, red beavers, and green frogs washed up on Sitka beaches after 16 November 1992 (Fig. 7). It took a speed coefficient multiplier of 1.5 (toys travelling 50% faster than the water) to get the OSCURS trajectories to match the first recovery. Following the initial landfall, at least 400 more toys were reported along beaches from Sitka to Kodiak through the summer of 1993, agreeing with the model trajectories. Beyond Kodiak and after 1993 there were only a few, sporadic, new reports at Shumagin, Unalaska, and St. Paul Islands which generally matched the direction of model tracks southwestward in the Alaskan Stream then northwestward through Unimak Pass continuing along the edge of the shelf in the Bering Slope Current. No reports were received from the western Pacific but

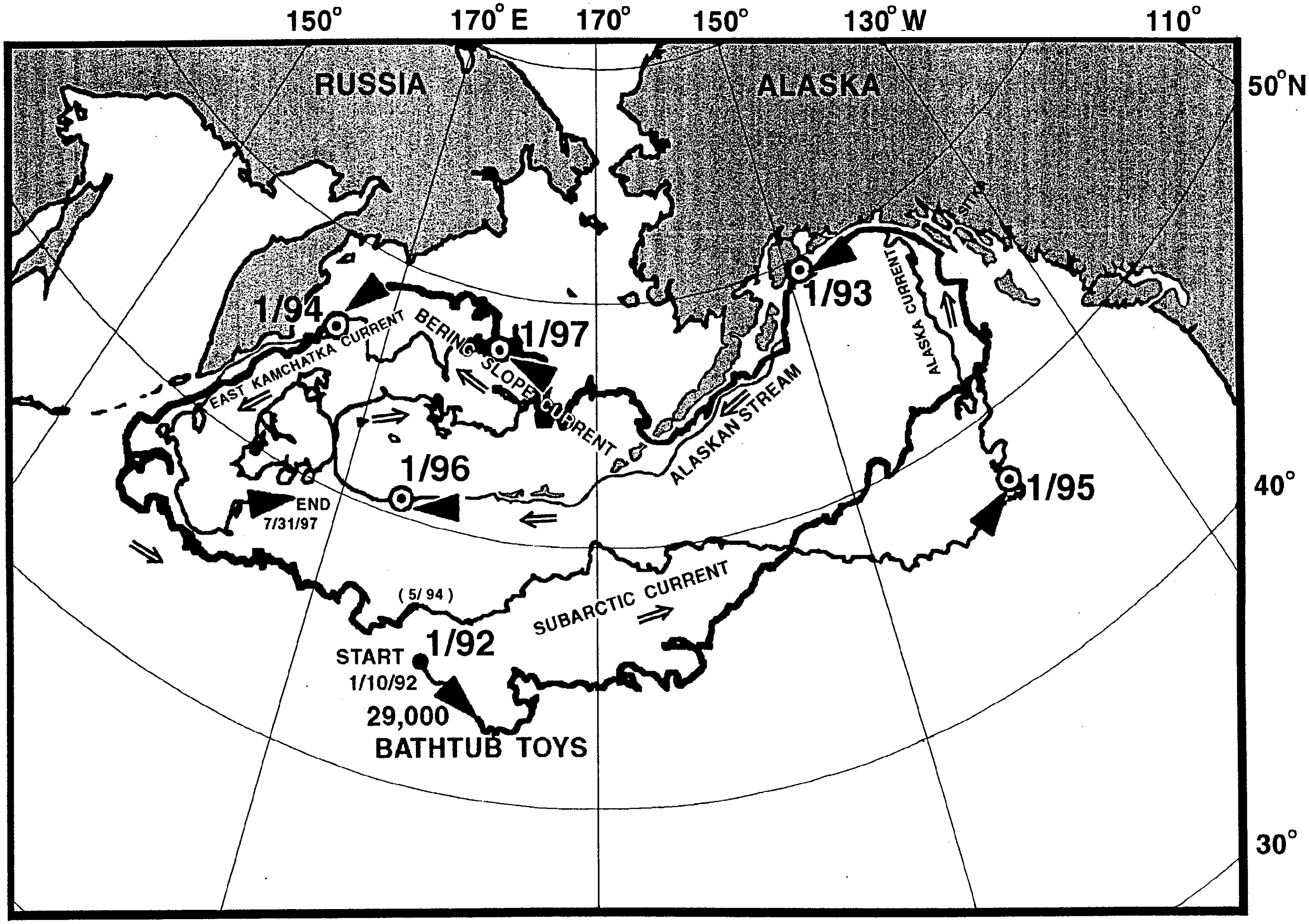

Figure 7. Counterclockwise Drift Around the Subarctic Gyre: Return of the Bathtub Toys? Locations where 29,000 bathtub toys were spilled overboard on 10 January 1992; location of first reported recoveries by beachcombers in Sitka, Alaska; and one OSCURS trajectory tuned to the first recoveries. Track continues for 6 years, twice circumnavigating the Subarctic Gyre. January 1 locations are marked each year and major currents are labeled.

the model track continued across and out of the Bering Sea in the southwestward Kamchatka Current, turned eastward off the Kuril Islands continuing back to and past the spill site (May 1994) nearly crossing the Pacific by January 1995. The next year the model was back at Sitka and Kodiak and the Alaskan Stream where it avoided Unimak Pass going westward to the end of the Aleutian Islands. After January 1996 it turned northward at Attu Island and entered the Bering Sea's slower counterclockwise circulation. After January 1997, the fifth year of the simulation, the trajectory again left the Bering Sea in the Kamchatka Current, again turned eastward at 45°N, almost reaching the spill site at the conclusion of this 5½ year update, 31 July 1997. Thus, the model shows the toys completing the first circumnavigation of the Subarctic Gyre quickly in 2 ½ years and the second circumnavigation in about 3 years. The complexity of coastal diffusion is highlighted with two recoveries from the Washington coast in March-April 1995 that probably came from the first set of circumnavigators.

1,100 LOGS ARE FLOATING HAZARDS

On 20 February 1996, about 1,100 peeled Douglas fir logs were lost overboard by the log transport vessel *Ocean Orchid* in the center of the Gulf of Alaska (52°02′N, 148°54′W). These 20-ft long, 1- to 2-ft diameter logs were potentially hazardous to fishing vessels transiting the Gulf of Alaska. The trajectories and monthly locations of the drifting logs were calculated by OSCURS. Fifteen diffusing trajectories estimated that the logs should have 1) drifted northward from start point in the Alaska Current, 2) turned southwestward in the Alaskan Stream after reaching the continental shelf fishing grounds south of Prince William Sound, 3) made a right angle turn offshore south of Unimak Island into the eastward Subarctic Current, 4) completed the first circuit of the Gulf of Alaska Gyre and turned northward again, 5) reentered the Alaskan Stream boundary current just off the shelf edge, and 6) near the end of the model run, turned offshore again ready for completion of the second circuit of the Gulf of Alaska in a few months. Episodes of onshore winds could have sent a cluster to shore along the shelf but the model suggests many could still be found in a broad area within about 200 miles of shore. Although most apparently continue to circulate around the offshore gyre, one verifiable report came from Unalaska Bay confirming the westward extension in the Alaskan Stream and passage into the Bering Sea. The update through July 1997 showed the hazard continues for fishing vessels transiting the Gulf of Alaska.

Please report any sightings of shoes, toys, or peeled fir logs on the beach or offshore to Jim Ingraham (206)526-4241, e-mail jim.ingraham @noaa.gov, to help fine-tune the OSCURS model. The logs have an identifying plastic tag with a unique number code (e.g., AH10043) stapled to one end.

OSCURS AND THE WORLD WIDE WEB

OSCURS' data are available to other researchers studying surface current variability in relation to various species of fish and marine mammals inhabiting the North Pacific Ocean and Bering Sea. Members of REFM's computer modeling task are working to make OSCURS available through the AFSC web site at "http://www.refm.noaa.gov/oscurs." Monthly current trajectory fields for the North Pacific and Bering Sea will be the first model-derived product (Fig. 8). Other products will be designed and included when feedback is received from users. The OSCURS model will be available in early 1998 for users to calculate a surface drifter trajectory from three chosen inputs: 1) a starting latitude-longitude location, 2) start date between January 1946 and the end of last month (pressure fields updated monthly by the first week of the month), and 3) the number of days in the run (initial limitation 1 year).

REVERSE OSCURS (ROSCURS)

A numerical model the reverse of OSCURS (ROSCURS) is being developed in order to go backwards in time from a given spot because it is not

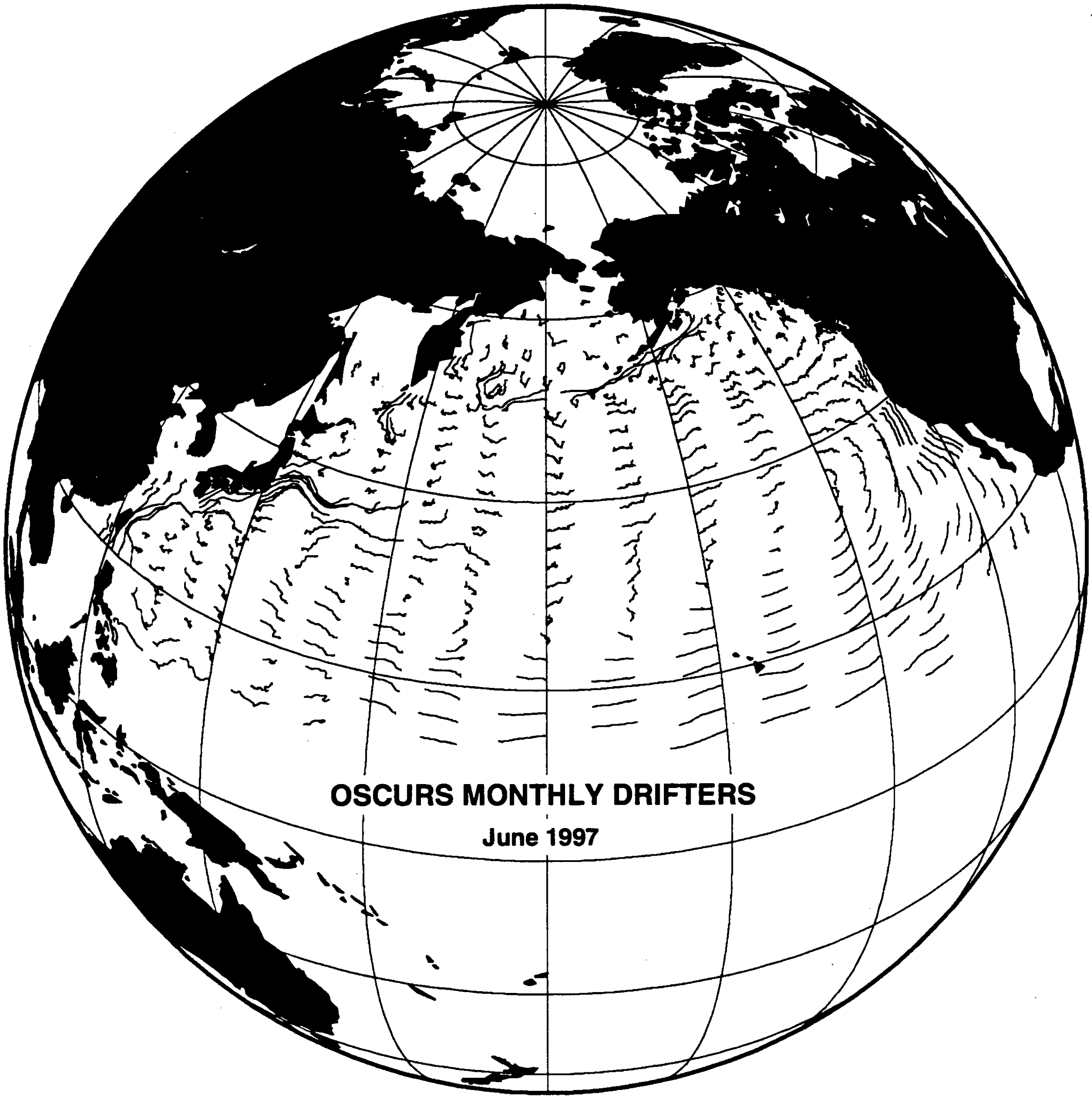

Figure 8. OSCURS Monthly Surface Currents for June 1997. Thirty-day trajectories from selected starting points within the North Pacific Ocean and Bering Sea calculated with the OSCURS numerical model based on daily sea level pressure fields and empirical functions of the wind speed, June 1997.

always easy to pick an affective start point that drifts to a particular end point. Assuming the user knows the start point, OSCURS will respond to the question "Where did the water go in a chosen time interval?" by returning a series of daily latitude-longitudes forward in time from start point to end point. If the user is at an end point of particular interest and wants to know "where the water came from and how long it took to reach that point at a certain date," ROSCURS is the appropriate model. For example, ROSCURS could be used if the desired end point is somewhere at the mouth of the Columbia River on April 15th when the salmon smolts leave the river and enter the ocean, and the user wants to know where the ocean water that the fish encounter came from 6 months earlier in order to assess its quality. The ROSCURS model will be available in 1998. Stay tuned.