Cruise Report: DOLCE VITA 1 and 2, 31 January – 24 February and 26 May – 15 June, 2003

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Technical Report

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Abstract

As part of the U.S. Office of Naval Research sponsored DOLCE VITA (Dynamics of Localized Currents and Eddy Variability in the Adriatic) program, a team of U.S., Italian, Croatian and Austrian investigators conducted two research cruises in the Northern Adriatic Sea designed to investigate mesoscale and submesoscale response to intense, small-scale Bora wind forcing and buoyant riverine discharge. A winter cruise (February 2003, R/V *Knorr* 172-03) observed the response of the largely unstratified northern basin to Bora forcing, which extended over the entire duration of the measurement program. Winter sampling centered on quasi-synoptic, three-dimensional surveys of physical and optical properties conducted using a towed, undulating profiling vehicle (TriSoarus). Additional measurements were made using a bottom-moored five-beam Acoustic Doppler Current Profiler, a free-falling microstructure profiler, surface drifters, and conventional hydrographic sampling. Dedicated synoptic meteorological forecasts allowed us to focus wintertime sampling efforts on mesoscale features during periods of intense forcing. The summer cruise (May–June 2003, R/V Knorr 172-11) sampled during a period of weak winds and anomalously weak river discharge. This report presents preliminary results from both field efforts.

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Part 1

Introduction

1.1 Objective

As part of the Office of Naval Research sponsored DOLCE VITA (Dynamics of Localized Currents and Eddy Variability in the Adriatic) experiment, two cruises focused on investigating strongly forced mesoscale dynamics in the Northern Adriatic Sea. Small-scale wind- and buoyancy-forcing, combined with riverine input, complex bathymetry and proximity to the coastal boundary, support a wide variety of energetic fronts, filaments and eddies. These features have short temporal and spatial scales and can play critical roles in governing basin-scale circulation, cross-shelf transport, watermass transformation and subduction. Because these features often dominate variability near the coasts and within marginal seas, our ability to characterize these environments rests upon our understanding of their dynamics. This component of the DOLCE VITA program focused on understanding:

- The dynamics of shallow water fronts, filaments and buoyant plumes, with particular emphasis on their response to small-scale variations in atmospheric forcing, background stratification and river discharge strength
- Dynamics of watermass formation and subduction in a shallow sea regime

These objectives contribute to long-term investigations of:

- Processes governing exchanges between the shelf and deep ocean
- Strongly forced mesoscale dynamics
- Processes that communicate atmospheric forcing to the ocean interior
- Use of dynamical understanding to improve performance of shallow water analysis products

1.2 Cruise overviews

Winter (February 2003) and spring (May 2003) cruises brought together investigators from the United States (University of Washington, University of Southern California, University of Miami

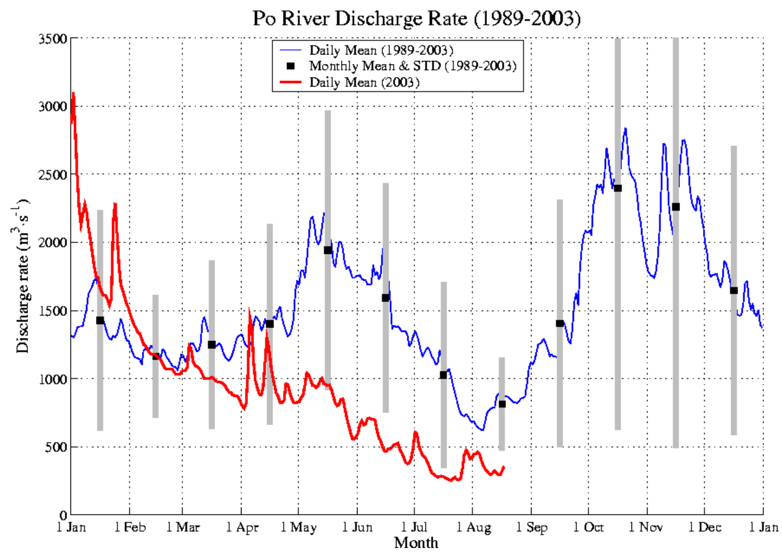


Figure 1.1: Monthly mean Po River discharge rates (blue) with red bars indicating one standard deviation. Monthly average discharge rates for the first part of 2003 (dashed, magenta) indicate above average outflow in winter, but extremely low values during the time of the climatological spring freshette. Data provided by Ufficio Idrographico del Magistrato per il Po (Pama).

and the Naval Research Laboratory), Italy (1st Naz. Oceanografia e Geofisica Sperimentale, University of Ancona, Istituto di Ricerche sulla Pesca Marittima), Croatia (University of Zagreb) and Austria (Austrian Military Weather Service) to study the evolution of selected fronts and filaments under two distinctly different regimes of background stratification, riverine input and wind forcing. During February 2003 the northern basin (with the exception of the Po-influenced region along the Italian coast) was largely unstratified. Po discharge was weak (Fig. 1.1) and strong Bora wind events provided the dominant forcing (Fig. 1.2(a)). These cold air outbreaks typically had lateral scales of O(10 km) and durations of 1–2 days, driving the northern and central basin through intense, laterally sheared wind stress and large net surface heat loss. Although the May cruise was timed to sample the spring freshette, when Po outflow reaches its annual peak and winds are weak, discharge rates were anomalously weak (over one standard deviation below the 12-year mean) and provided only weak buoyancy forcing to the northern basin (Fig. 1.1).

Both cruises followed an adaptive sampling strategy, using remotely sensed sea surface temperature (SST) and ocean color images to select energetic fronts and filaments. We used dedicated short-term meteorological forecasts to coordinate survey timing with atmospheric events, ensuring that target features were sampled during the periods of strong forcing. The observational program employed a towed, undulating sensor platform (TriSoarus, a hybrid SeaSoar vehicle) to conduct high-resolution, three-dimensional surveys of physical and optical variability. Measurements conducted during the two cruises included:

- Continuous underway measurements of ocean currents (150 KHz Broadband acoustic Doppler current profiler (ADCP)) and meteorological variables.
- Towed, undulating profiler (TriSoarus) measurements of temperature, salinity, chlorophyll and DOM fluorescence, 660 nm beam attenuation, dissolved oxygen, nine-channel absorp-

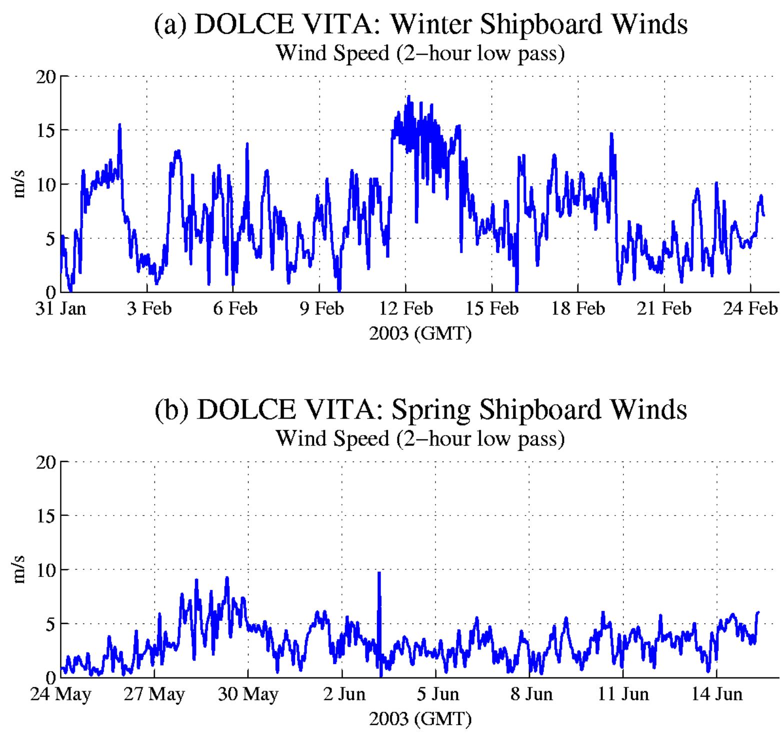


Figure 1.2: Two-hour low-pass wind speeds measured from the R/V Knorr during the (a) winter and (b) spring field programs.

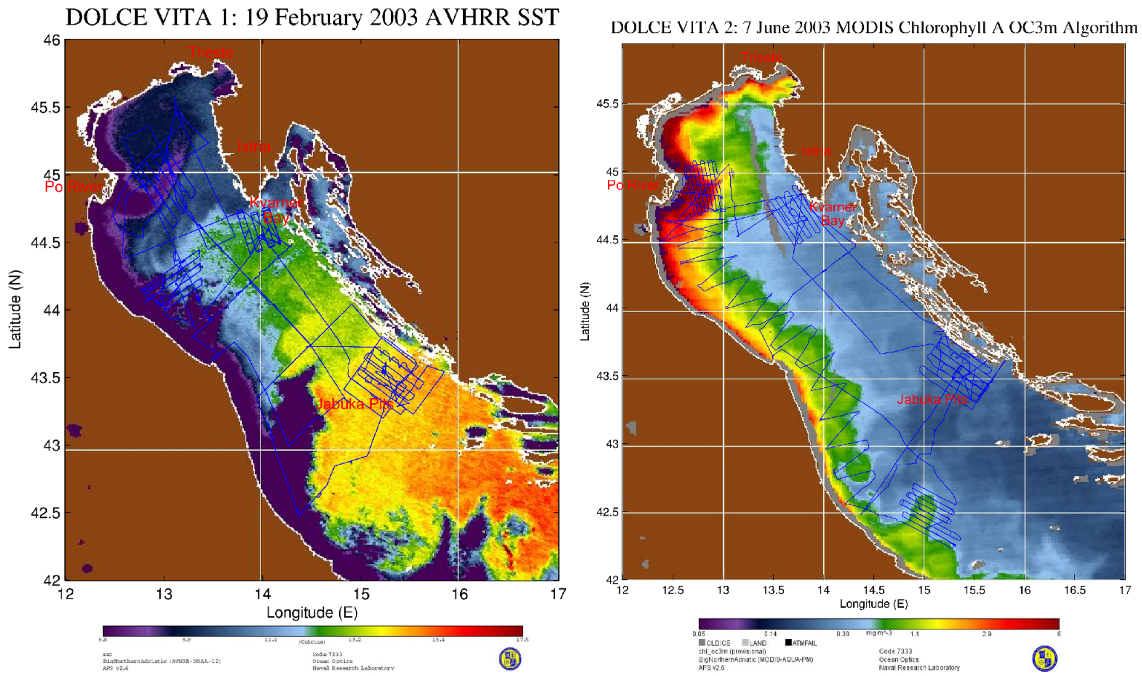
tion and attenuation (AC-9) and currents (1200-kHz broadband ADCP). TriSoarus typically profiled from 1–2 m depth to within 5 m of the bottom at tow speeds of 7–8 knots. Typical along track resolution was approximately 150 m (1500 m) at minimum (maximum) profiling depths of 20 m (200 m), with cross-track distances of 3–5 km.

- Optical profiling sampling temperature, salinity, chlorophyll and DOM fluorescence, 660 nm beam attenuation, spectral optical backscatter (Hydroscat), nine-channel absorption and attenuation (AC-9) and upwelling and downwelling irradiance (Dr. B. Jones, University of Southern California)

- CTD/rosette casts sampling temperature, salinity, dissolved oxygen, chlorophyll fluorescence, 660 nm beam attenuation, nutrients and pigments (Dr. B. Jones, University of Southern California; Dr. M. Marini, IRPEM)

- Plankton sampling using vertical net tows and rosette water samples (Dr. D. Vilici, U. Zagreb)

- Surface drifter deployments coordinated with the intensive towed surveys. (Dr. P. Poulain, OGS-Trieste) item Microstructure profiles and time series of velocity profiles (5-beam bottom-moored ADCP) (Dr. H. Peters, U. Miami)



(a) 19 February 2003 sea surface temperature.

(b) 7 June 2003 chlorophyll concentration (derived from MODIS ocean color)

Figure 1.3: Ship tracks (blue lines) of winter (a) and spring (b) cruises. Images courtesy of R. Arnone, NRL-SSC.

The winter (February 2003) field program sampled the response to small-scale Bora wind forcing in the absence of significant riverine buoyancy input. Northeasterly (Bora) winds were present throughout the entire cruise, with a mean wind speed of 7 m/s punctuated by strong events of up to 18 m/s lasting 1–3 days (Fig. 1.2(a)). At the start and end of the cruise, we executed broad-scale surveys spanning the region north of the Jabuka Pits (Fig. 1.3(a)). These were designed to identify dense water formation regions, characterize wintertime variability and provide length scale statistics to aid other analysis. To investigate the relative roles of bathymetric steering and wind forcing, we executed a set of intensive surveys at the northern end of the Jabuka Pit, where the East Adriatic Current (EAC) bifurcates, part flowing westward to follow the bathymetry (forming the Mid-Adriatic Filament (MAF)), with the remainder continuing north along the Croatian coast. A set of nested surveys occupied after a strong Bora event captured the counter-rotating gyres and up-wind extension of the Po River plume (Fig. 1.4) anticipated from numerical results[1]. These features dominate the northern basin and are hypothesized to be the response to intense, small-scale [O(10 km)] wind stress curl associated with Bora jets passing though the Gulf of Trieste and Kvarner Bay.

A strong shallow-water front that extended westward from the tip of the Istrian peninsula marked

[1]Orlic, M., M. Kuzmic, and Z. Pasaric, 1994: Response of the Adriatic Sea to the Bora and Sirocco forcing. Continental Shelf Research, 14, 91-116.

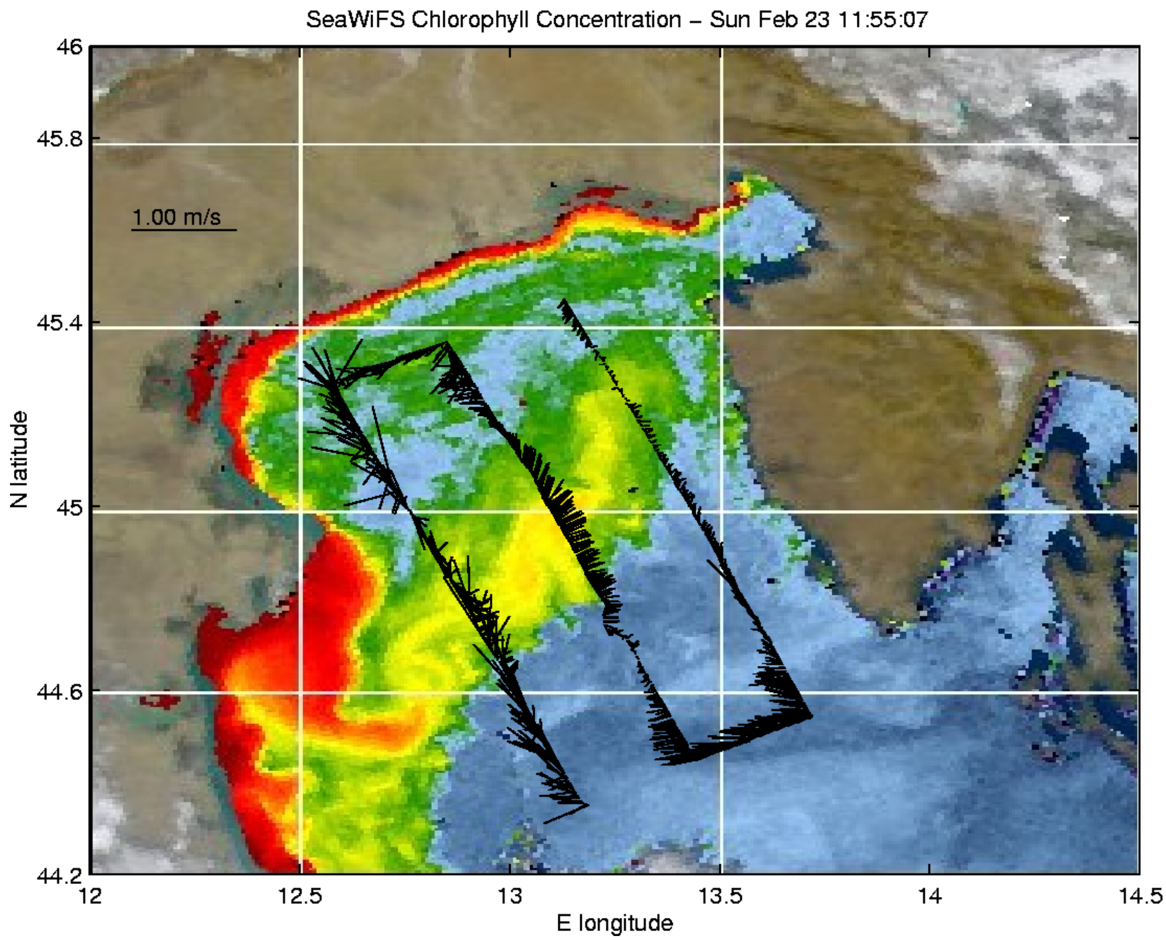


Figure 1.4: Shipboard ADCP currents (12 m) plotted over SeaWiFS-derived chlorophyll concentration (23 February 2003). Currents flow northeastward within the Po plume extension, with cyclonic (anticyclonic) flow to the north (south). Shallow water depths prevented the ADCP from generating reliable velocity profiles in the northwest corner of the survey. The vectors displayed in this region are inaccurate. Images courtesy of R. Arnone, NRL-SSC.

a transition between the northern and central basins, separating two hypothesized dense water formation sites. Guided by real-time SST images and dedicated meteorological forecasts, we executed a sequence of four surveys to document the front's evolution through a strong Bora event. Frontal temperature and salinity contrasts were largely compensating and occurred over extremely small scales (1°C in less than 100 m). The interface remained nearly vertical during the period of strong wind forcing, but began to tilt as the winds subsided (Fig. 1.5). This could be driven by slumping, distortion by shear in the upper layer flow or distortion by the deep offshore-moving return flow that balances wind-driven downwelling off the tip of Istria. A narrow band of anomalously dense water occupied the frontal interface (Fig. 1.6). Elevated levels of chlorophyll fluorescence and beam attenuation were also associated with the dense-water regions. Although cabelling can produce density anomalies across sharp temperature–salinity interfaces, the observed density contrasts are too large to be explained by this mechanism. The associated optical signal and strong westward flow along

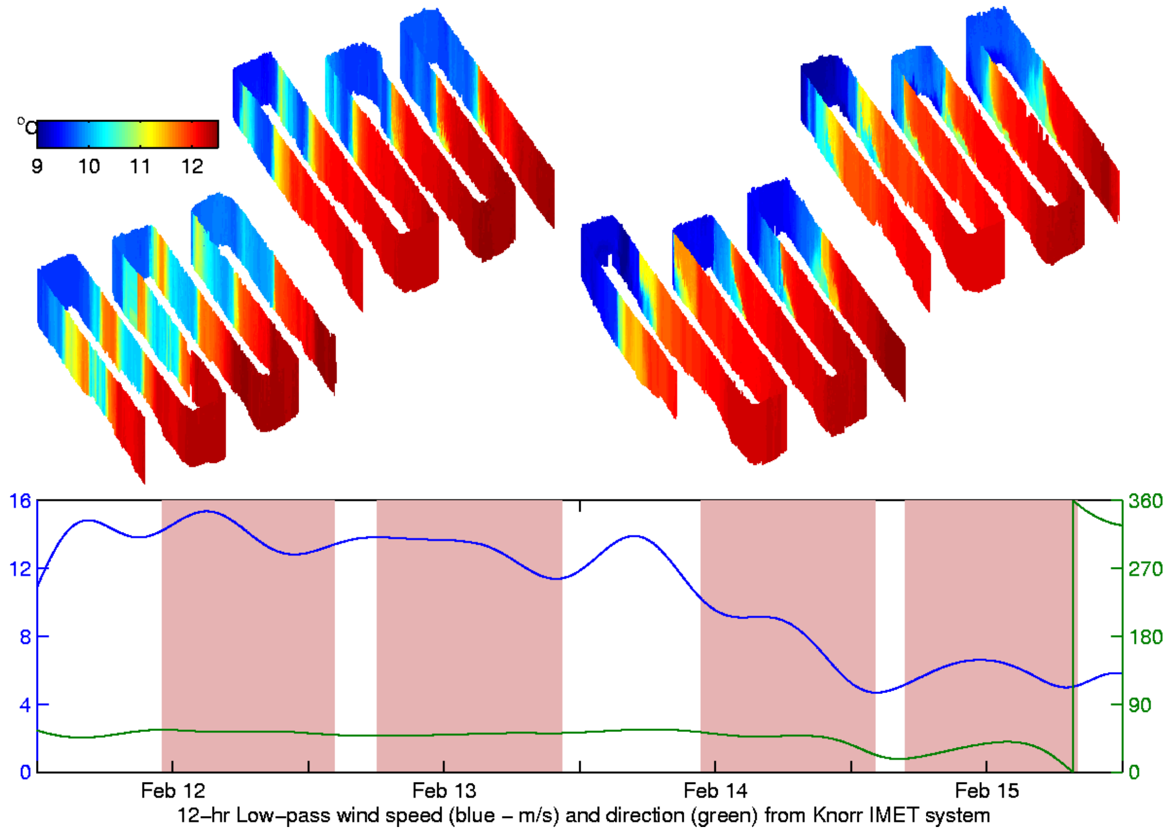


Figure 1.5: A sequence of four Istria front surveys occupied during and following a strong Bora event. The top panels depict potential temperature over each survey (survey lines point roughly north), from the sea surface to approximately 40 m. The bottom panel displays wind speed (blue, left axis) and direction (green, right axis), with pink bands marking the times of the four surveys. The front remained sharp and vertical during the period of strong forcing, with the interface tilting as the winds weakened.

the front hint that advection may play a role in establishing the observed density structure.

In sharp contrast to wintertime conditions, the May/June cruise occurred during a period of extremely weak wind and riverine forcing. In the absence of significant wind-induced mixing, intense surface warming produced very shallow (0–5 m) mixed layers with significant stratification extending throughout the water column. Intensive surveys focused on the MAF, the Istria front, the Po plume bulge and a Po plume instability located well downstream of the inflow region (Fig. 1.3(b)). A series of cross-shelf sections extending from the Po delta to the Jabuka Pit documented downstream physical and optical evolution of the Po plume. All surveys exhibited energetic small-scale velocity and T–S variability, with both TriSoarus and drifter measurements suggesting a significant near-inertial component. Even weak winds may have been enough to set the thin surface layer in motion.

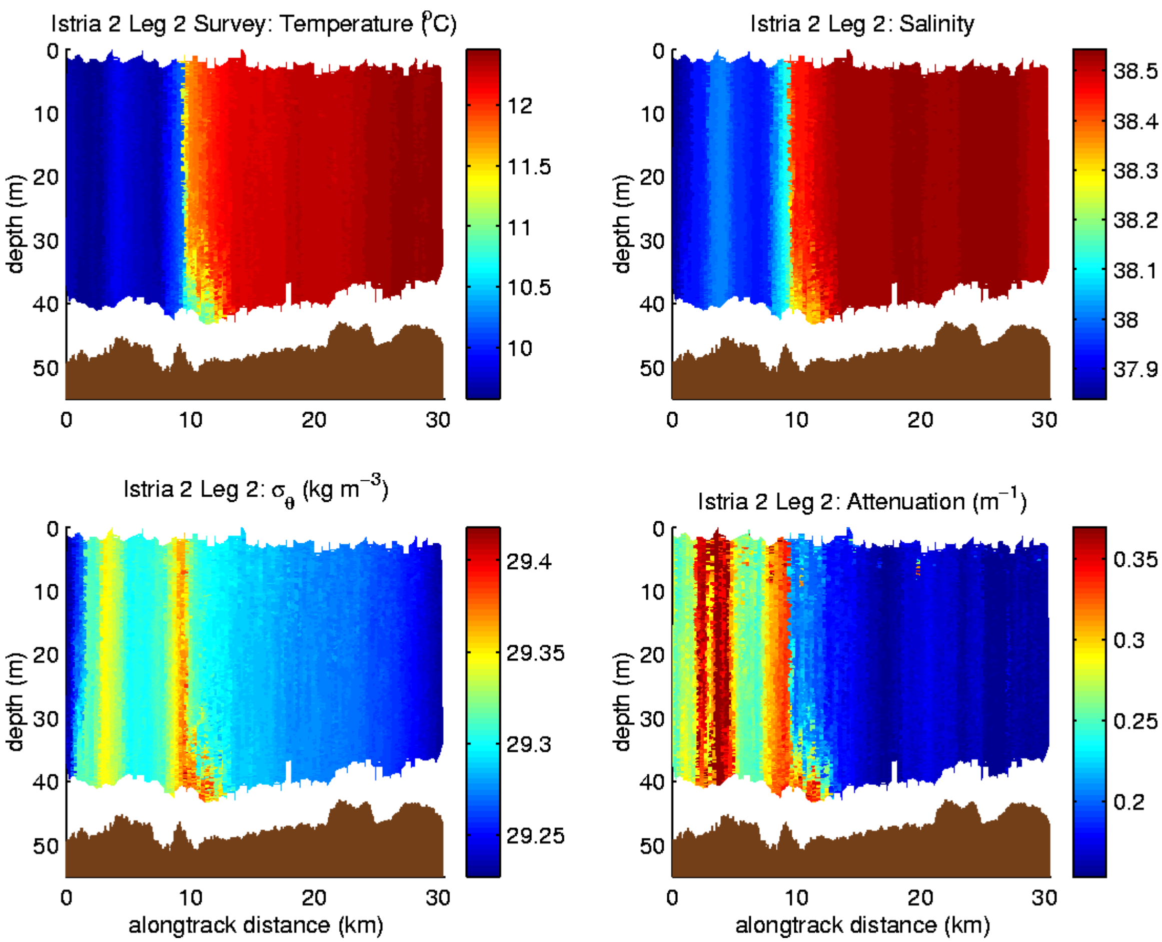


Figure 1.6: Temperature, salinity, potential density and 660 nm beam attenuation sections from the second occupation of the Istria front survey. Along-track distance runs north to south. Bora winds remained near their peak during this occupation, and the frontal interface was sharp and nearly vertical. Note the narrow band of dense water at the frontal interface. Examination of individual profiles found lateral temperature changes of over 1°C in less than 100 m.

1.3 Cruise narratives

1.3.1 DOLCE VITA 1

31 January 2003

R/V *Knorr* departs Ancona at 16:00 (all times GMT), sailing at the onset of a strong Bora. Forecasts indicate that strong northeasterly winds will begin in the northern Adriatic, producing significant wave heights near the Italian coast of 2 m late in the day. By 1 February, strong winds and waves will spread to the region south of Ancona, with 4 m wave heights over the Italian half of the basin. We deploy Trisoarus offshore of Senigallia, planning to occupy the survey line between Senigallia and Susak.

1 February 2003

At approximately mid-basin, we lose communications with Trisoarus. On recovery, we find that the termination mainboard has failed. We replace the board and redeploy, towing toward the start of the Pula–Cessenatico line. As we learn to tune the auto pilot, a series of hard, steep dives produces high cable tensions, eventually causing the termination shear pin to yield with resulting loss of power and communications. We recover Trisoarus on its safety line and rebuild the termination. A brief late-night redeployment reveals cracks in the power bulkhead connector (main control bottle) that cause the system to short when immersed. We recover briefly to swap main bottles.

2 February 2003

After one hour of towing, severe chaffing produces a leak in the vehicle's power cable. We replace both the cable and the termination bulkhead connector (which may have sustained damage due to shorting), and swap out the termination jaw, which appears to be developing excessive play. System performs well when we redeploy, and we complete the Pula–Cessenatico line, transit to the Po delta region, and begin towing toward Perec. With the system performing well, we decide to explore the upper end of potential tow speeds, working upward from 7 knots. At 10 knots the wings failed to actuate at the top of the climb, trapping the vehicle at the surface until we reduced speed to 9 knots. The vehicle left the surface at an overly steep dive angle that caused it to overshoot, glancing the bottom before turning around. Some combination of the abuse associated with prolonged trapping at the surface and the bottom impact caused the termination shear pin to fail. We recover Trisoarus for repairs, taking additional time to recalibrate the load cell on our winch, which we have come to believe is underreporting cable tensions.

6 February 2003

Recover Trisoarus at the end of the broad-scale survey, just before midnight. Inspection reveals that the chaffing gear protecting the power cable has shifted, exposing the neoprene jacket to wear. As planned, we pull the main bottle so that we can reconnect the dissolved oxygen and CDOM fluorometer.

8 February 2003

At 09:30 we recover Trisoarus mid-way through the Jabuka survey so that we can attempt to rescue OGS's prototype ADCP drifter, which stopped communicating its position to ARGOS during the night. The drifter was deployed alongside two CODE-style GPS drifters, which have continued to communicate. The hope is that the pack has stayed close together, so that we can steam to the CODE drifters and then locate the ADCP unit using the RDF. Because drifter recoveries must take place during the day, timing considerations for tomorrow's operations dictate that we recover all of the drifters at this time. We invest the remaining daylight hours to searching for drifters, recovering two optical units and four CODE GPS drifters, but fail to make contact with the ADCP prototype. Interference from the radio beacons of the other units may be preventing communications, and perhaps having fewer active units in the region would help. Ultimately, we exhaust our daylight and end the search, returning to our survey line.

Maps of the ADCP velocities suggest that we increase our lateral resolution in the region where the filament bends southwestward over the northern flank of the Jabuka Pit. We thus decide to tow through a few additional lines intended to bolster our resolution in this region. Trisoarus is flying well, but shows signs of building difficulties. Current draw is slightly irregular, and the DIMM PC reboots a couple of times during the tow. The Triaxus/Trisoarus control program crashes hard, locking up the console and requiring system level termination of the process. We need to remember to explicitly restart payload when this happens, as the controller comes up with payload unpowered. Shortly after this (21:45), we loose communication with Trisoarus. Current draw jumps to 1.5 amps, indicating a severe short, so we power down and initiate recovery. Tests of the termination power cable reveal shorted conductors. This cable was spliced together from two ends recovered from previous failures, and it is likely that the splice has been leaking slowly. Because this exhausts our supply of 4-pin power cables, we switch to running using 8-pin cables and connectors. McGinnis and Gobat had already prepared a termination end cap and a main electronics bottle for this contingency. Thus, the repair involved only a switch of bottles in Trisoarus and a swap of end caps (with a little internal connectorizing) on the tow cable termination.

9 February 2003

We redeploy Trisoarus after a two-hour deck period and finish the first Jabuka survey without incident. We then steam to a point just beyond the southern end of line 4 to begin our CTD/BOP/SWAMP section. The section consists of seven stations with 5 km resolution across the front and 10 km outside. In addition to making optical, chemical and biological measurements not possible from Trisoarus, these profiles will extend to within a few meters of the bottom, past the typical 180 m maximum Trisoarus profile depth. This provides measurements in the NADW.

Dietmar Thaler forecasts a moderate Bora beginning in the evening of 11 February. The science party weighs whether to make the run north, to set up in the obvious SST front south of Pula to await the Bora onset or to execute one more occupation of the Jabuka survey, tuning the scope and cross-track resolution to capture the branching of the mid-Adriatic filament as it turns offshore along the northern edge of the pit. Ultimately, we decide to stay for the additional survey, reasoning that the forecast indicates that there is sufficient time afterward to transit north prior to the onset of strong winds.

10 February 2003

Weather remains mild. We are officially experiencing Bora (winds from the northeast), but the winds are weak and the seas remain calm. Trisoarus experiences severe rolls during the peak of its climb and dive cycles, limiting its profiling range to depths shallower than 120 m (considerably worse than that achieved earlier in the cruise). We speculate that the vehicle may have caught something, or that the ailerons have become misaligned, though neither is a very satisfactory answer. The limited depth range prevents sampling below the Levantine waters in the Jabuka Pit, but we are still able to resolve the jet skirting the depression's northern flank. We decide to postpone recovery until we meet Dallaporta, at which time we will inspect for damage and, hopefully, implement a solution. Heavy seas near Ancona slow Dallaporta, and she does not arrive until after dark. Crew transfer goes smoothly, with Adam Seamans and Bill Dunn shuttling people back and forth with Knorr's RHIB. Fortunately, we receive our supply of spares (MacArtney and APL-UW), including replacement power and signal cables, optical transceivers and shear pins. We have not needed any of these in the past few days, but it provides peace of mind knowing that they are there if needed.

11 February 2003

Finished Trisoarus Jabuka Pit survey around 06:00 with an uneventful recovery. *Knorr* conducted a half-hour engine test following recovery, during which the OGS group heard a weak signal that might have been the missing prototype ADCP drifter. The RDF indicates that the source lies in the general direction of our transit to the Pula survey site, so we commit a half hour to searching for the unit. We begin by recovering the second of two GPS CODE drifters that were deployed with the prototype. This was done to disable its radio transmitter, in case it was obscuring the prototype's signal. Unfortunately, we were still unable to distinguish a clear signal from the ADCP-equipped unit, and thus abandoned the search after approximately 45 minutes of effort.

Winds increase as we transit to the Pula survey site, likely a combination of location (the Pula survey is intentionally located in a region of strong Bora influence) and the onset of the forecasted event.

12 February 2003

Initial testing of the SWAMP microstructure profiler in strong winds reveals some line handling problems. The tether blows back onto the ship, and must be tended to prevent fouling.

The first occupation of the Pula ('Istria') survey reveals a strong, vertically homogeneous front. Temperature and salinity largely compensate, producing only weak density contrasts across the front. The first and second occupations take place under strong Bora winds.

13 February 2003

The second occupation of the Pula survey crosses the primary front, which has shifted northward, but fails to find the small intrusive feature observed north of the front during the first occupation. Bora winds weaken slightly by the end of the second survey, when we begin occupying a series of stations (CTD/rosette, BOP and, at some stations, SWAMP). Because the Trisoarus data indicate that the front is very narrow (1 km), we specify the two end member stations, well to either side, and determine locations for the intermediate casts by first assigning positions using the Trisoarus data, and then refining the coordinates by carefully monitoring the underway data for the expected changes at the front. SWAMP casts prove to be difficult, as the strong winds blow the lightweight tether back onto the *Knorr* deck. Lowering the power block appears to alleviate this problem. At the end of the hydro section, we deploy Trisoarus for a third occupation of the Pula survey.

14 February 2003

We terminate the third occupation of the Pula survey early (when we are approximately three-quarters through the final line) to ensure recovery of the bottom-moored ADCP during daylight. Recovery goes without incident. The popup float system works well. A combination of an orange and a green float indicate the direction of the surface currents by how they stream on the surface.

15 February 2003

The fourth occupation of the Istria survey finds the front shifted northward. Frontal gradients are more diffuse, with the formerly vertical interface distinctly sloped. We finish the survey mid-morning, and spend the remainder of the daylight hours recovering drifters, securing one thermistor chain, two optical and one GPS unit. These were deployed at the start of the Istria survey, during which they were carried rapidly westward and then southwestward along the Italian coast. Thus, the drifters had traveled significantly further than originally anticipated and required additional transit time to recover. Searches go rapidly for those units for which we have a recent GPS fix, but much more slowly when the position information is stale. Darkness prevents us from locating a last GPS drifter, which the RDF indicates is extremely nearby, though we cannot locate it with the searchlights.

After concluding our search we steam to the ADCP lander deployment site, located in the center of the Rimini/Pesaro survey pattern. Deployment goes smoothly, but we loose all GPS except P-code and the Ashtech ADU2 as we enter the area. Before we sailed our Italian colleagues told us of a region off the coast where the military blocked GPS signals. Perhaps this is it. After some retooling we switch from differential to P-code and begin towing for the first occupation of the survey.

16 February 2003

We complete first occupation of Rimini survey and begin a second pass. Today and tomorrow are supposed to be the peak winds of the current Bora. Conditions remain relatively mild (15–20 knot winds, modest wave heights). We fail to find dense Northern Adriatic Deep Water along any of the legs of this survey, though vehicle limitations prevented us from sampling within 7–10 m of the seabed.

18 February 2003

Begin CTD/BOP/SWAMP section at approximately 04:00. To ensure full daylight for the optical measurements conducted closest to shore (where the remote sensing returns a strong color signal) we start at the offshore end of the third leg in the Trisoarus survey. Station work proceeds as planned, though it becomes apparent that the front has shifted westward since the preceding Trisoarus occupation. Though our original plan called for a break in the station work for an early morning recovery of the bottom-moored ADCP, the mate on watch decides that it is too rough to conduct the recovery and asks that we delay until later in the day. All measurements find a vertically uniform water column, with no trace of the North Adriatic Deep Water we expected to find flowing southward near the bottom. Hartmut Peters decides to forgo SWAMP profiling after it becomes clear that the entire region is mixed top to bottom. The last station is taken in 13 m of water.

We begin chasing the two optics-equipped drifters immediately following the last station. Both have been carried just beyond the southeastern boundary of the survey, requiring a 10-nmile transit to close the gap. Fortunately, recent GPS fixes are available for both units, and they are quickly located and recovered. At this point we are running short on daylight, with projections placing us over the mooring with less than an hour of usable light remaining. The mooring recovery goes less smoothly than the first. We arrive on site in time to release the pop-up floats in daylight. The floats are quickly snagged and aboard, but winds and wave action bring the ship across the recovery line, forcing the bosun to release it as a precaution against entanglement. Without the line the mooring crew are forced to fire the second release, leaving the anchor on the seabed but recovering the float, releases and sensors. An on-board strobe makes location and recovery of the ADCP top section straightforward, despite the failing light. Motivated by a recent pair of AVHRR and SeaWiFS images depicting a large plume of Po water being drawn into the central basin, we elect to spend the remaining days sampling what we expect to be a double gyre system generated by the two northernmost Bora jets. The survey begins with a large-scale survey consisting of three along-basin lines centered on the Po delta. These sections are meant to characterize the large-scale variability associated with the gyre and jet systems. We will follow with a smaller pattern focused on the plume itself. This deployment marks the first flight of our new 1.2-MHz ADCP, which sits in a downward looking tail mount. The mounting complicates deployment and recovery, as we can no longer set the vehicle down on its tail. Two people are now required to handle the tail until the entire vehicle is well off the deck. This deployment also gives us our first failure in many days — a short somewhere within the system that manifests within the first few minutes. We quickly track the problem to the dummy plug protecting the four-pin power bulkhead. The plug has been installed incorrectly, with the guide pin bent and pressed into one of the power leads. Because the four-pin power is tied directly to the eight-pin power, which we are now using, this shorted the entire system. To effect a quick repair, we swap end caps with the second main bottle and redeploy the vehicle. All goes smoothly following the repair.

19 February 2003

Three along-basin sections extend from the warm, saline waters south of the Istria front, across a plume of Po River water that stretches northeastward across the basin and into the cold, vertically homogeneous waters of the shallow northern shelf. The Po plume appears in the two western sections as a narrow (20 km), fresh, cold feature that extends to 20 m depth. The survey reveals eastward flow in the region of the plume, with strong westward flows to the north and south. These currents are jet-like in the western sections, but weaker and more confused along the eastern line. At the end of the survey, we recover Trisoarus and deploy three GPS drifters in the northeast corner of the Gulf of Venice, where it opens into the Gulf of Trieste. These deployments reoccupy sites where drifters have been launched previously during SACLANTCEN cruises aboard R/V *Alliance*.

20 February 2003

Following the drifter deployments we begin a smaller survey focused on the offshore extension of the Po plume. In an effort to maximize efficiency, we deploy three drifters (two optical and one thermistor) while towing. This is accomplished by shortening the Trisoarus cable to 5–10 m and slowing the 2 knots. We then deploy drifters from the starboard corner, accelerating after the drogue clears the Trisoarus cable. All three deployments proceed well, and we will likely adopt this technique for all future deployments in calm to moderate seas. The focused survey captures the Po plume as it is drawn offshore.

21 February 2003

We finish the first occupation of the Po plume survey near daybreak, after which we begin a series of stations arranged across the plume. Though our intent is to sample with the rosette, BOP and SWAMP, a connector failure sidelines the microstructure profiler (the same connector that had been repaired earlier in the cruise) at the first station. Unfortunately, no spares are available, and not enough time remains in the cruise to effect another repair. We finish the section using the other two packages, and then proceed to track and recover three drifters. The drifters have not dispersed significantly, reducing transit times, and recent GPS fixes provide excellent starting locations for each search. Recoveries proceed quickly, and we are free to begin towed surveys well before sunset.

Guided by remotely sensed SST and color, we decide to execute a section along the axis of the plume, running from the western edge of the Venezia survey inshore to a point on the 20-m isobath near the mouth of the Po. This section will document the evolution of Po waters as they flow into mid-basin and provide end member measurements near the Po outflow. We use a recent image to choose initial waypoints, and then steer *Knorr* based on the realltime Trisoarus data. This works well, with only one course correction required to keep us within the plume. As we approach the Po outflow we begin to see highly interleaved water masses, with temperature and salinity varying in complex layers having thicknesses of 2–5 m. These features extend north of the outflow region, and we observe them en route to the start of our second occupation of the Venezia survey.

22 February

We finish the second Po plume survey.

23 February

We finish the second repeat of the small-scale Venezia survey. The offshore plume extension is becoming less distinct as the forcing weakens.

25 February

We return to Ancona 12:00.

1.3.2 DOLCE VITA 2

26 May 2003

Knorr departs Ancona at 09:00 under clear, sunny skies. Our sampling begins with a reoccupation of the northern broadscale survey sampled in February. We have just enough time to complete the sections that lie north of Ancona, followed by a thalweg section extending to the Jabuka Pit before meeting H. Peters late Wednesday or early Thursday (28 or 29 May) to begin coordinated sampling of the MAF.

Immediately after arriving on station (approximately 2 hours out of Ancona) we deploy BOP for a test cast. Initial TriSoarus deployment follows, but intermittent problems with the CTD force us to recover a few hours into the initial section. Inspection reveals a leak in the primary pump connector. There is considerable corrosion (the base of the narrow pin is eaten about one-third the way through), but because the connector has not been inspected since the February cruise, we do not know how recently the damage occurred. We redeploy TriSoarus only to find that the problem persists. The failure is associated with a drop in current draw, suggesting that it is a component cut-out rather than a short or leak. Recovery and troubleshooting trace the problem to the cable connecting the vehicle's main bottle to the SBE-9. Jiggling the cable interrupts the connections and, as the cable carries both signal and power, causes the SBE-9 to drop out. We replace the cable and continue with the survey. During the evening, we notice artifacts in the real-time salinity data that we attribute to strong vertical temperature contrasts and the fact that data are not lagged for presentation in the real-time display.

27 May 2003

Initial section across the region of the Istria front reveals it to be capped by a warm surface layer. Temperature contrasts across the front are weak, thought there is a transition from fresher northern waters to more saline waters to the south.

The real-time conductivity/salinity display indicates that both primary and secondary conductivity cells are experiencing longer-than-expected lags. The effect is large enough to impact data quality, motivating us to recover the vehicle for diagnosis and repair. In ordered to reach the Jabuka Pit in time for our meeting with Dallaporta, we shorted the survey pattern and continue sampling using BOP through the TriSoarus deck period. We consider several possible mechanisms that could produce reduced pump efficiency. The fact that both T–C pairs exhibit identical problems constrains the field. Candidates include degraded pump performance, problems associated with pump power (supplied by the SBE-9) and issues associated with the extensive plumbing required to supply the internally mounted fluorometers and dissolved oxygen sensor. Various tests reveal that the main bottle supplies insufficient power to the SBE-9, causing the pumps to operate poorly. The main bottle drives the SBE-9 at 12 volts (which both SBE and MacArtney indicated as sufficient). Unfortunately, at this 12 voltage the pumps overtax the system and thus operate at a reduced speed. The problem disappears when the SBE-9 is placed on a 15-volt supply. We reconfigure the system to power the pumps directly from one of the payload channels of the main bottle, bypassing the SBE-9. As we also suspect possible sensor contamination, we clean and flush all sensors and upstream plumbing before redeploying the vehicle. This appears to work, and analysis of the resulting data finds 1.75 scan lag (the same as that expected from stock SBE CTD systems) for both sensor pairs.

28 May 2003

We begin the day working sections across the northern basin, attempting to complete a coarse survey prior to departing to meet Dallaporta early Thursday morning. The region influenced by Po River discharge extends well into the northern basin and exhibits energetic small-scale (5–10 km) variability. Recent measurements (extending to 15 May 2003, provided by Nello Russo, UNIAN) estimate Po discharge at approximately 1000 m^3s^{-1}, considerably weaker than the 2000–3000 m^3s^{-1} typical for this time of year. This reduced flow is expected to persist, meaning that we will likely experience only weak buoyancy forcing throughout our measurement period.

Although the estimated sensor lags were satisfactory, the real-time data suggest that further improvements are needed. Having already investigated and addressed pump performance, we adopt a phased approach to evaluating the effects of sensor plumbing. We begin by converting the secondary T–C pair to free-flow operation. Comparison with the (pumped) primary pair indicates that the free-flow sensors respond more rapidly to sharp temperature and salinity gradients, suggesting that our plumbing introduces significantly long lags. We next plan to alter the plumbing of the primary pair such that they are serviced by a dedicated pump, with short plumbing runs and no other sensors in-line. We will then compare the short-plumbing system with the free-flow configuration, implementing the better of the two on both sensor pairs.

In the afternoon we learn that an accident on Dallaporta has destroyed all of H. Peter's instrumentation, leaving him with no tools with which to carry out his planned measurement program. Peters decides to return to Ancona. We are thus reduced to a one-ship operation, free to maneuver as necessary.

29 May 2003

We deviate eastward from the February thalweg section to obtain a preliminary section across the Jabuka Pit, with which we hope to capture the MAF and thus refine our small-scale synoptic survey. The section reveals considerable small-scale variability, none of which we interpret to be the MAF. Upon reaching the pit, we recover TriSoarus in order to calibrate the AC-9 and to convert the primary T–C pair to a short plumbing system. TriSoarus now carries one free-flow T–C pair and one connected directly to a pump, with no additional sensors and through a short plumbing run. We use this deck period to deploy a 12-drifter array, including optical and T-chain units, in the region upstream of our tentative survey site.

We then begin a 30-hour TriSoarus survey designed to sample both the East Adriatic Current (EAC) and (if present) the MAF. In an attempt to resolve the anticipated small-scale variability, we set cross-track spacing to 6 km. Sections closest to the Croatian coast reveal a thin freshwater cap and weak, variable currents. Farther offshore, currents strengthen, with a westward flowing jet in the southern part of the survey and an eastward countercurrent to the north. These are accompanied by T–S features that introduce significant isopycnal slopes. Small-scale interleaving features dominate T–S variability, perhaps generated by interactions between fresh surface waters, saline Levantine intermediate waters and recently formed North Adriatic deep waters. Though the strong westward current may be the MAF, it becomes difficult to trace as it nears the western side of the survey. The velocity field contains aliased inertial and tidal flows. These may distort the observed currents, complicating interpretation. The Adriatic possess relatively weak tidal currents, and the region experienced only weak wind forcing during the period prior to our survey. Tidal and inertial currents should thus be weak.

Changes to the TriSoarus autopilot, introducing a delay before applying down-flap at the surface, result in smoother dive profiles, reduced roll and lower peak line tensions. Modifications to vehicle trim (added weight in the nose) combined with the redesigned aileron appears to have improved stability during deeper dives, and the steep rolls we experienced at 160–180 m during wintertime operations have vanished. However, the vehicle is flying with approximately a 20-degree list, perhaps due to wing asymmetries, aileron biases or trim. Gear lash complicates aileron adjustment, and prevents precise alignment of the flaps.

30 May 2003

Complete the first survey of the northeastern Jabuka Pit region. In an attempt to estimate the northward transport of the EAC, we occupy a cross-basin section that runs into the Croatian coast. In contrast to the along-basin section closest to the coast, which revealed weak, variable currents, the section across the EAC shows a relatively strong flow concentrated close to shore. We ended the section well inside a deep embayment, where the ADCP still indicated strong northwestward flow.

Both beam-c and chlorophyll fluorescence show a subsurface peak, often as deep as 70–80 m (not far off the seabed). This seems too deep for active phytoplankton, but the fluorescence suggests that the signal is not simply suspended inorganic particulates.

TriSoarus profiling range typically extended from the surface to 180 m (or 8 m above the bottom, whichever was shallower). We experienced some problems with the wing blow-back and sticking during climbs, which often resulted in the vehicle being temporarily stuck at the surface. Upon recovery, we discover a thick, viscous goo coating the sensor guards of both T–C pairs. The substance does not appear to have penetrated into the plumbing.

To explore the deep fluorescence signal and better characterize optical variability, we occupy a section of six CTD/rosette and BOP stations.

31 May 2003

Following the hydrographic survey, we redeploy TriSoarus and begin a second occupation of the Jabuka Pit survey. Survey legs were extended southward to better straddle the region of the previously observed strong southwestward flow, though we maintained coverage to the north, where the previous survey found energetic small-scale currents. Shortly after deployment TriSoarus suffered compete telemetry loss, which we traced to a break in (both) fibers somewhere in or near the termination. Because retermination requires considerable time (minimum 6 hours), we accelerated our plans to occupy a CTD/BOP section along the deepest part of the Jabuka Pit, extending between the Croatian and Italian coasts. TriSoarus repairs were conducted while we carried out the hydrographic survey.

1 June 2003

The bulk of the day was spent finishing the Jabuka section, with the last stations (off the Italian coast) completed in early afternoon. The section revealed dense, cold North Adriatic Deep Waters, presumably formed earlier in the year, flowing southward over the Italian shelf and slope. Po river discharge produced a 25-m thick low-salinity surface layer that extended 25 km (well beyond the 100-m isobath) over the broad Italian shelf.

Following the Jabuka section we diverted to recover three drifters that were threatening to exit the southern bound of the study area. The first two recoveries go smoothly, but the third extends past dusk and thus requires additional time to locate the drifter and maneuver for pick up. Drifter tracks reveal near-inertial oscillations of 10 cm/s superimposed on small-scale [O(10 km)] background flows. Though the combination of weak wind forcing and strong inertial oscillations seems odd, the water column is stratified nearly to the surface, with mixed layer depths of meters. Even weak winds may provide sufficient momentum to accelerate the thin surface layer. The presence of significant inertial (and, perhaps, tidal) velocities combined with length scales estimated from both drifter and shipboard ADCP measurements motivate us to execute a series of rapidly repeated small surveys. We focused the pattern on a strong, distinct southwestward flow (which we believe to be the MAF), balancing the competing requirements of short repeat time, short cross-track resolution and broad spatial coverage. Ultimately, we intend to occupy the pattern four times, ending with a fifth, broader survey that would encompass the smaller domain while providing larger scale context.

2 June 2003

Continued small-scale, rapid repeat surveys. The feature we believe to be a meandering, southwestward flowing current persists in the southern half of the survey region, though we observe considerable variability between surveys repeated at 7-hour intervals. Isopycnal doming accompanies the strongest currents.

TriSoarus performs well throughout the surveys, though a near-critical tension spike resulting from an abrupt dive motivates us to bring the vehicle aboard to change the shear pin. The transmissometer has begun producing odd looking measurements, so we plan to inspect cabling and, perhaps, replace the sensor during our brief deck period. We find the shear pin slightly bent and thus replace it. The sensor bulkhead and cable appear clean, so we opt to swap the transmissometer for a spare (provided by Burt). We finish repairs well before we arrive at the start of our next survey pattern, and deploy immediately after arriving on site. The replacement transmissometer performs well, suggesting a failure in the original sensor.

3 June 2003

Rapid repeat surveys continue. We observe significant temporal evolution with each pass, though the strong flow we associate with the MAF remains distinct. TriSoarus develops intermittent communications dropouts, which manifest as errors on the SBE 11 deck unit, dropouts in the real-time data display, and acquisition faults in the Wetlabs AC-9 software. The dropouts are infrequent, but appear in bursts such that we see several in one hour, and then none for a long period afterward. In one instance, the dropout is accompanied by two reboot cycles of the subsurface CPU. Though the reboot occurred at the same time as the communications dropout, we were unable to identify a mechanism to link the two events. Late in the evening, near the start of the final, large-scale survey, TriSoarus abruptly lost both communication and power, with current draw dropping to zero (an open circuit failure rather than the more typical short). Tests following recovery isolate the fault to the mechanical section of the termination, indicate failures in both fibers and, in contrast to the initial failure mode, shorting of the conductors. Inspection of the termination reveals that an armor wire was sandwiched between the cone and the inner jacket that protects the fibers and conductors. Over time, repeated working drove the wire through the jacket, where it severed the fibers and shorted one conductor to the outer armor. Further working during recovery and handling on deck probably caused the wire to penetrate further, eventually shorting two of the conductors. Faced with a lengthy deck period for retermination, we decide that the best way to maintain the time series begun with the rapid repeat surveys is to finish the fifth pattern using only the shipboard ADCP. Though we sacrifice the hydrographic data, the velocity profiles will prove useful in investigations of near-inertial and tidal variability.

4 June 2003

After finishing the fifth survey, we recovered the four drifters that were arrayed along the northern edge of the survey region. We then transited to the southern tip of Istria, where we occupied a survey designed to sample a filament that appears to extend from Kvarner Bay, occupying the region of the strong Istria front we observed during the previous winter. Numerous drifters were deployed at various points along the three easternmost lines, some at full speed while others required slowing the ship. Currents were weak but highly variable across the array, with tidal flows of O(10 cm/s) likely accounting for half the observed variance. A stronger westward flow is associated with the filament, though the feature is somewhat obscured by the surrounding velocity variability. Numerous small-scale T–S interleaving features populate the region.

5 June 2003

We completed the Istria survey just before nightfall and began a CTD/BOP section sampling the middle of the third (counting from the west) line occupied during the TriSoarus survey. Problems with the hydro winch cable delayed the third cast. Several wraps of wire had gone slack, crossed over the drum and bound. The cable was undamaged and it appeared that none of the sheaves have fouled. On a subsequent cast, the tension sensor began to produce bogus high readings, forcing us to ignore its output.

6 June 2003

We completed the CTD/BOP section at approximately 05:00, at which time we broke off to recover drifters. Working under the time constraint imposed by our appointment with the transfer launch (at the Ravenna pilot buoy), we recovered six drifters, including all of the optical and thermistor chain units and two CODE drifters. We then steamed to Ravenna, where Pierre Poulain, Riccardo Barbanti, Mirko Orlic, Zoran Pasaric and Silvia Boncori disembarked. On evaluating data from the Istria survey and reviewing recent ocean color images, we decide to occupy an intensive survey of the region offshore of the Po mouth. In winter, we observed a strong filament extending from the Po region into mid-basin, eventually reaching the Croatian coast. Images from the beginning of the summer cruise revealed a similar feature, though it appeared to have weakened considerably and was less prominent in the images taken over the previous few days. Our initial survey is oriented along the shelf (to sample the filament), while a second survey will likely run cross-shelf (to sample the plume.).

7 June 2003

We completed the alongshore lines, characterizing the offshore extension of the Po plume, and began a set of cross-shelf sections spanning the same survey region. Winds remained weak, allowing the intense solar heating to establish a thin, warm surface layer. Surface waters were very green and unpleasantly fragrant. As expected, the fresh surface layer thins with distance offshore, though the view provided by TriSoarus is somewhat distorted by ship-induced mixing.

8 June 2003

Near the end of the cross-shelf TriSoarus survey, a software glitch caused TriSoarus to profile into the bottom. Although all sensors except for the secondary T–C pair continued normal operations, a 4500 lb tension spike and some flight irregularities motivated an earlier-than-planned recovery. As the survey was nearly finished, and because we wanted to maximize available daylight for the next operation, we chose to abandon the remaining track. Following recovery we embarked on a cross-plume CTD/BOP section designed to characterize optical properties during the period of maximum sunlight. We found sediment clogging the intakes of the starboard (secondary) T–C pair, which, when combined with scarring on the starboard wing and the flight data taken just before impact, suggests that the vehicle landed on its starboard side. We also found that the termination shear pin had begun to yield, requiring replacement. Post-impact flight irregularities were probably caused by misaligned ailerons, likely the result of jarring as the vehicle collided with the bottom. The CTD/BOP section found the surface cap as fresh, warm waters to be as thin as 2 m, with strong vertical gradients below. Preliminary comparisons with towed profiling measurements suggest that the ship's wake mixes the upper 5 m of the water column.

During TriSoarus deck testing, we discovered what appeared to be a heat-related communications failure. The TriSoarus termination bottle had spent the day sitting in the sun, and refused to function when powered back on. When taken into the lab and opened, it began to function again. We replaced the electronics assembly, after which the termination provided only intermittent signal, and appeared very sensitive to small vibrations and shocks (gently slapping or tapping the pressure case would cause it to fail). The problem was traced to a loose transceiver module, which was replaced and re-secured. We also replaced the cable connecting the CTD to the main bottle, largely to reduce the bulk of excess cable stowed inside TriSoarus, but also because we had begun to suspect that intermittent cable failure might be the cause of occasional, brief data dropouts.

We completed the CTD/BOP survey in the evening and moved to begin an extended series of sections working southward along the Po plume. Immediate communications failures to the CTD and AC-9 necessitated recovery. On inspection, all connectors looked normal, and the CTD cable rung out properly. The AC-9 pump cable provided a puzzle. Although the sensor had been working properly for many days, the cable was clearly miswired (such that the unit should have received no power). We could identify no obvious changes in the AC-9 subsystem, though some aspect of power delivery (either in the AC-9 or in the cable) must have been altered, perhaps during the previous bottom collision. We replaced the AC-9 and pump cables (using a new AC-9 cable and the pump cable from the wintertime cruise), but still suffered communications problems upon redeployment. Subsequent replacement of the CTD cable (replacing the new short cable with the original, long cable) fixed the problem, though we were unable to replicate the cable failure during bench testing. With a solution in place, we began the Po survey early on 9 June.

9 June 2003

We continued zig-zagging in and out of the Italian coast, dodging drilling platforms, fishing boats and other vessels. TriSoarus sensors, especially the AC-9, show signs of periodic clogging. Conditions are right for rapid mucilage growth, and we observed numerous large aggregates along all of our survey lines. Eventually, AC-9 data quality declined far enough to necessitate recovery. During the deck period, flow tubes and plumbing were cleaned. Breaking the Impulse end of the AC-9 pump cable revealed a connector leak (considerable corrosion on the pins). A newly spliced cable was substituted. Mucilage problems plagued us throughout the Po plume survey, forcing a total of six recoveries (to unclog and clean sensors) over a three-day period. Reorienting the AC-9 intake hoses to face aft helped relieve the problem, often allowing the system to self-clear and reducing the number of on-deck cleanings required.

10 June 2003

Continued the Po survey, periodically recovering to clear mucilage from the AC-9 plumbing.

11 June 2003

Last full day of the Po survey. Mid-morning, the bridge spots what appears to be a body floating nearby. Knorr diverts to investigate, only to find that it is actually a blow-up doll. We encounter heavy fishing traffic at all the inshore turn-around points, complicating navigation and restricting our ability to make the shallowest waypoints. Heavy nighttime traffic prevents occupation of the shallowest part of the next-to-last section pair.

12 June 2003

Just prior to recovery at the end of the Po survey, confusion regarding the settings of the Knudsen echosounder results in erroneous depth readings, sending TriSoarus skimming across the bottom. Fortunately, the bottom was soft and the mistake was quickly corrected. We found no damage when the vehicle was brought aboard. During the three-hour transit to the start, the AC-9 receives a cleaning and water calibration while TriSoarus undergoes preventative maintenance.

For our last intensive survey we choose a filament that extends offshore from Pt. Penna (south of Pescara). The initial survey focused on the offshore extension, with plans to follow up with a cross-filament CTD/BOP section and a TriSoarus grid sampling the region where the filament turns offshore. We designed the initial survey based on two day old ocean color images, and some adjustments were necessary.

15 June 2003

We ended sampling shortly after midnight, initially steaming toward Ancona at a reduced speed to facilitate cleaning and lubing of our electro-optical cable. This operation proceeded rapidly, with approximately 700 m treated in under two hours. *Knorr* arrived at the Ancona pilot buoy at approximately 09:30, and we tied up shortly afterward. Breakdown and container packing were largely complete by the end of the day, though a few items, including the winch, remained to be taken care of the following day.

1.4 Cruise participants

Figure 1.7: DOLCE VITA 1 science party. Back row, L-R: Zoran Pasaric, Damir Vilicic, Davide Deponte, Don Johnson, Clive Dorman, Dietmar Thaler, Robert Jones, Matthew Ragan, Wesley Goode, Hartmut Peters, Eric Boget, David Bigazzi, Tim McGinnis. Center row, L-R: Mirko Orlic, Pierre-Marie Poulain, Elena Mauri, Laura Ursella, Jason Gobat, Marlene Jeffries, Alessandra Caampanelli, Federica Frilli, Ivona Cetinic, Craig Lee. Front row, L-R: Burton Jones, Zhihong Zheng, Mirco Di Marco.

Dr. Craig Lee	University of Washington, Applied Physics Laboratory
Dr. Jason Gobat	University of Washington, Applied Physics Laboratory
Mr. Timothy McGinnis	University of Washington, Applied Physics Laboratory
Mr. Eric Boget	University of Washington, Applied Physics Laboratory
Ms. Marlene Jeffries	University of Washington, Applied Physics Laboratory
Dr. Burton Jones	University of Southern California
Mr. Matthew Ragan	University of Southern California
Mr. Zhihong Zheng	University of Southern California
Dr. Hartmut Peters	Rosenstiel School of Marine & Atmospheric Science, Univ. of Miami
Mr. Robert Jones	University of Miami
Dr. Clive Dorman	Scripps Institution of Oceanography, UCSD
Dr. Don Johnson	Naval Research Laboratory
Mr. Wesley Goode	Naval Research Laboratory
Dr. Pierre-Marie Poulain	1st Naz. Oceanografia e Geofisica Sperimentale, Trieste
Ms. Elena Mauri	1st Naz. Oceanografia e Geofisica Sperimentale, Trieste
Ms. Laura Ursella	1st Naz. Oceanografia e Geofisica Sperimentale,Trieste
Mr. Davide Deponte	1st Naz. Oceanografia e Geofisica Sperimentale, Trieste
Mr. Giulio Notarstefano	1st Naz. Oceanografia e Geofisica Sperimentale, Trieste
Dr. Mirko Orlic	University of Zagreb
Dr. Damir Vilicic	University of Zagreb
Ms. Ivona Cetinic	University of Zagreb
Dr. Zoran Pasaric	University of Zagreb
Mr. Mirco Di Marco	University of Ancona
Mr. Luca Bolognini	University of Ancona
Mr. David Bigazzi	University of Ancona
Ms. Paola Fornasiero	National Research Council IRPEM, Ancona
Ms. Federica Grilli	National Research Council IRPEM, Ancona
Ms. Alessandra Campanelli	National Research Council IRPEM, Ancona
Mr. Mag. Dietmar Thaler	Ministry of Defense/Austrian Airforce

Table 1.1: DOLCE VITA 1 winter cruise science participants.

George Silva	Master
Kelly Sweeny	Chief mate
Douglas Mayer	2nd mate
Adam Seamans	3rd mate
Linwood Swett	Com-ET
Peter Liarikos	Bosun
Bill Dunn	AB
Edward Graham	AB
James McGill	AB
Cecile Hall	OS
William Eident	OS
Steve Walsh	Chief engineer
Jack McGrath	1st assistant engineer
Piotr Marczak	2nd assistant engineer
Jeff Bernier	3rd assistant engineer
John Taylor	Electrician
Todd Meeker	Oiler
Keith Strand	Oiler
Kevin Fisher	Oiler
Mirth Miller	Steward
Brian O'Nuallain	Cook
Karen Johnson	Mess attendant

Table 1.2: DOLCE VITA 1 winter cruise R/V Knorr crew.

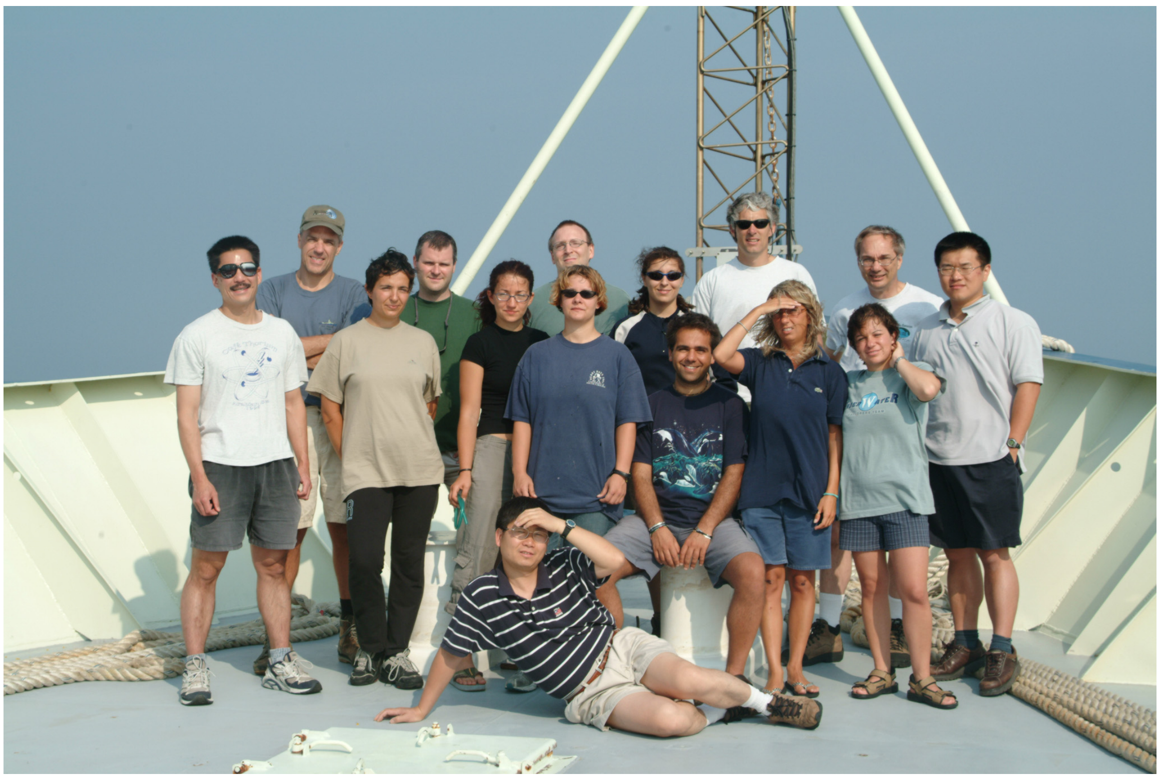


Figure 1.8: DOLCE VITA 2 science party. Standing L-R: Craig Lee, Tim McGinnis, Zrinka Buric, Jason Gobat, Ivona Cetinic, Quinn Roberts (front), Dietmar Thaler (back), Marlene Jeffries, Mirco Di Marco, Eric Boget, Federica Grilli, Allesandra Campanelli(front), Burton Jones (back), Kyungho Kang. Lying on deck: Zhihong Zheng.

Dr. Craig Lee	University of Washington, Applied Physics Laboratory
Dr. Jason Gobat	University of Washington, Applied Physics Laboratory
Mr. Tim McGinnis	University of Washington, Applied Physics Laboratory
Mr. Eric Boget	University of Washington, Applied Physics Laboratory
Ms. Marlene Jeffries	University of Washington, Applied Physics Laboratory
Dr. Burton Jones	University of Southern California
Mr. Zhihong Zheng	University of Southern California
Mr. Kyungho Kang	University of Southern California
Ms. Quinn Roberts	University of Southern California
Dr. Pierre Poulain	1st Naz. Oceanografia e Geofisica Sperimentale, Trieste
Mr. Riccardo Barbanti	1st Naz. Oceanografia e Geofisica Sperimentale, Trieste
Dr. Mirko Orlic	University of Zagreb
Dr. Zoran Pasaric	University of Zagreb
Ms. Zrinka Buric	University of Zagreb
Ms. Ivona Cetinic	University of Zagreb
Ms. Alessandra Campanelli	National Research Council IRPEM, Ancona, Italy
Ms. Federica Grilli	National Research Council IRPEM, Ancona, Italy
Mr. Mirco Di Marco	University of Ancona
Ms. Silvia Boncori	University of Ancona
Mr. Mag. Dietmar Thaler	Ministry of Defense/Austrian Air Force

Table 1.3: DOLCE VITA 2 spring cruise science participants.

A.D Colburn	Master
Kent Sheasley	Chief mate
Deidra Emrich	2nd mate
Louis Boone	3rd mate
Jeffrey Perkins	Com-ET
Alan Hopkins	Bosun
Kelly Landen	AB
Kevin Butler	AB
Jenifer Hickey	AB
Lorna Alison	OS
James Brennan	OS
Patrick Mone	Chief engineer
Wayne Sylvia	1st assistant engineer
Paul McGrath	2nd assistant engineer
Lee Crosley	3rd assistant engineer
Thidiane Kanoute	Electrician
Tom Keller	Oiler
Daniel Govig	Oiler
Richard Wyatt	Oiler
Brian O'Nuallain	Steward
Victoria Sims	Cook
Brett Bluestien	Mess attendant

Table 1.4: DOLCE VITA 2 spring cruise R/V Knorr crew.

Part 2

Data processing and preliminary results

2.1 Shipboard ADCP

Processing for the ship mounted 150-kHz broadband ADCP consisted of transformation to earth coordinates of individual pings followed by one-minute bin averaging of the transformed pings. Transformations were performed using data from the shipboard Ashtech ADU-2, ship's gyro, and heading from the ship's GPS VTG string (in order of preference). Several large gaps occured in GPS coverage during both cruises. Different receivers on the ship worked at different times, including the ADU-2. The ADU-2 was also prone to occasional lockups. Geolocation of profiles in areas of GPS gaps was done using interpolation. No attempt was made to dead reckon using gyro and knot log information. Fortuitously, all gaps occured during straight line portions of surveys.

GPS and gyro data were logged from their direct serial feeds by VmDAS on the ADCP acquisition PC. Ashtech data was logged as a capture file and synchronized using time stamped sentences contained in the data. Soundspeed corrections have been applied using temperature and salinity data from the ship's 5-m saltwater intake system. Inattention to this system during the initial days of the winter cruise resulted in some data loss. Except for this gap ADCP data was captured continuously during both cruises.

2.2 TriSoarus profiles

We explored several different approaches to correcting for what are generally known as lag effects in the temperature and conductivity data. During design of the TriSoarus we had hoped that by having the T and C sensors fully exposed on the exterior of the vehicle we would minimize these effects. In the highly stratified waters encountered during the spring cruise, however, it became apparent that significant issues remained when we saw large differences between adjacent dive and climb profiles in the real-time display (which is uncorrected for any sort of lag effect). During the cruise we explored several solutions, including repowering the pums on their own 12V power supply, running the sensors unpumped, and running the sensors on their own pumps with minimal plumbing (rather than sharing pumps with internal fluorometers and oxygen sensor). The final conclusion from these experiments was that fully powered pumps with short plumbing are the best option.

The raw data collected this way still exhibits large dive–climb differences. Initially we explored corrections that varied instantaneously with vehicle speed and attitude on the assumption that the differences were caused by changes in the flow rate through the sensors. In the end, however, this proved unnecessary and we chose corrections that varied between dive and climb and by the pump power and plumbing configuration. This leads to three sets of corrections: 1) underpowered pump on long plumbing, 2) fully powered pump on long plumbing, and 3) fully powered pump on short plumbing. The entire winter cruise was run with configuration one. During the spring cruise, with high stratification, problems with this configuration were apparent on the first day.

TriSoarus CT data has been corrected for

- vertical offset between CT intakes and pressure sensor, including pitch effect
- differing time responses of the C and T sensors
- lag between the pressure sensor and the CT intakes due to bow wave/boundary layer phenomena
- lag between C and T response caused by their separation in the plumbing
- thermal mass of the C cell

The first step in the sequence was to correct for the depth offset due to pitch

$$d = d + 0.2\sin\left(-\phi + 37\right), \tag{2.1}$$

where 0.2 m is the distance and 37° is the angle between the temperature intake and the pressure sensor. The depth was then smoothed with a 15-point triangular filter. The difference in time responses was corrected by low-pass filtering conductivity with a single pole butterworth filter with cutoff frequency

$$\omega_C = \frac{1}{2\pi f_n \tau_C}, \tag{2.2}$$

where f_n is the Nyquist frequency (12 Hz) and τ_C is the new time constant. For the pressure/bow wave correction depths were advanced (or lagged) by a_d samples using linear interpolation (to allow for fractional advances) and a fixed offset d_d was added. The plumbing lag between T and C measurements was implemented as an advance in temperature, a_T. A thermal mass corrected temperature at each sample i was then calculated from the lag corrected temperature samples T^i,

$$T_T^i = -bT_T^{i-1} + a\left(T^i - T^{i-1}\right) \tag{2.3}$$

and used along with the corrected, smoothed and advanced depth signal and time response corrected conductivity signal to calcuate salinity. The thermal mass filter coefficients, a and b, are calculated from the thermal mass correction coefficients, α and β as

$$a = 4 f_n \alpha \beta^{-1} \left(1 + 4 f_n \beta^{-1}\right)^{-1}, \text{and} \tag{2.4}$$

$$b = 1 - 2a\alpha^{-1}. \tag{2.5}$$

Entire time series for each survey were run through these corrections for both dive and climb coefficient sets. Profiles were then sorted into dives and climbs using peak detection on the climb corrected depth signal.

Table 2.1: Dive correction coefficients for TriSoarus temerature, conductivity, and pressure data.

	dive					
configuration	a_d	d_d	a_T	τ_C	α	β^{-1}
weak pumps, long plumbing	-12	0.0	-3.0	0.035	0.03	10
strong pumps, long plumbing	-11	0.0	-1.2	0.04	0.016	10
strong pumps, short plumbing	-10	0.0	-0.2	0.022	0.01	8.2

Table 2.2: Climb correction coefficients for TriSoarus temerature, conductivity, and pressure data.

	dive					
configuration	a_d	d_d	a_T	τ_C	α	β^{-1}
weak pumps, long plumbing	-12	-0.55	-3.0	0.035	0.03	10
strong pumps, long plumbing	-11	-0.55	-1.2	0.04	0.016	10
strong pumps, short plumbing	-10	-0.55	-0.7	0.066	0.011	10.8

Coefficients for each correction were chosen for dives and climbs in each of the three pump power/plumbing configurations based on reducing the area between the dive and climb average T–S curves over representative sections. The average of the areas between adjacent dive and climb profiles and visual inspection of the contoured potential density sections were also considered. Coefficients used in the results that follow are given in Tables 2.1 and 2.2.

For all configurations dissolved oxygen was calculated by advancing the SBE-43 voltage by 200 samples and merging with corrected T, S, and P data. Fluorometer data was aligned to T–S data by advancing 190 samples. The transmissometer was unpumped and mounted on the outside of the vehicle. Those data are uncorrected.

2.3 DOLCE VITA 1 profile results

Sections for temperature, salinity, and attenuation (from the transmissometer) are shown in Figs. 2.1 through 2.86 for all legs of all surveys. The map in the upper-left panel of each figure shows the location of the leg in the survey. The starting and ending decimal yeardays for each leg are indicated in the title of the map panel.

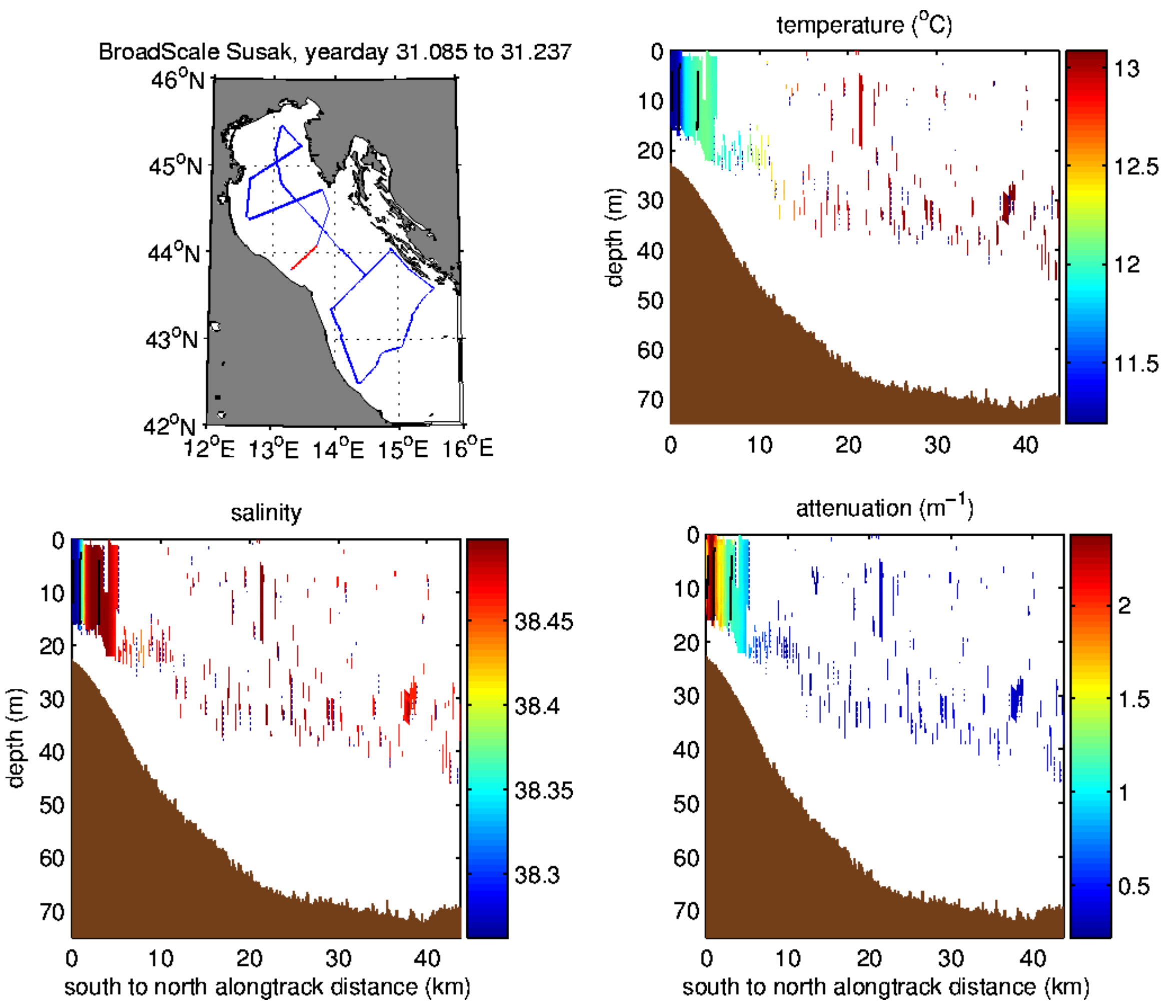


Figure 2.1: Temperature, salinity, and attenuation for BroadScale survey, Susak section. Overlaid contours are σ_θ.

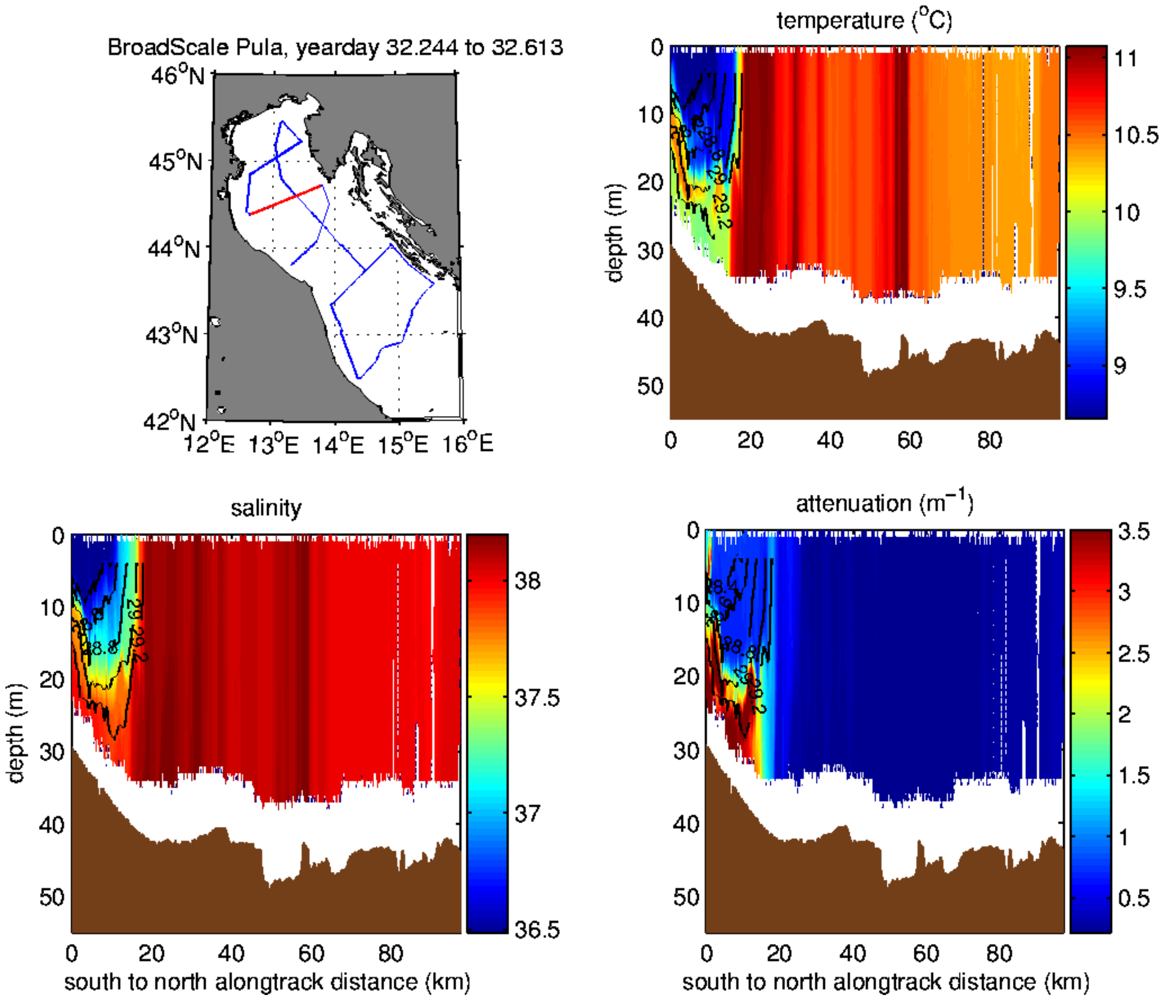


Figure 2.2: Temperature, salinity, and attenuation for BroadScale survey, Pula section. Overlaid contours are σ_θ.

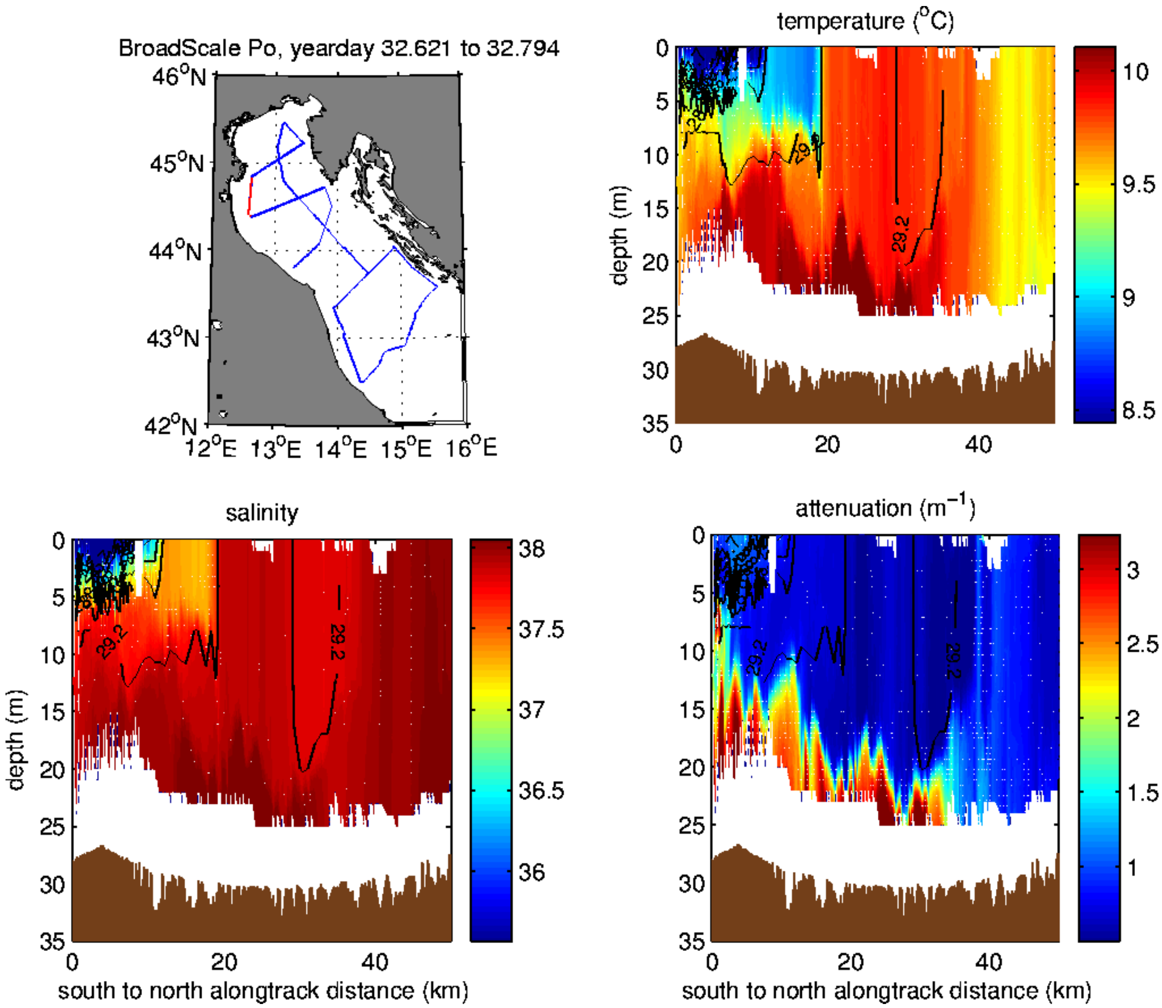


Figure 2.3: Temperature, salinity, and attenuation for BroadScale survey, Po section. Overlaid contours are σ_θ.

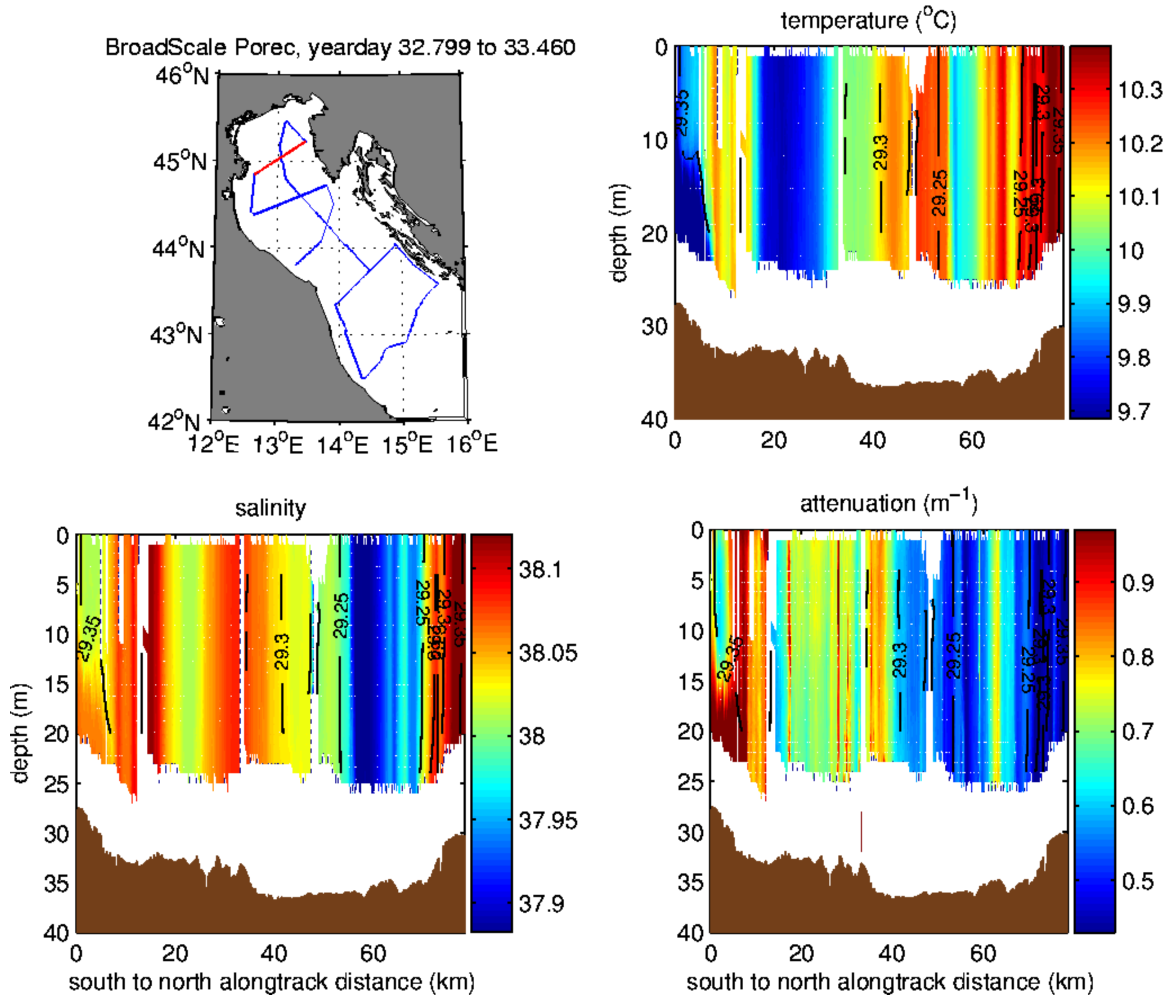


Figure 2.4: Temperature, salinity, and attenuation for BroadScale survey, Porec section. Overlaid contours are σ_θ.

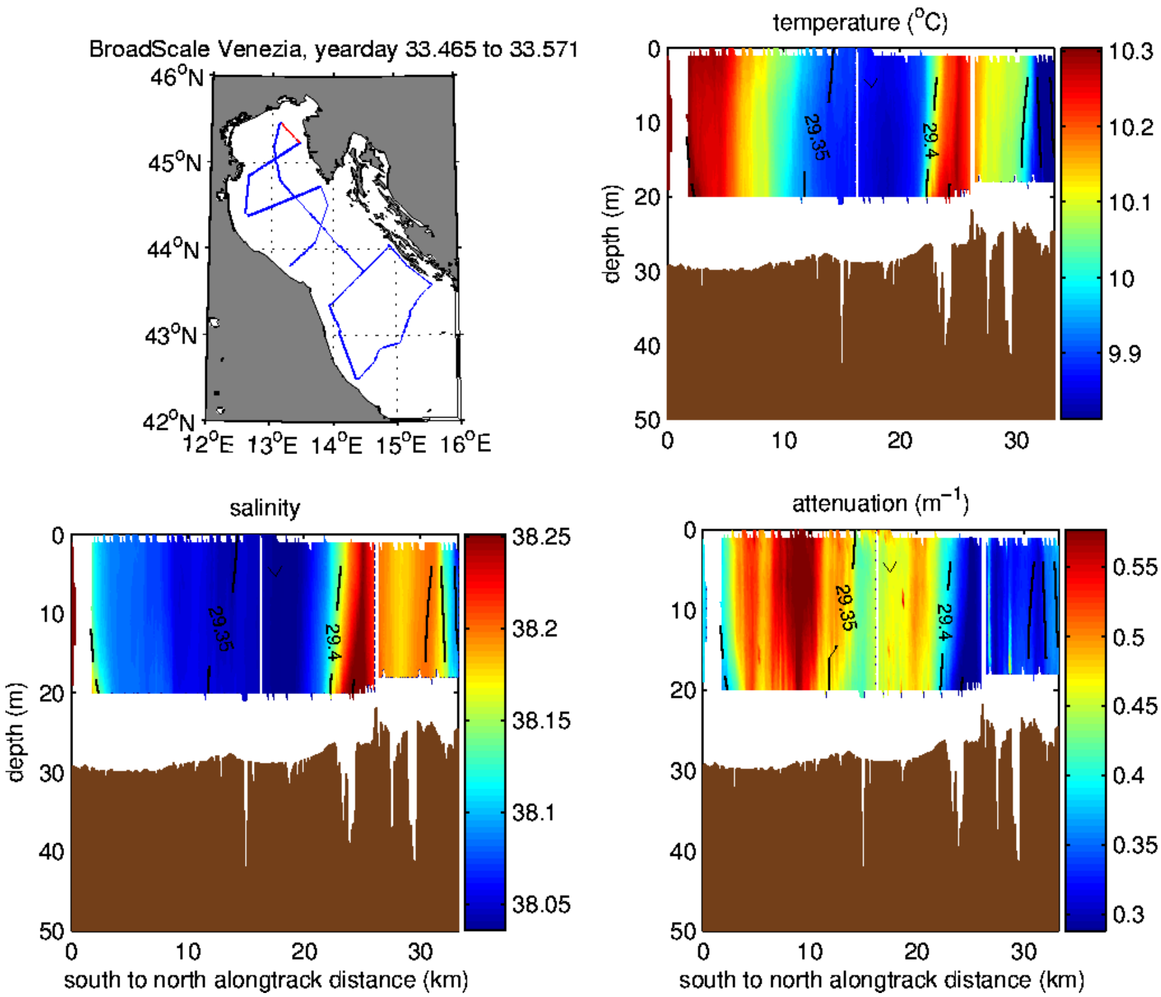


Figure 2.5: Temperature, salinity, and attenuation for BroadScale survey, Venezia section. Overlaid contours are σ_θ.

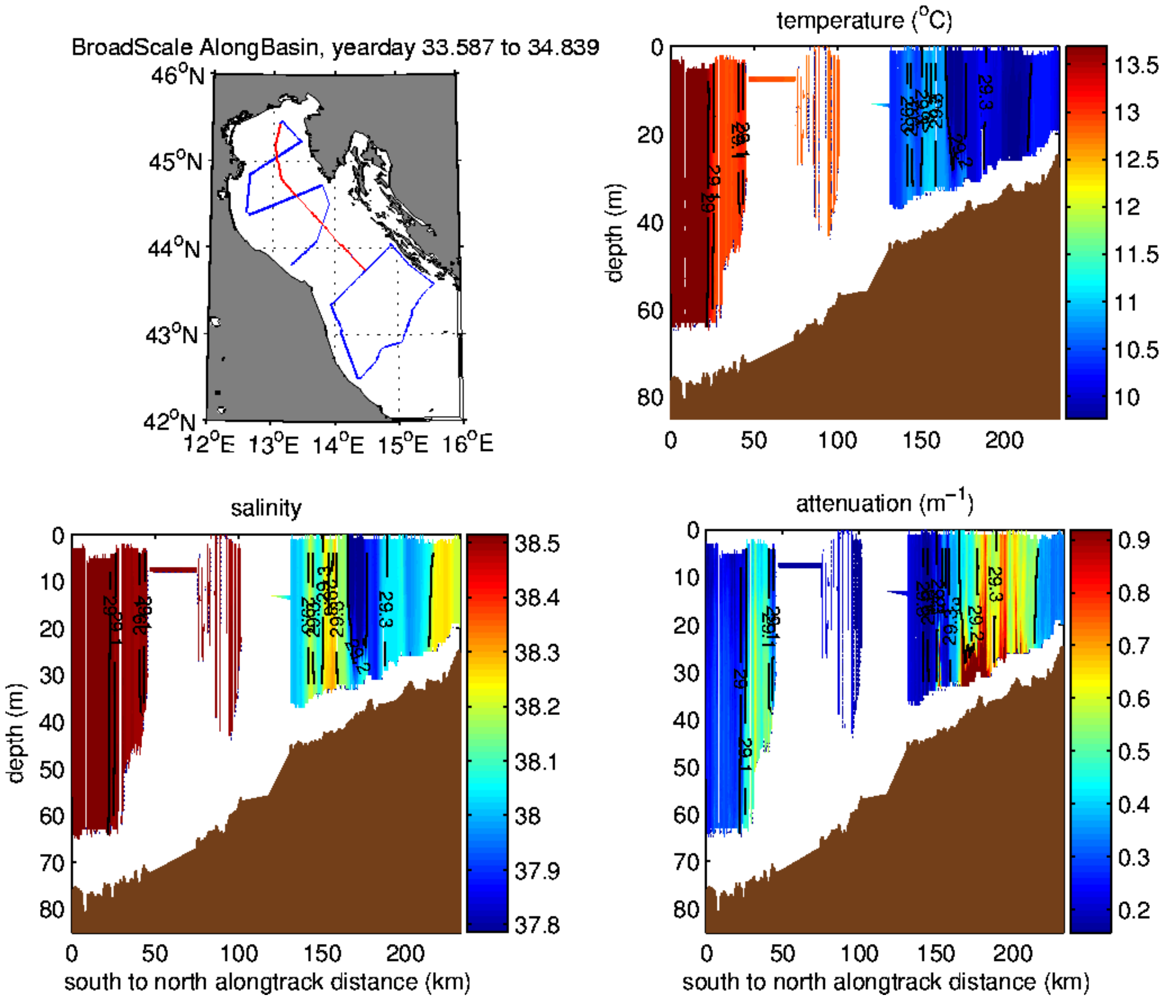


Figure 2.6: Temperature, salinity, and attenuation for BroadScale survey, AlongBasin section. Overlaid contours are σ_θ.

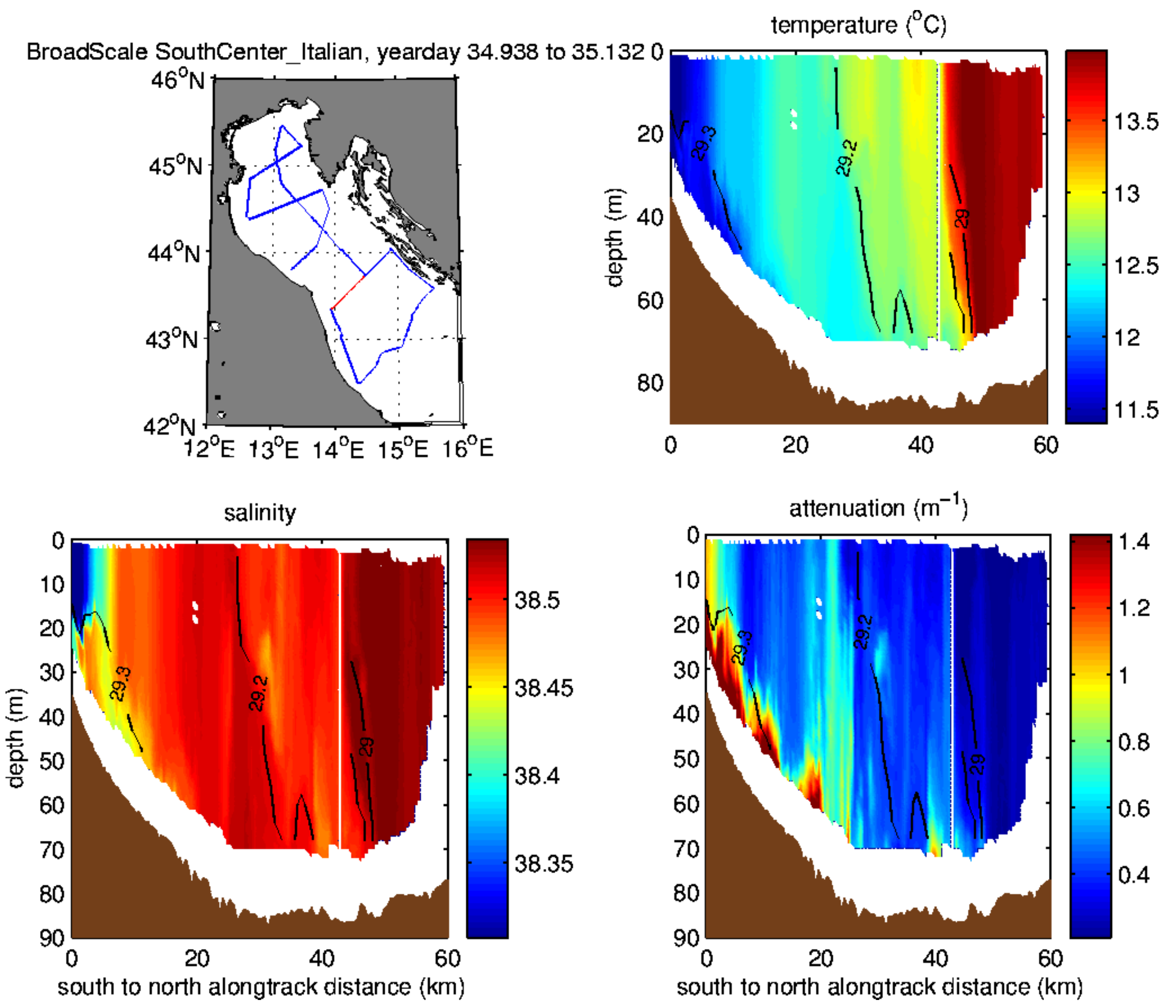


Figure 2.7: Temperature, salinity, and attenuation for BroadScale survey, SouthCenter Italian section. Overlaid contours are σ_θ.

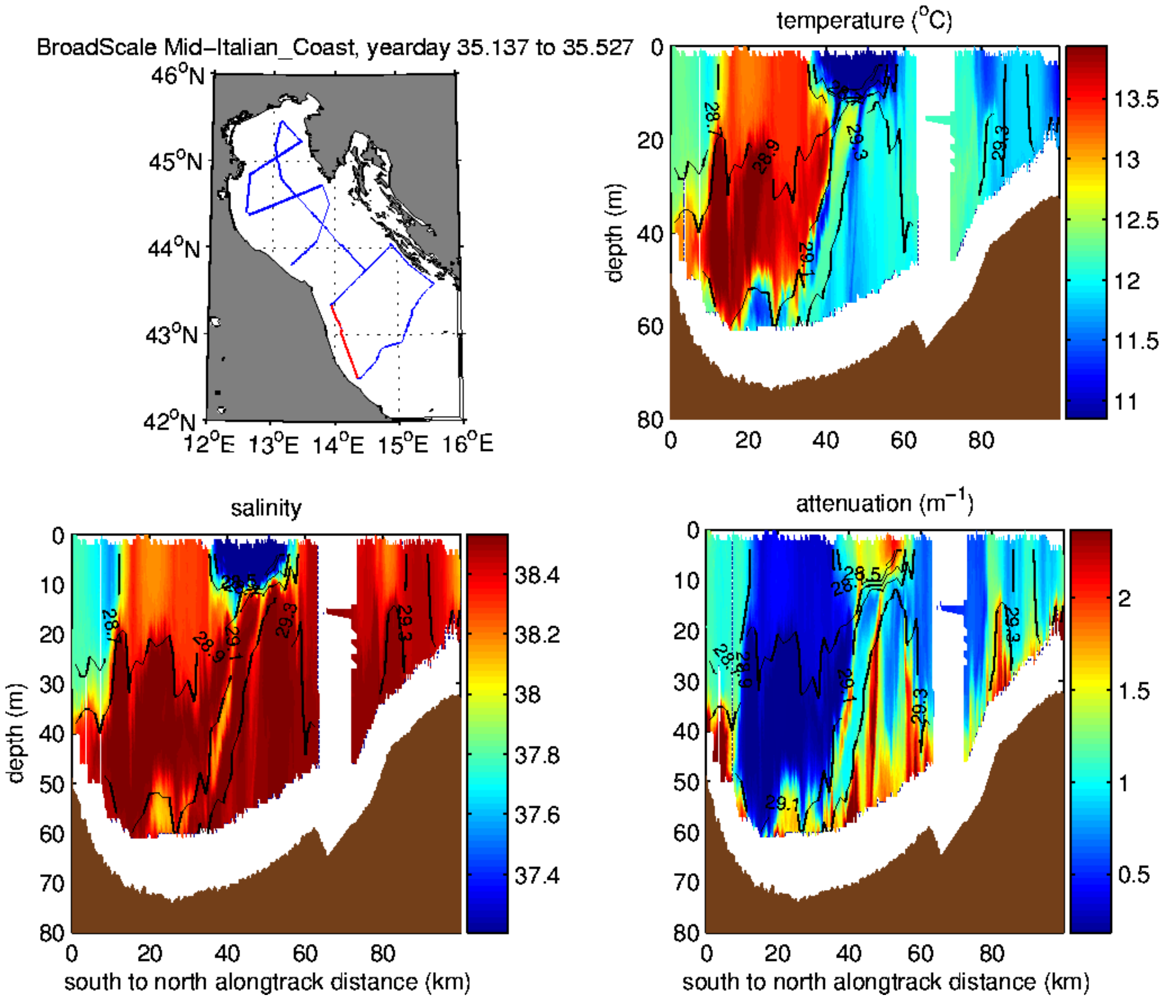


Figure 2.8: Temperature, salinity, and attenuation for BroadScale survey, Mid-Italian Coast section. Overlaid contours are σ_θ.

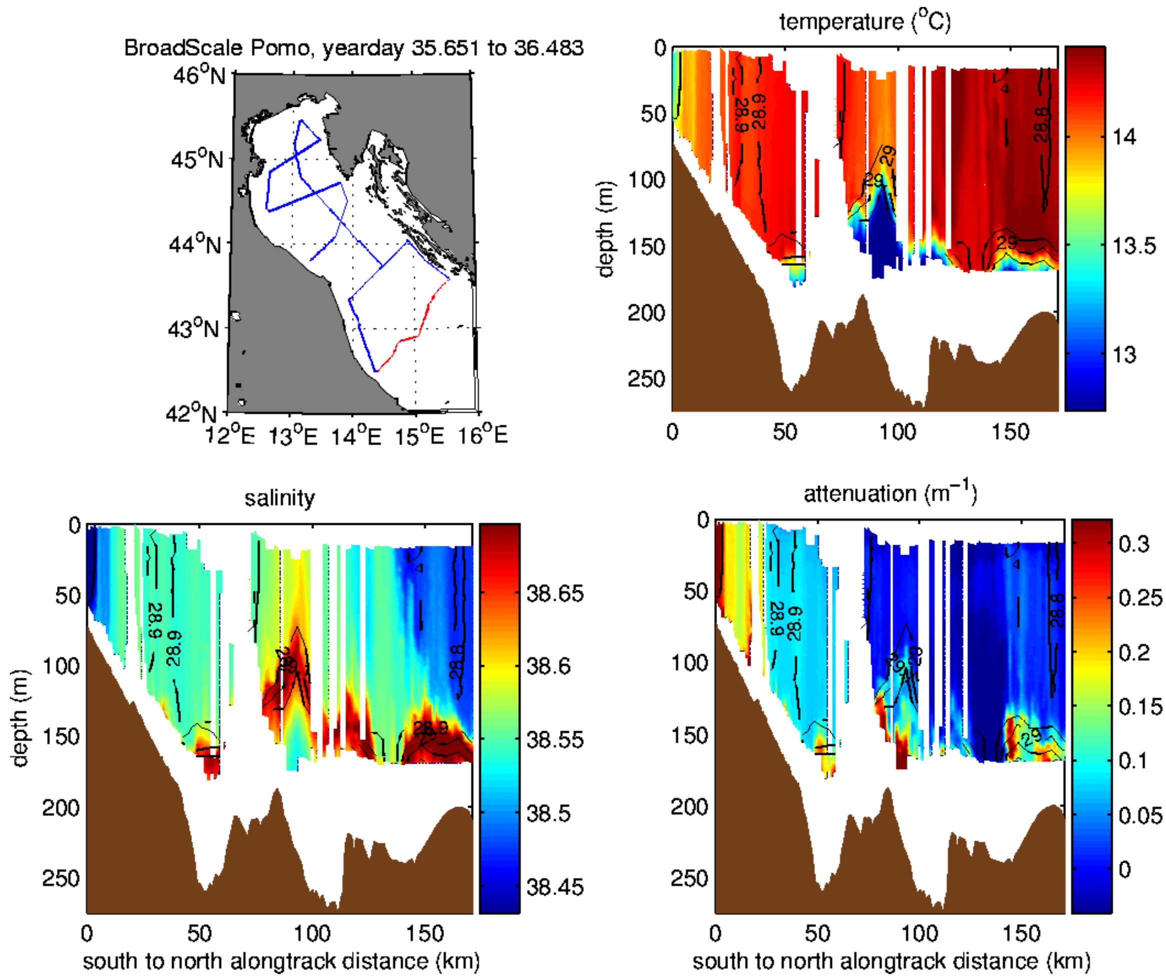


Figure 2.9: Temperature, salinity, and attenuation for BroadScale survey, Pomo section. Overlaid contours are σ_θ.

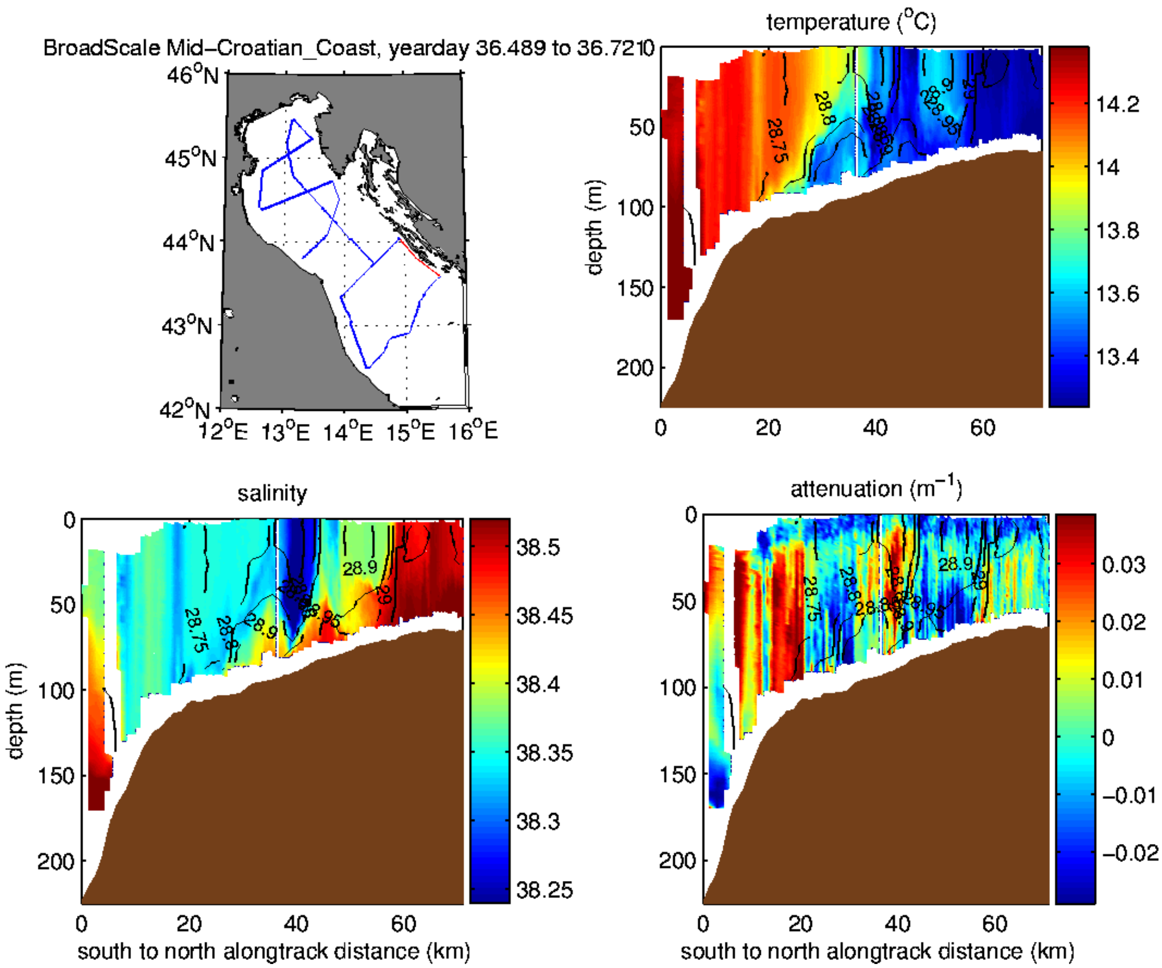


Figure 2.10: Temperature, salinity, and attenuation for BroadScale survey, Mid-Croatian Coast section. Overlaid contours are σ_θ.

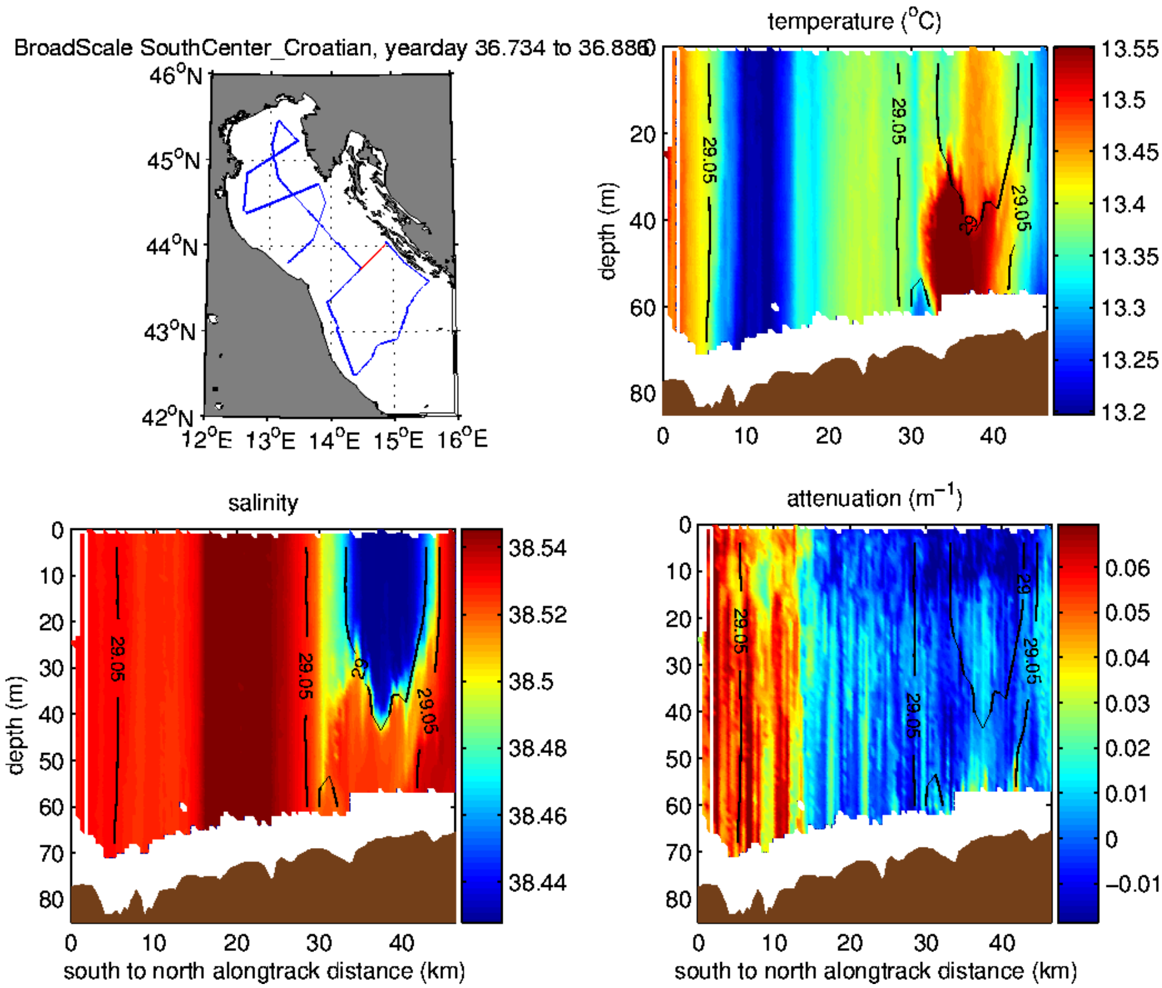


Figure 2.11: Temperature, salinity, and attenuation for BroadScale survey, SouthCenter Croatian section. Overlaid contours are σ_θ.

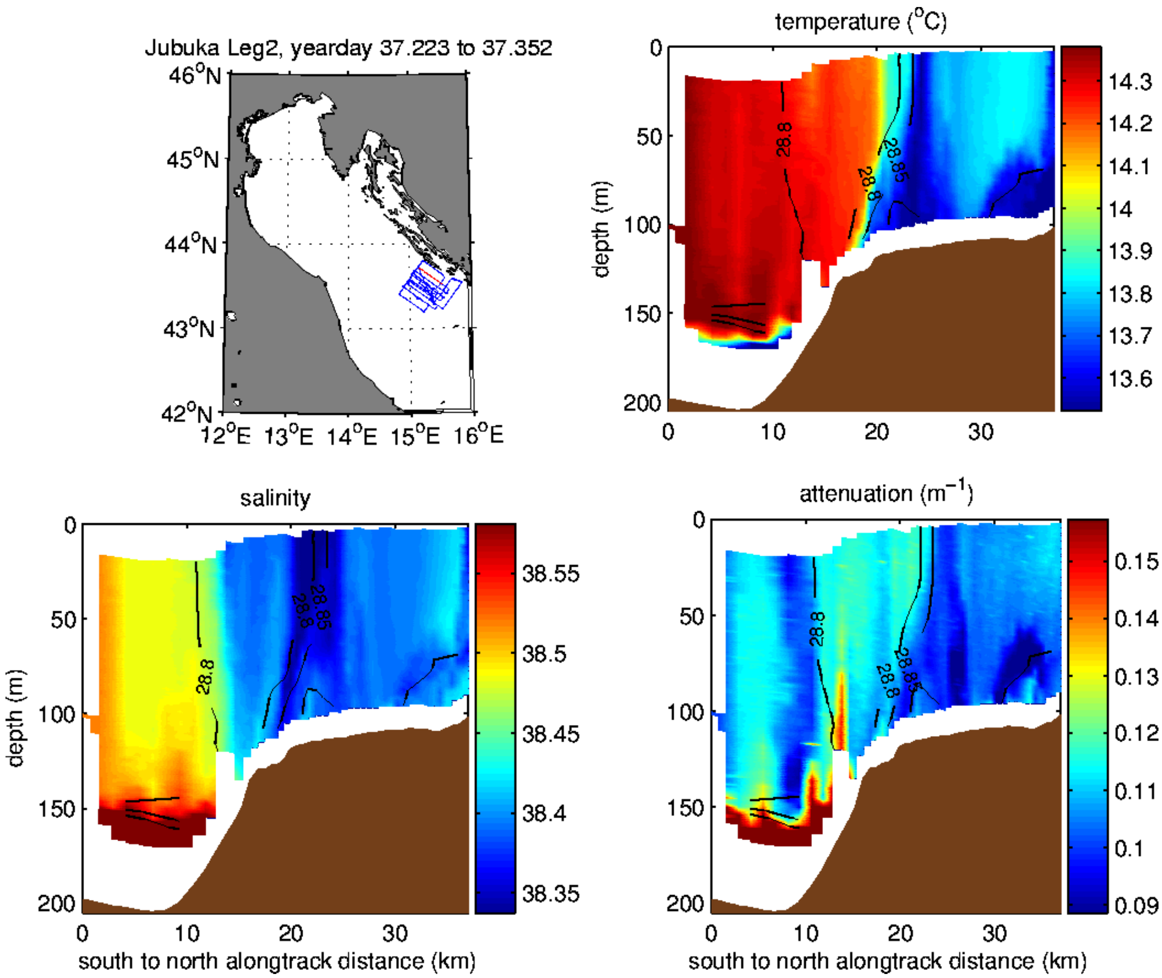


Figure 2.12: Temperature, salinity, and attenuation for Jubuka survey, Leg2 section. Overlaid contours are σ_θ.

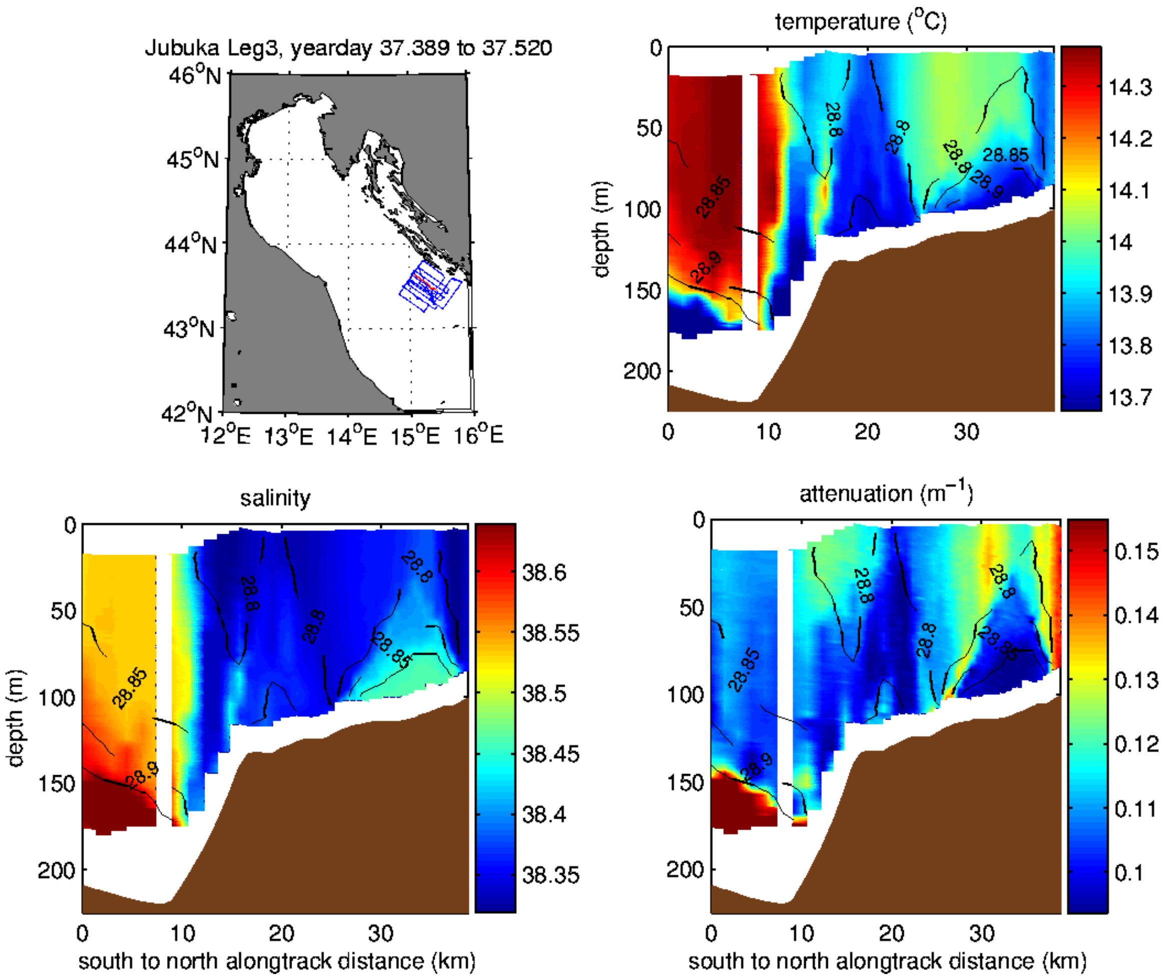


Figure 2.13: Temperature, salinity, and attenuation for Jubuka survey, Leg3 section. Overlaid contours are σ_θ.

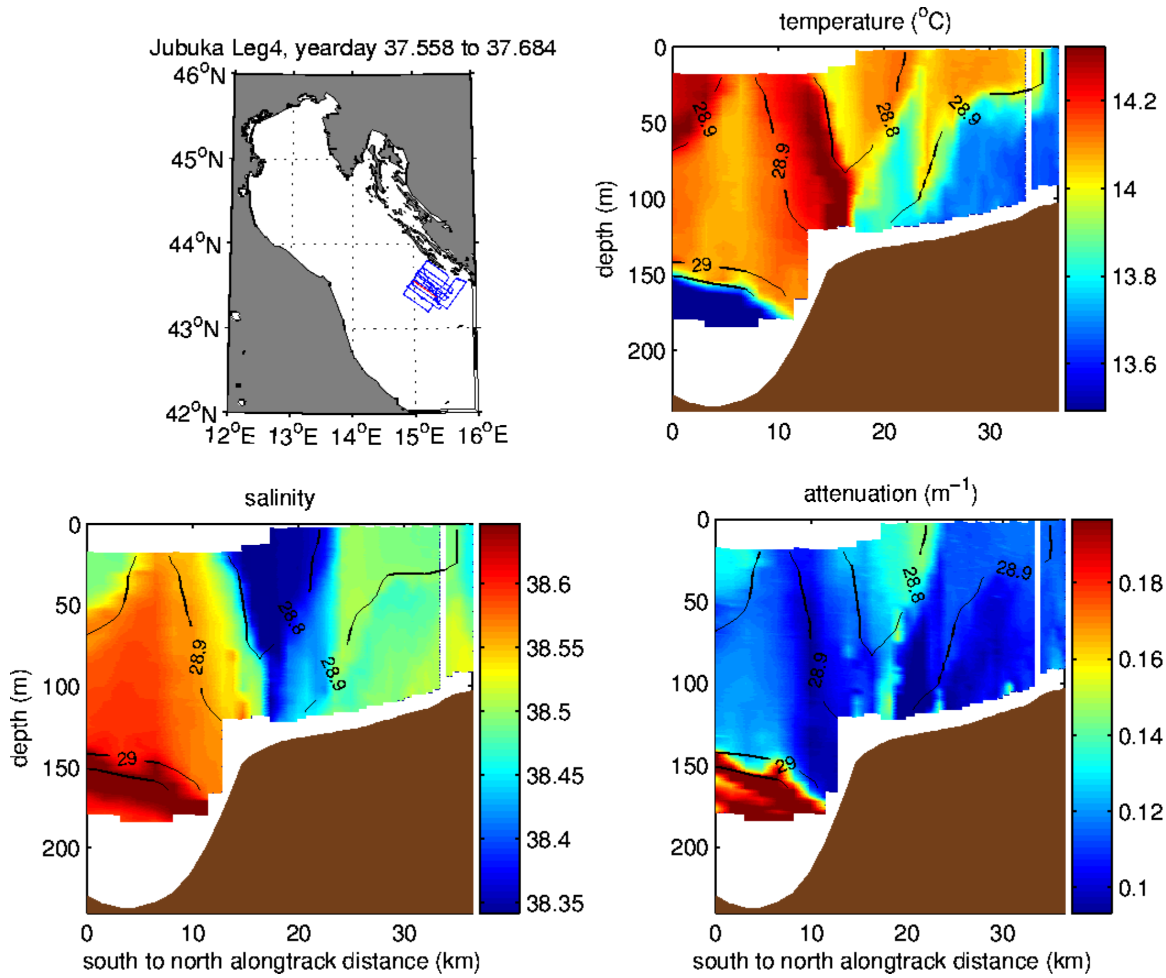


Figure 2.14: Temperature, salinity, and attenuation for Jubuka survey, Leg4 section. Overlaid contours are σ_θ.

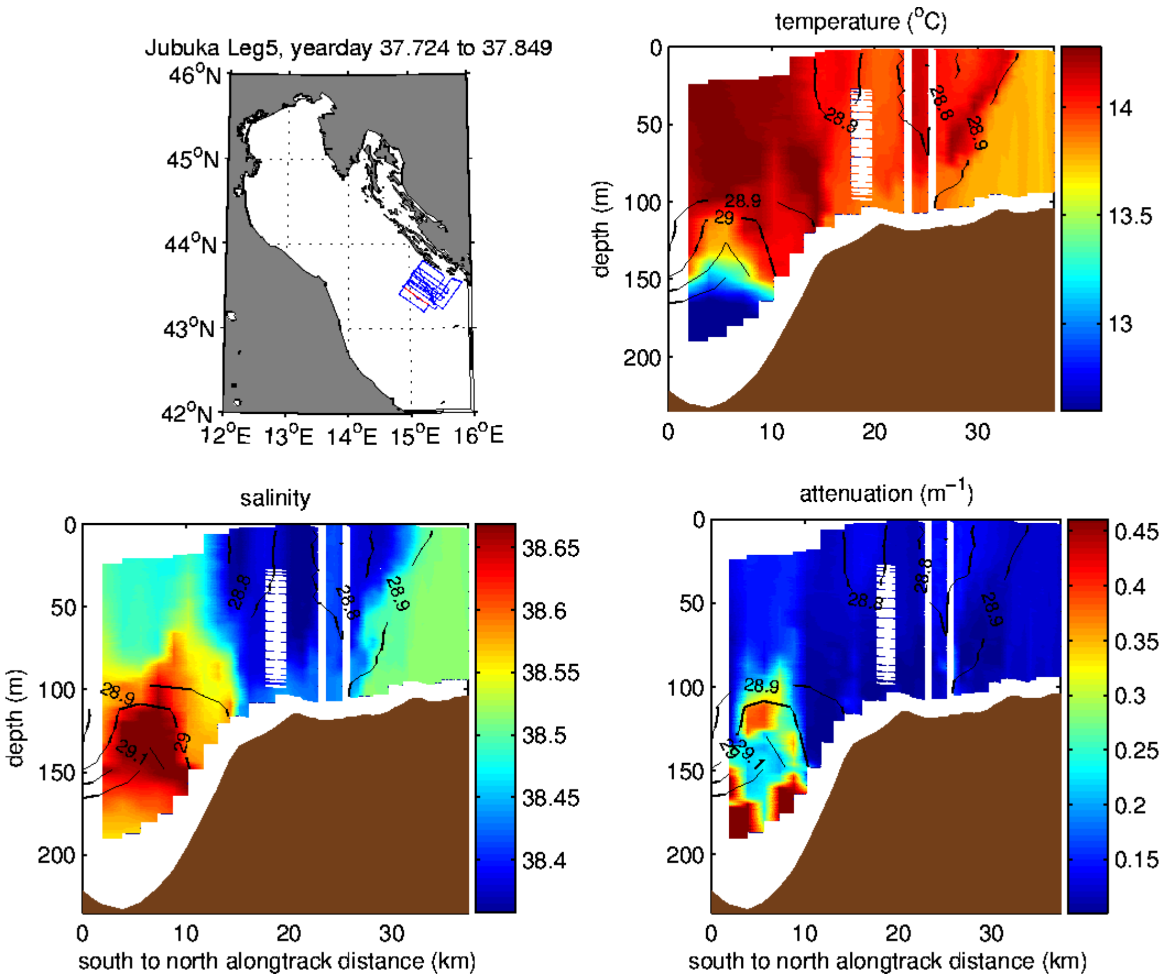


Figure 2.15: Temperature, salinity, and attenuation for Jubuka survey, Leg5 section. Overlaid contours are σ_θ.

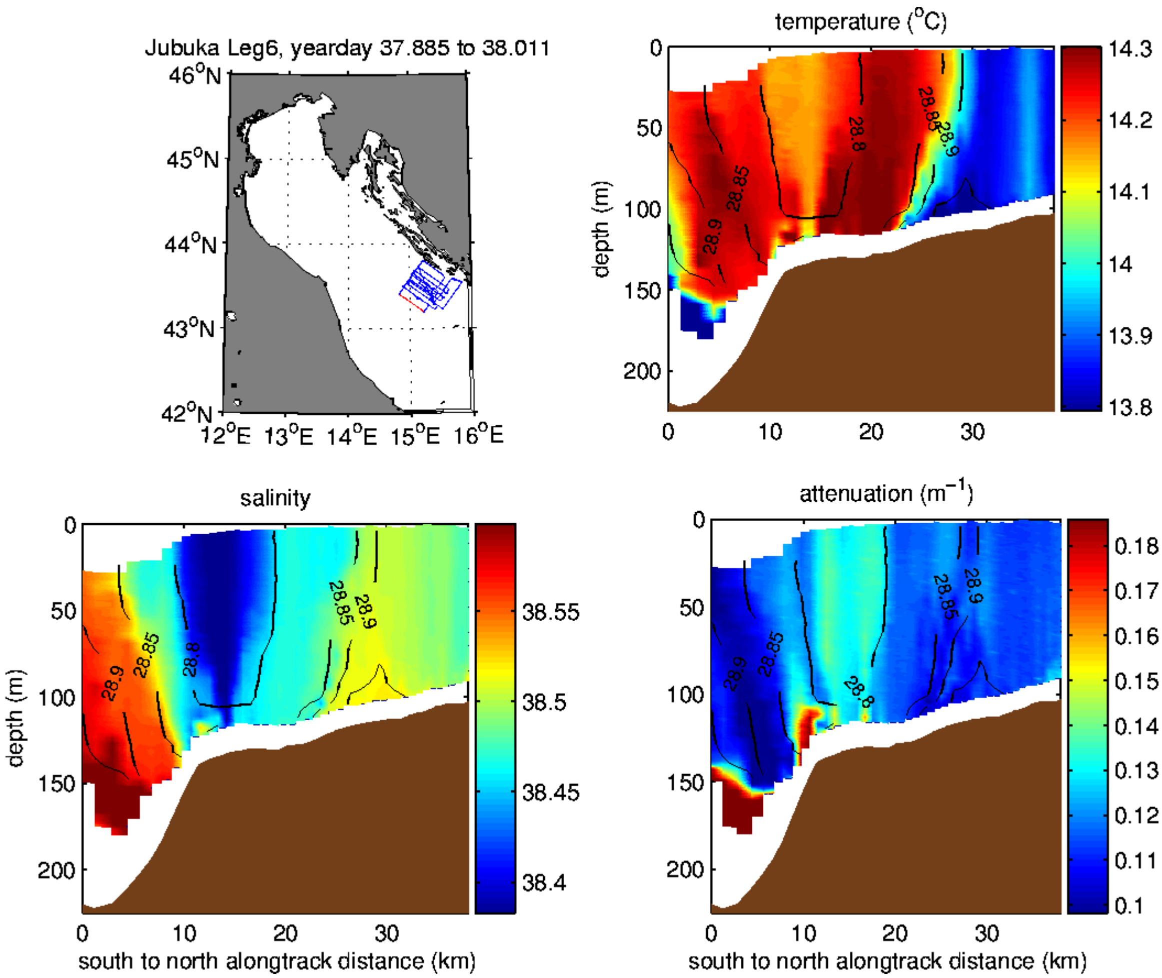


Figure 2.16: Temperature, salinity, and attenuation for Jubuka survey, Leg6 section. Overlaid contours are σ_θ.

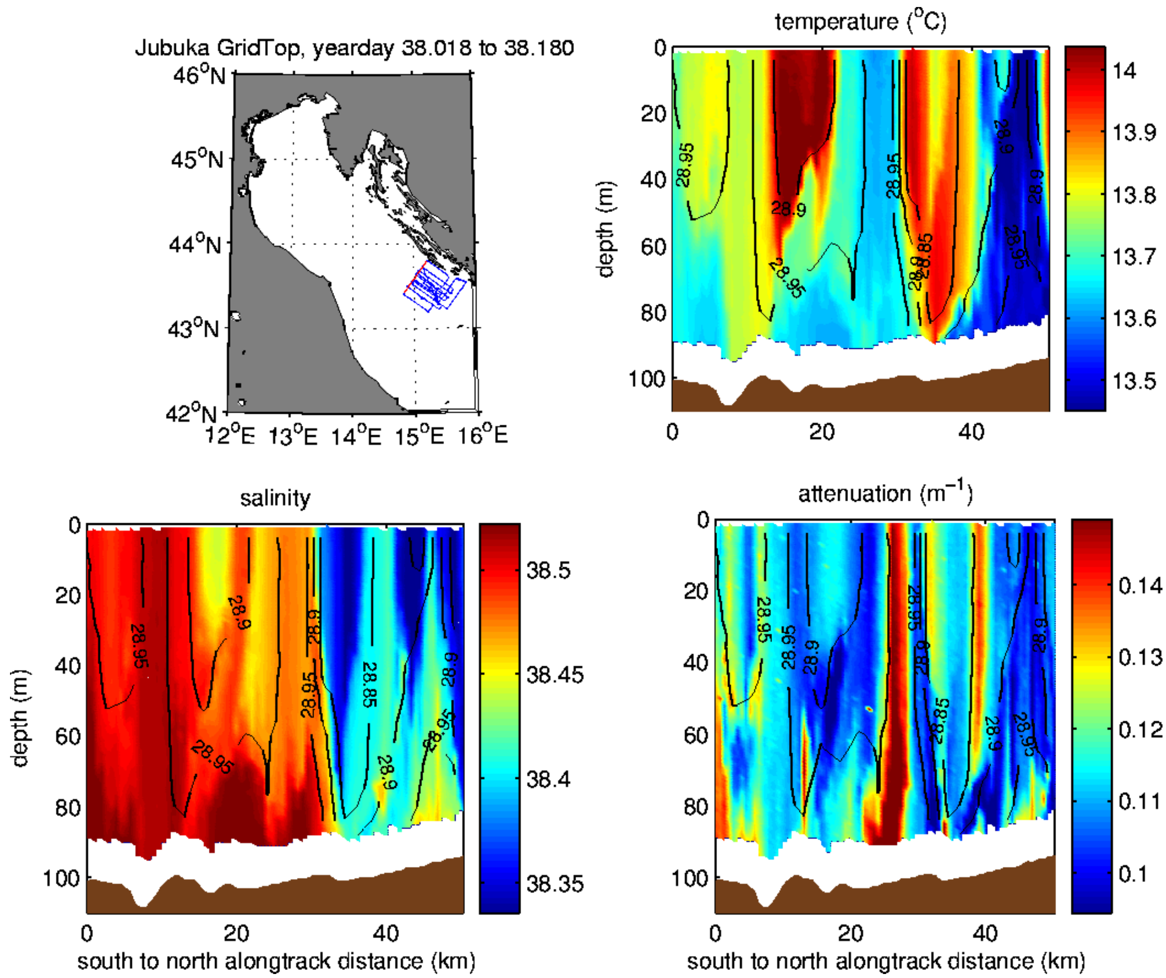


Figure 2.17: Temperature, salinity, and attenuation for Jubuka survey, GridTop section. Overlaid contours are σ_θ.

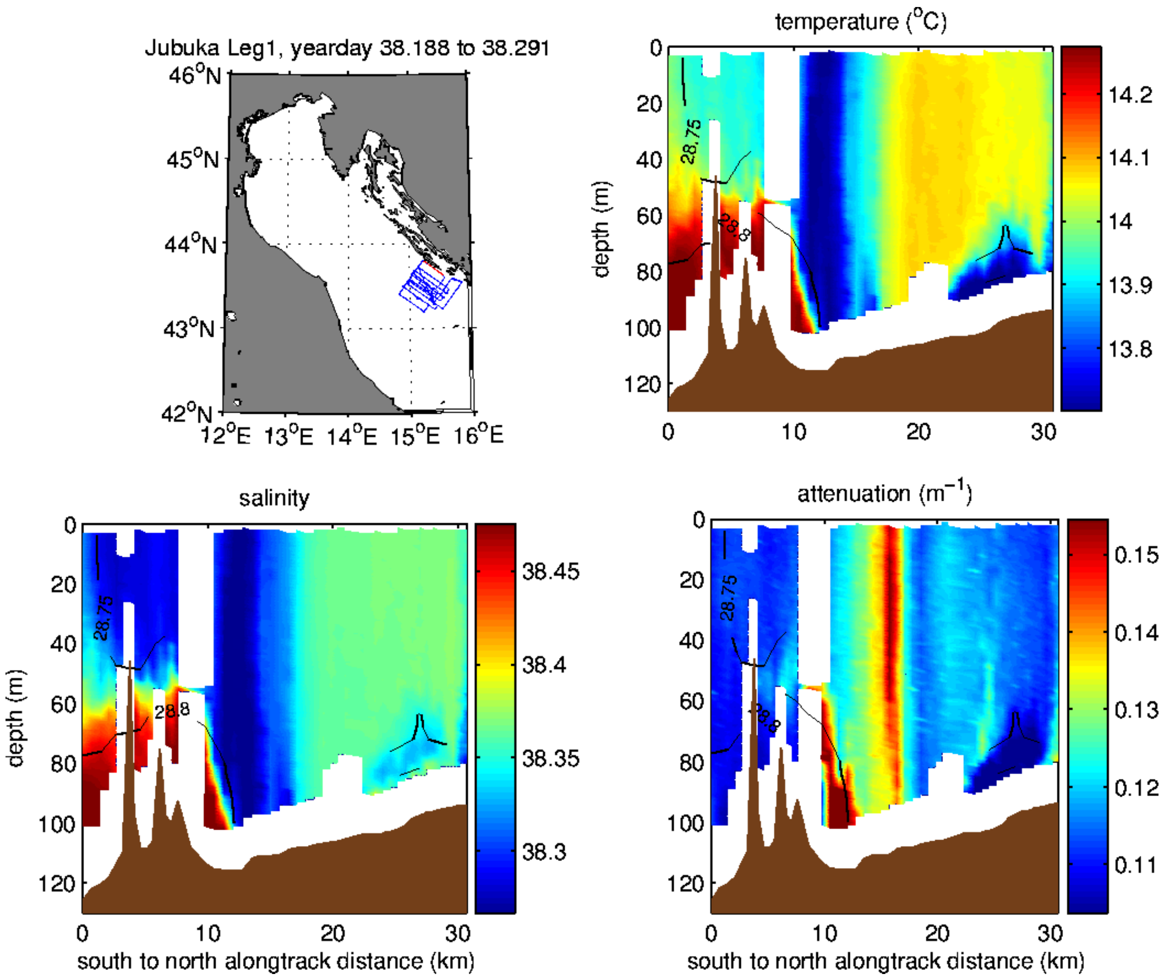


Figure 2.18: Temperature, salinity, and attenuation for Jubuka survey, Leg1 section. Overlaid contours are σ_θ.

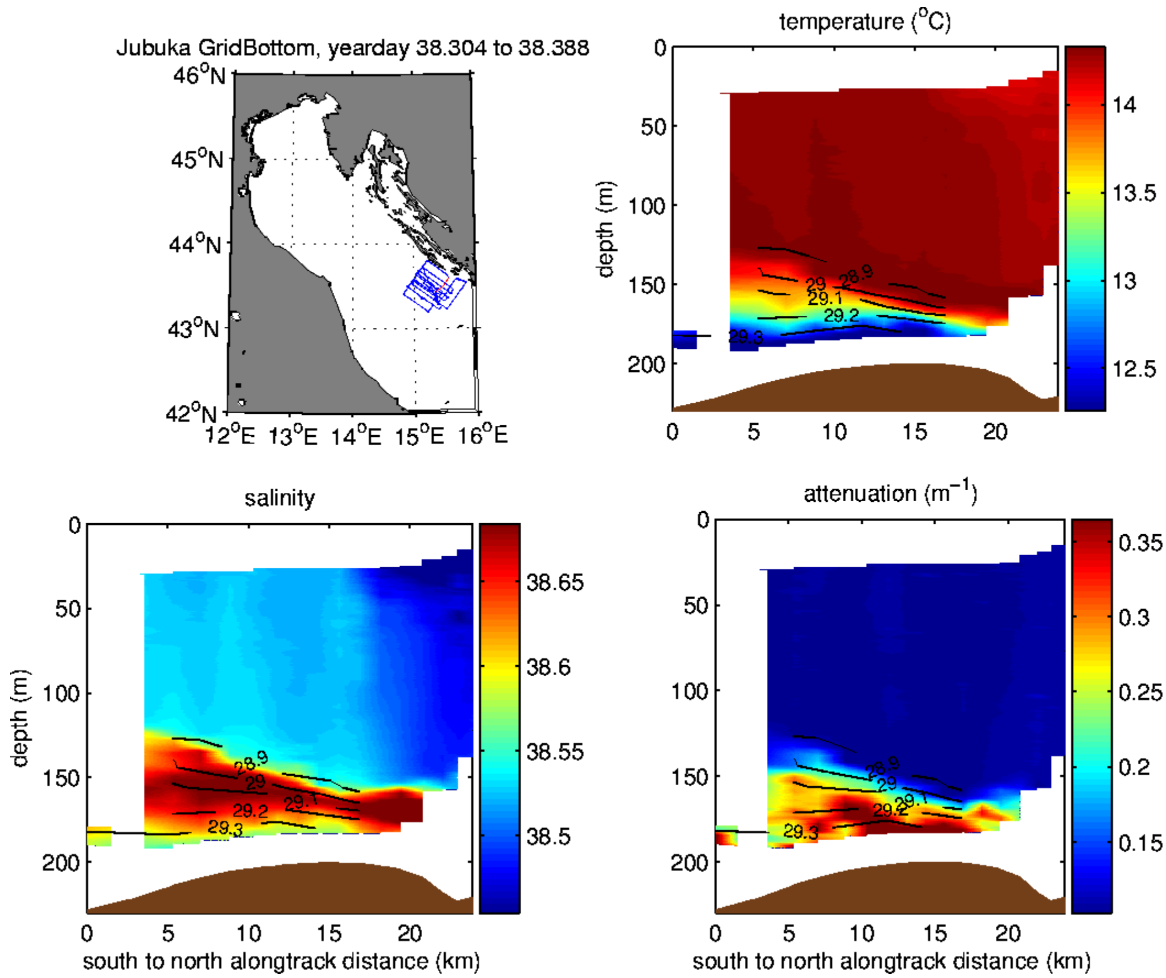


Figure 2.19: Temperature, salinity, and attenuation for Jubuka survey, GridBottom section. Overlaid contours are σ_θ.

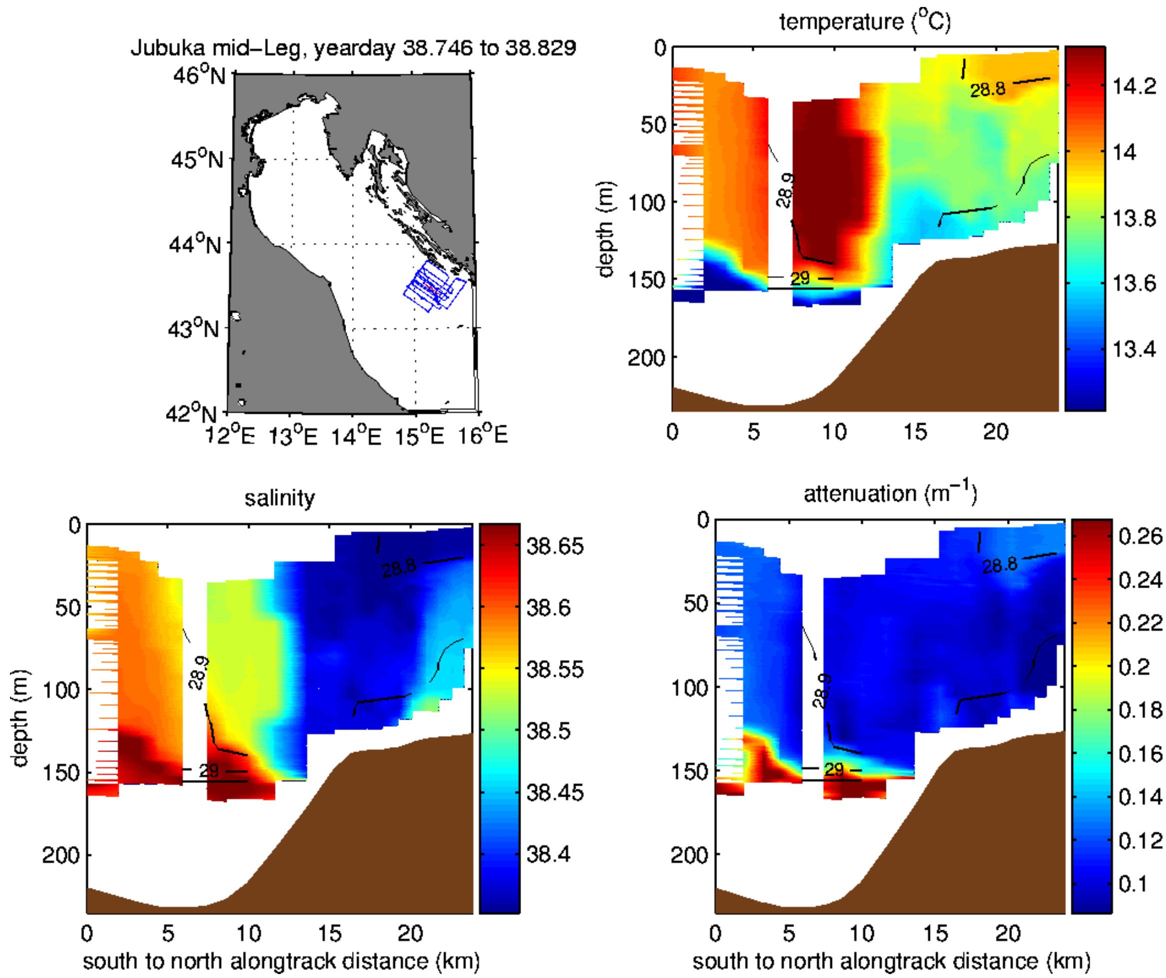


Figure 2.20: Temperature, salinity, and attenuation for Jubuka survey, mid-Leg section. Overlaid contours are σ_θ.

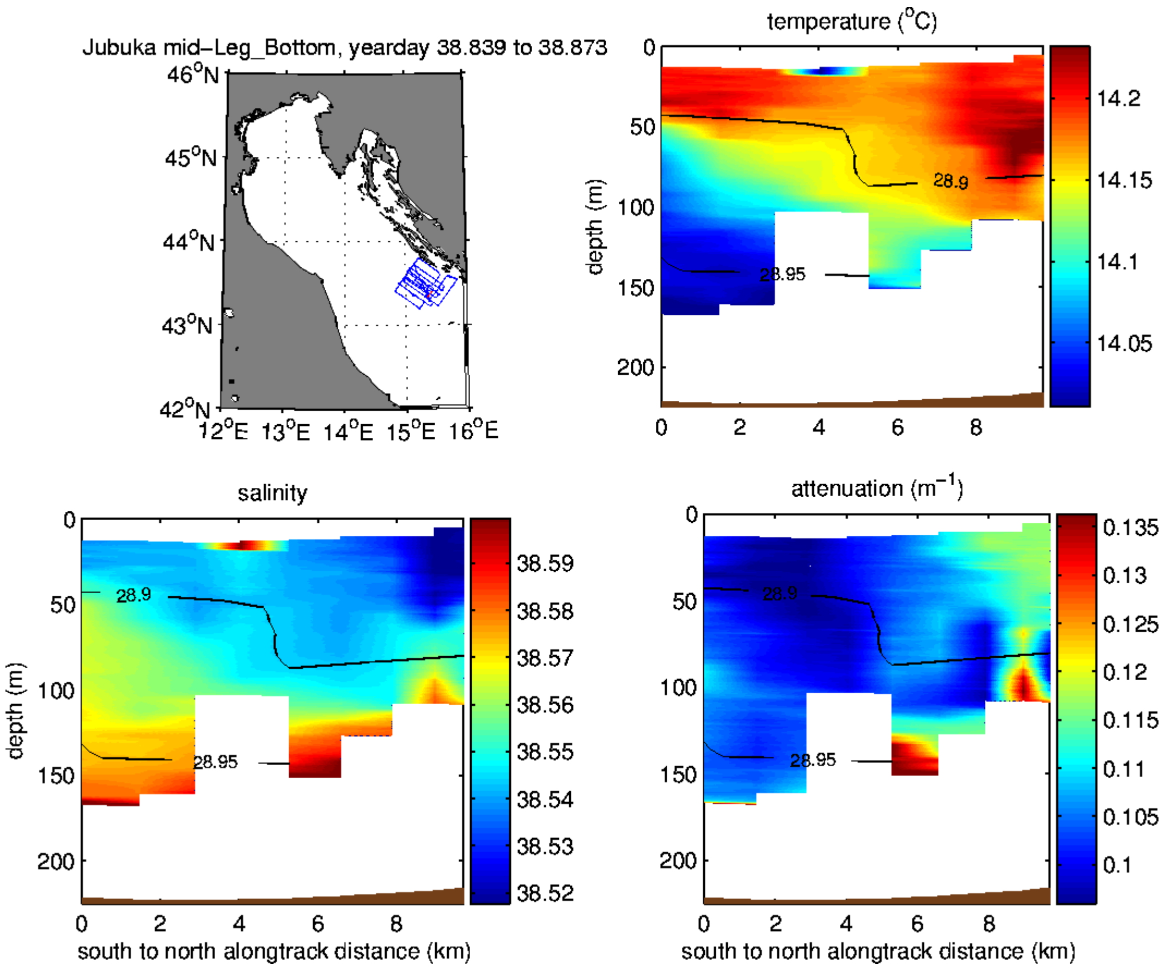


Figure 2.21: Temperature, salinity, and attenuation for Jubuka survey, mid-Leg Bottom section. Overlaid contours are σ_θ.

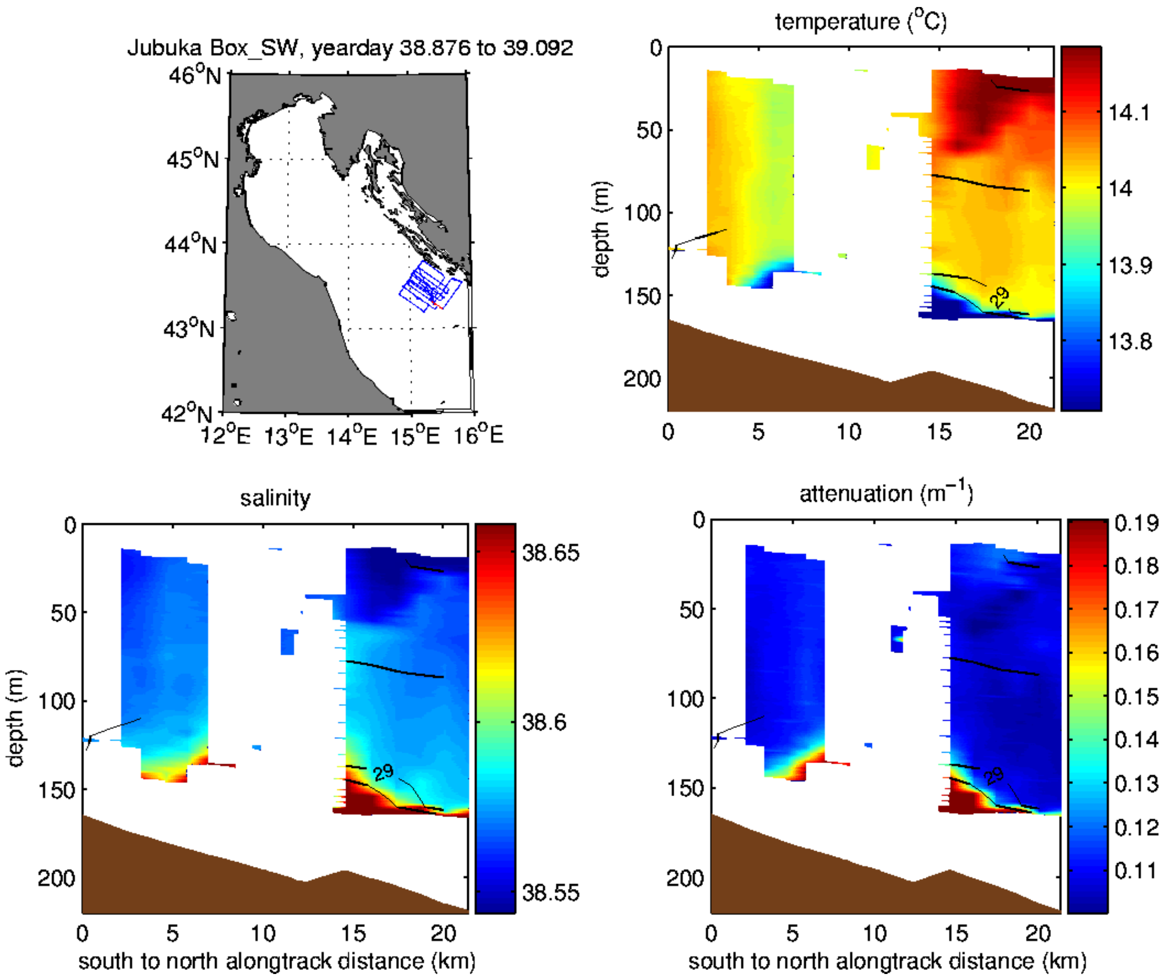


Figure 2.22: Temperature, salinity, and attenuation for Jubuka survey, Box SW section. Overlaid contours are σ_θ.

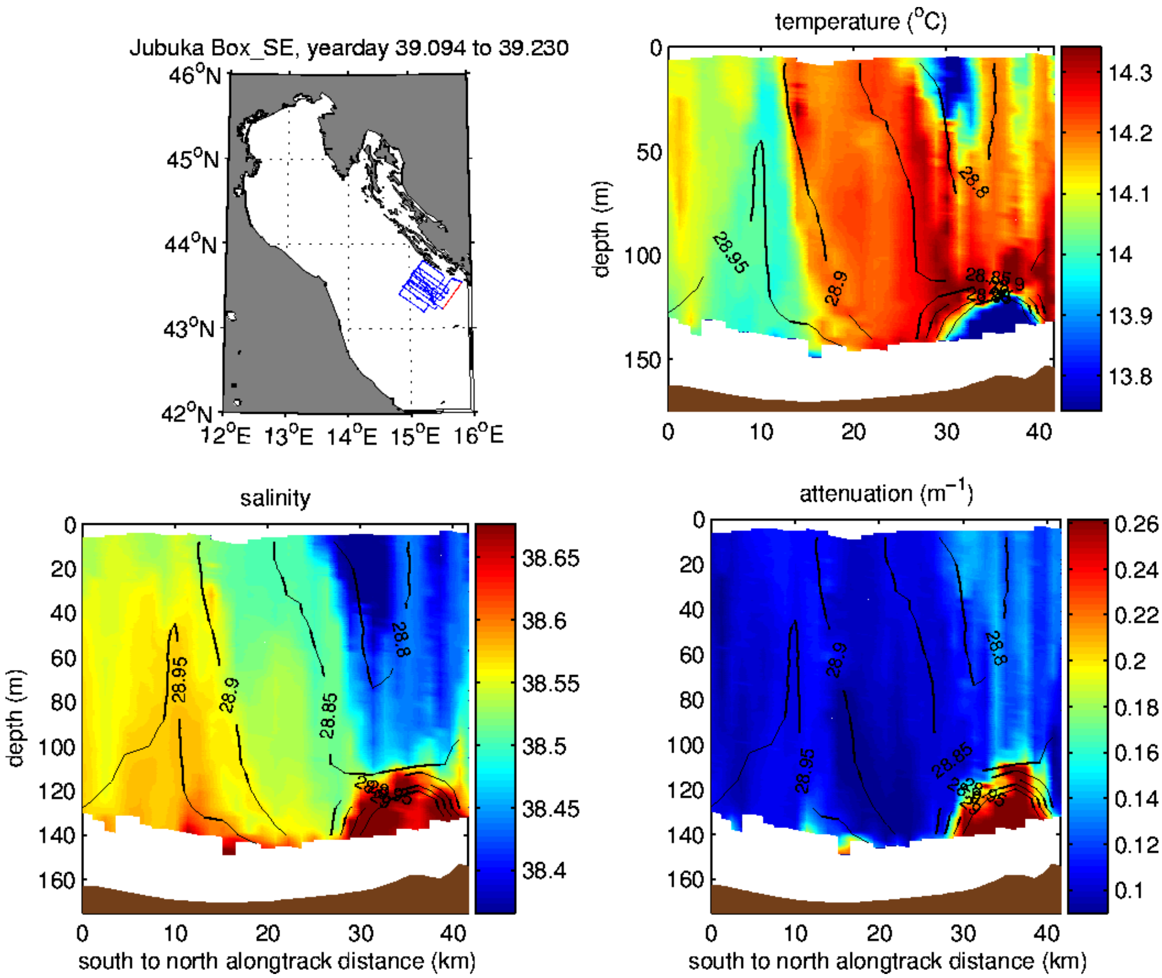


Figure 2.23: Temperature, salinity, and attenuation for Jubuka survey, Box SE section. Overlaid contours are σ_θ.

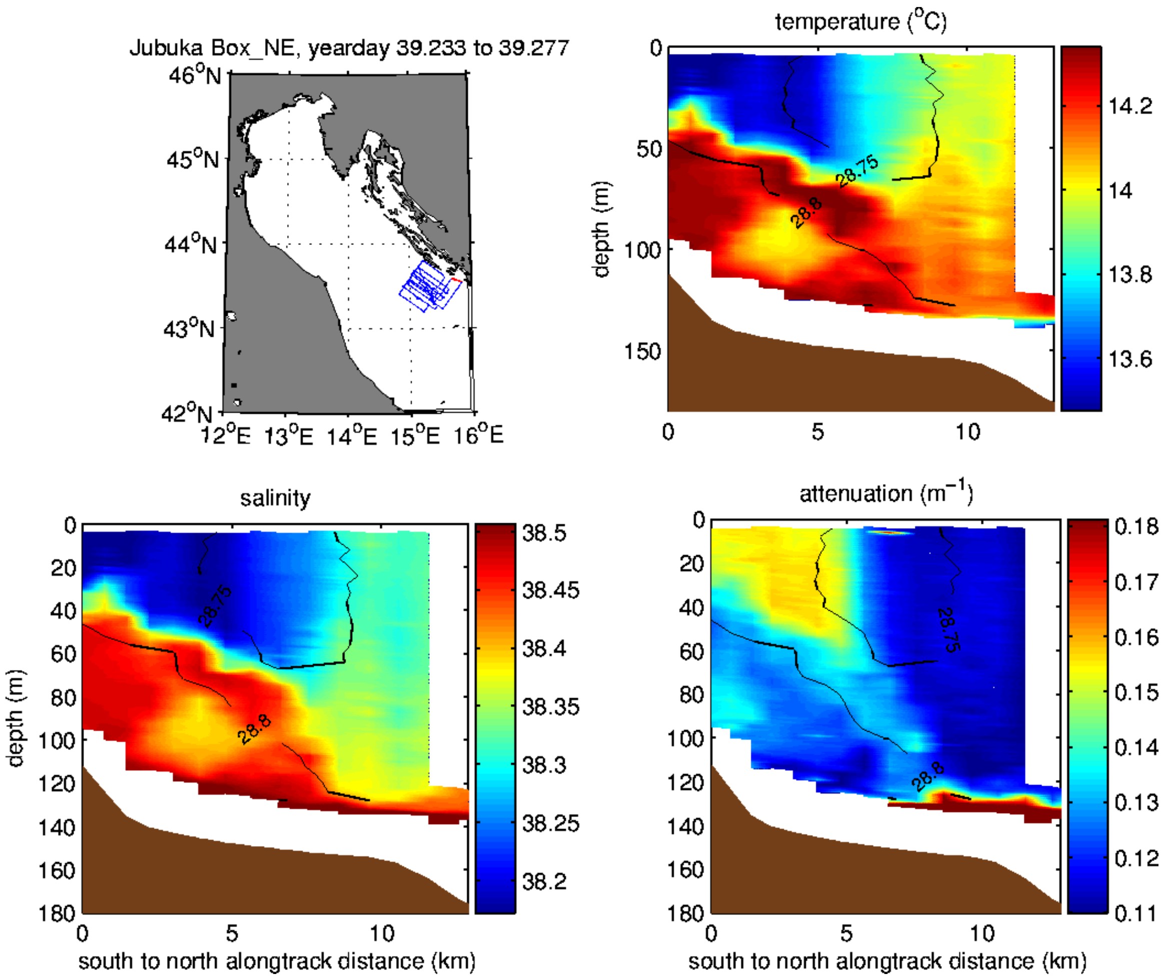


Figure 2.24: Temperature, salinity, and attenuation for Jubuka survey, Box NE section. Overlaid contours are σ_θ.

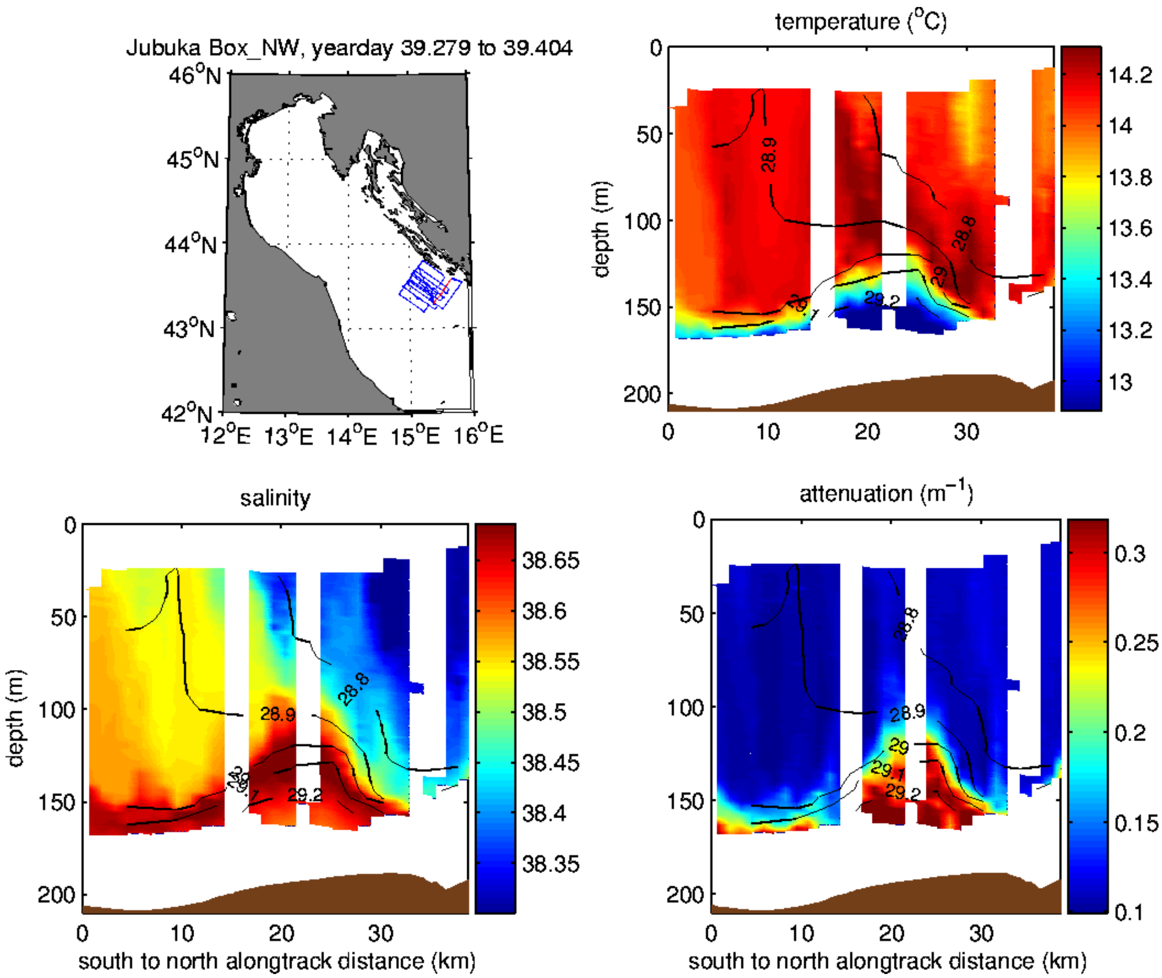


Figure 2.25: Temperature, salinity, and attenuation for Jubuka survey, Box NW section. Overlaid contours are σ_θ.

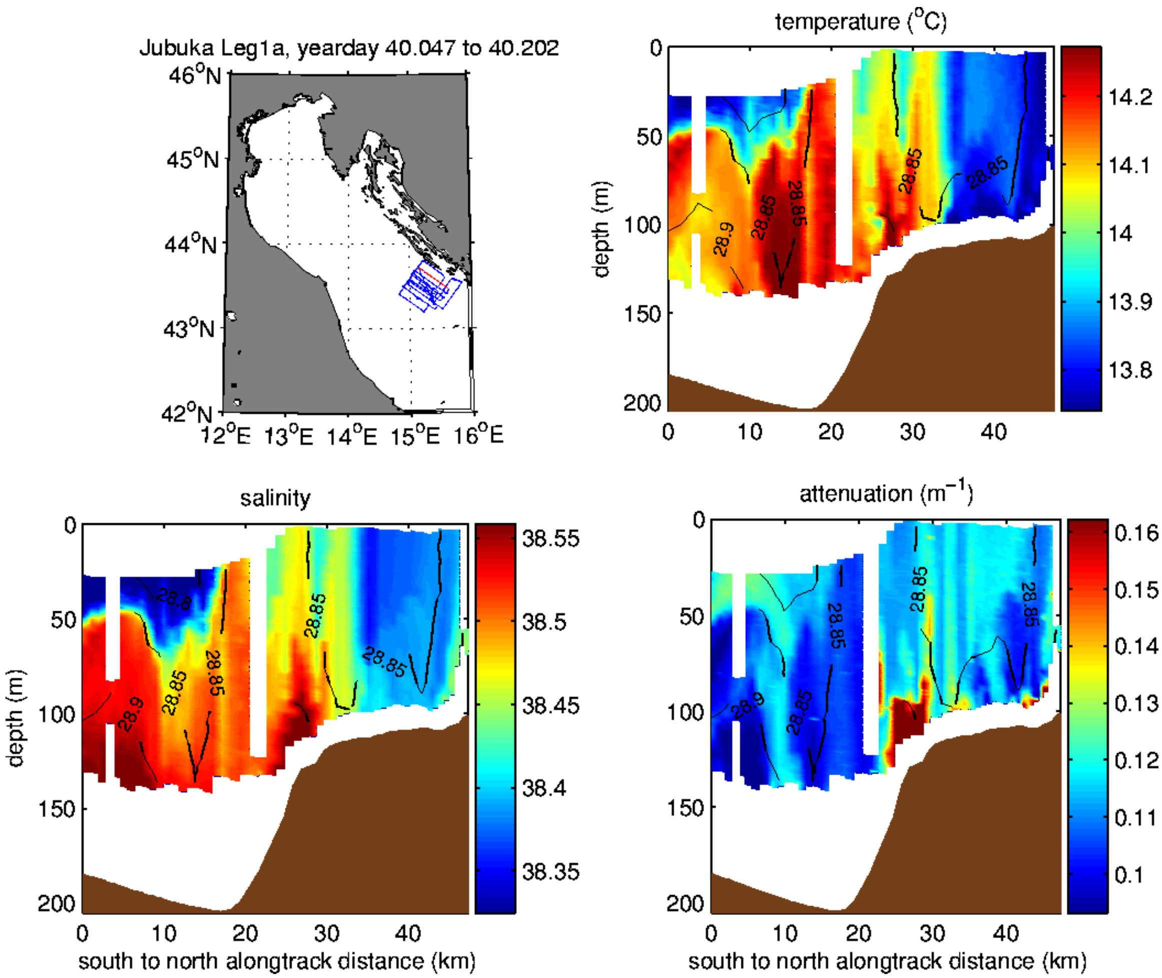


Figure 2.26: Temperature, salinity, and attenuation for Jubuka survey, Leg1a section. Overlaid contours are σ_θ.

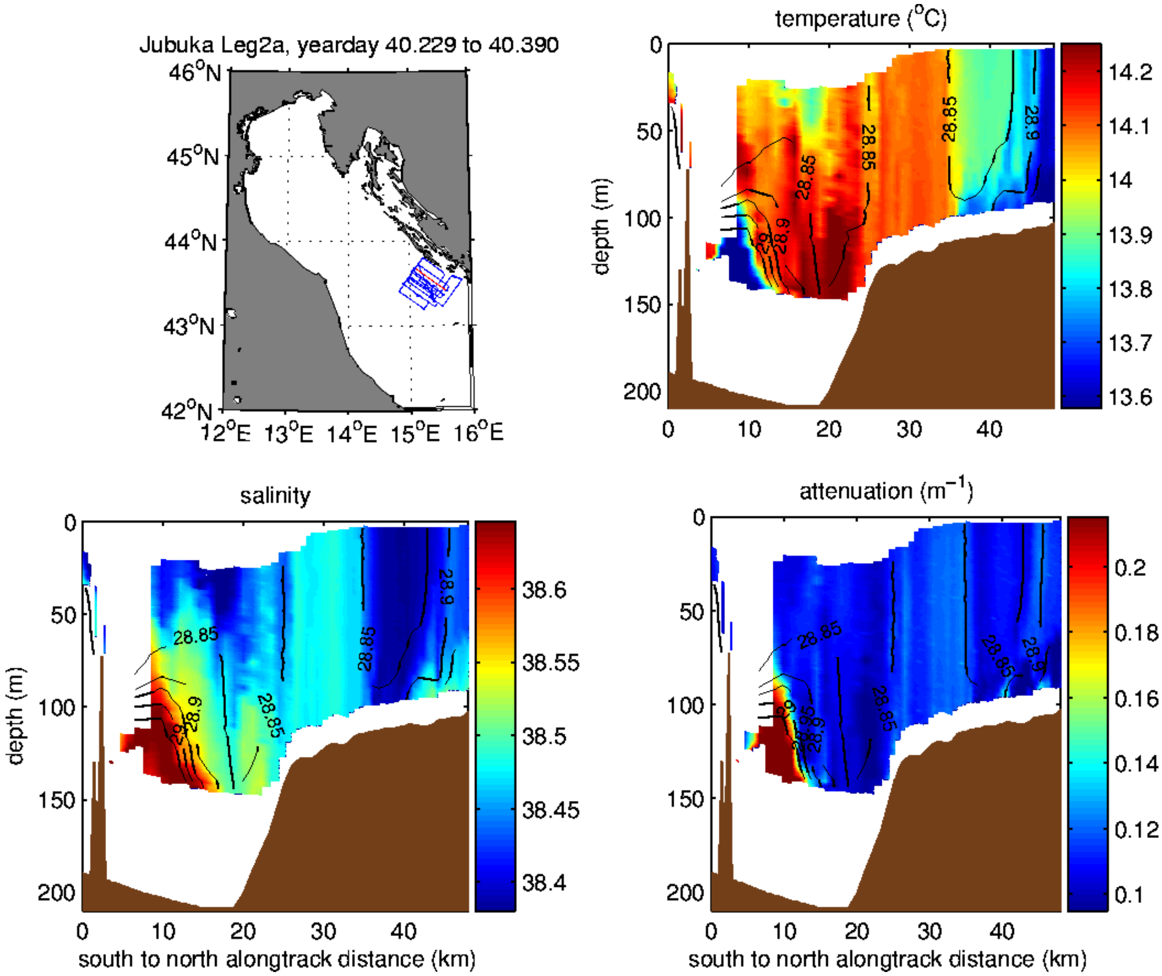


Figure 2.27: Temperature, salinity, and attenuation for Jubuka survey, Leg2a section. Overlaid contours are σ_θ.

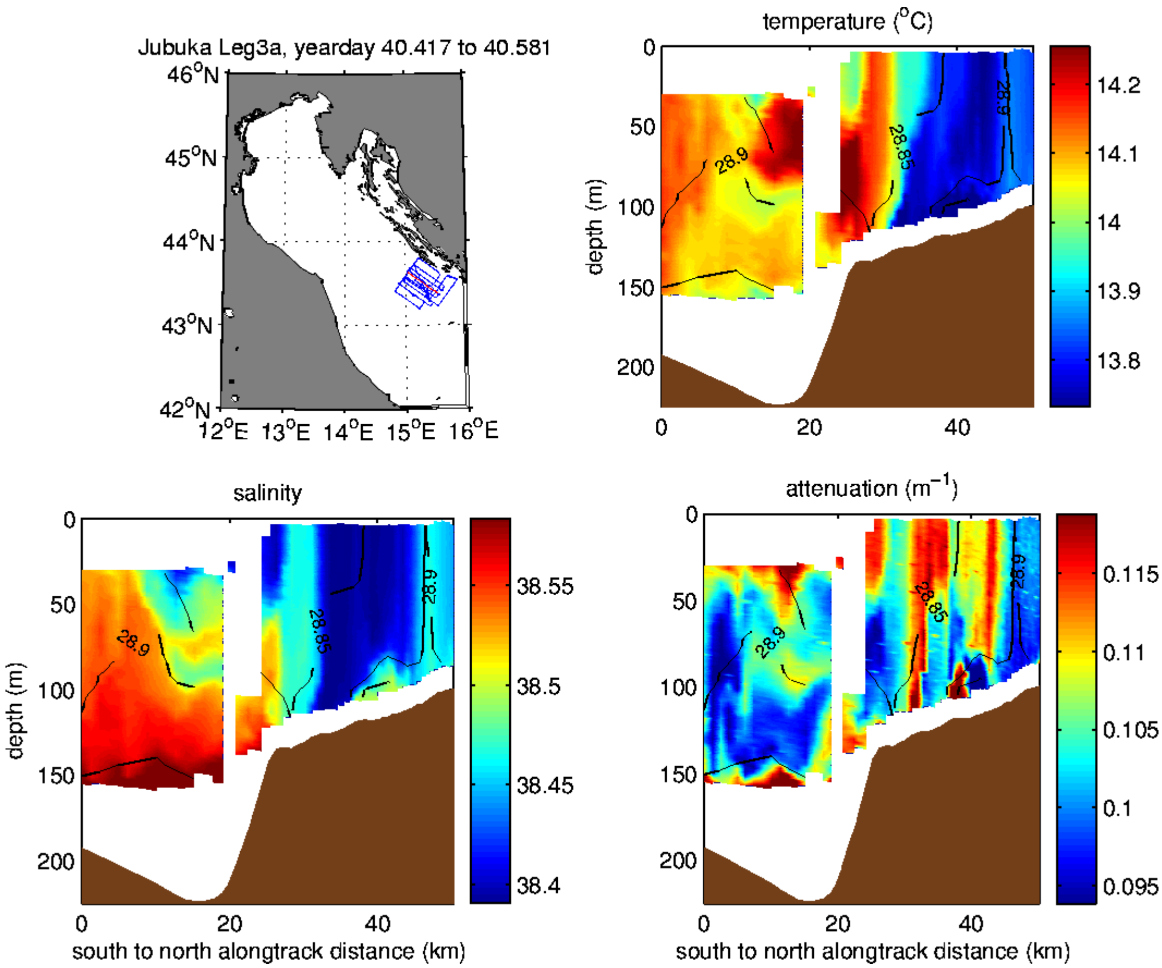


Figure 2.28: Temperature, salinity, and attenuation for Jubuka survey, Leg3a section. Overlaid contours are σ_θ.

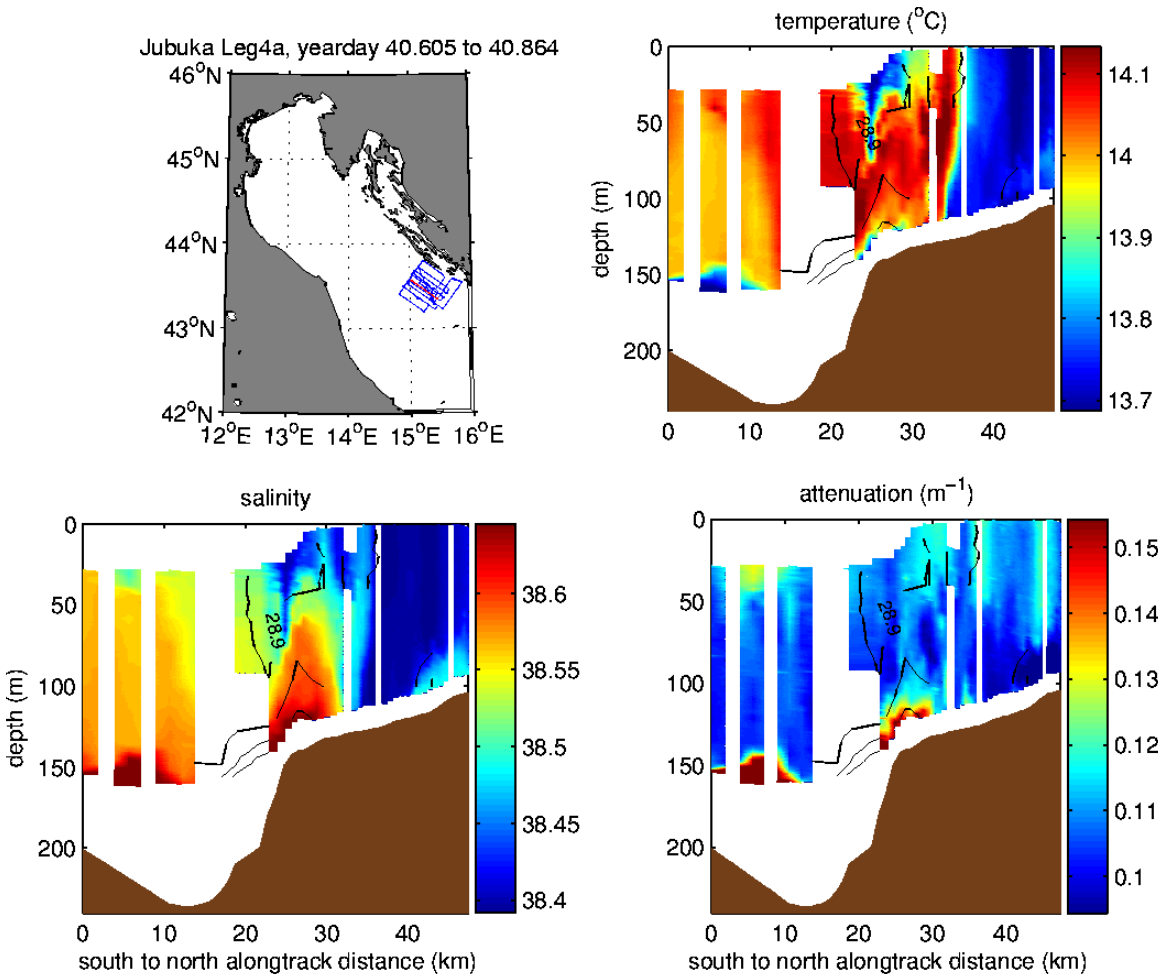


Figure 2.29: Temperature, salinity, and attenuation for Jubuka survey, Leg4a section. Overlaid contours are σ_θ.

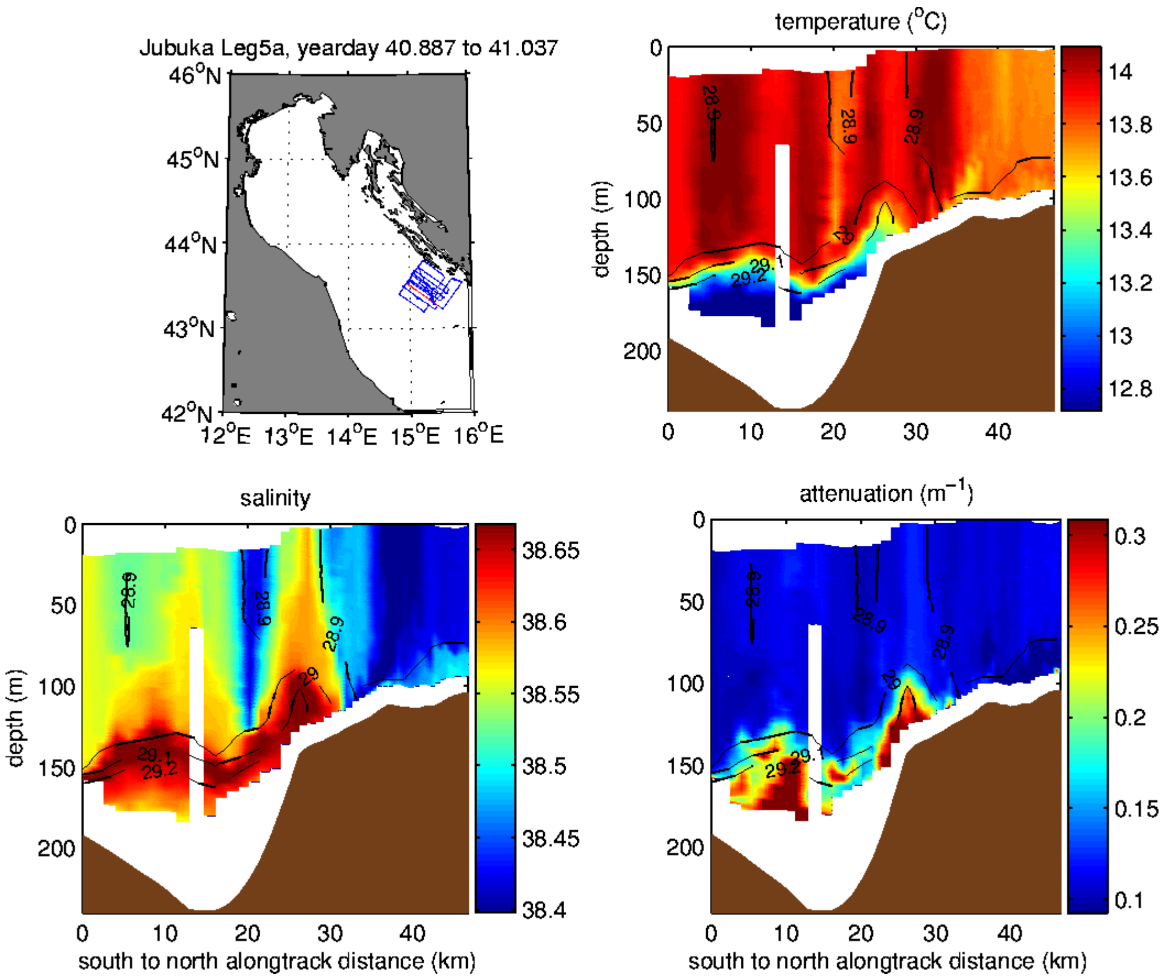


Figure 2.30: Temperature, salinity, and attenuation for Jubuka survey, Leg5a section. Overlaid contours are σ_θ.

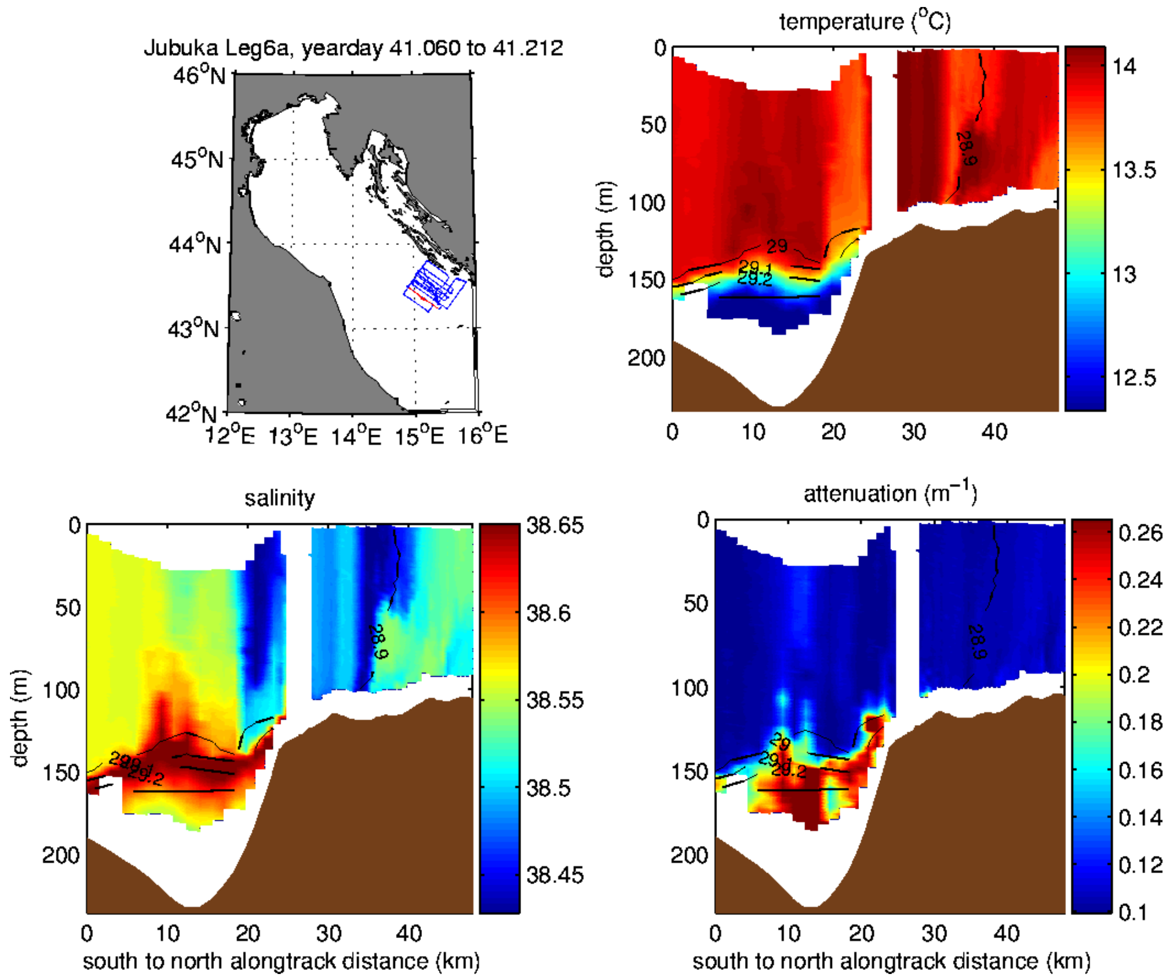


Figure 2.31: Temperature, salinity, and attenuation for Jubuka survey, Leg6a section. Overlaid contours are σ_θ.

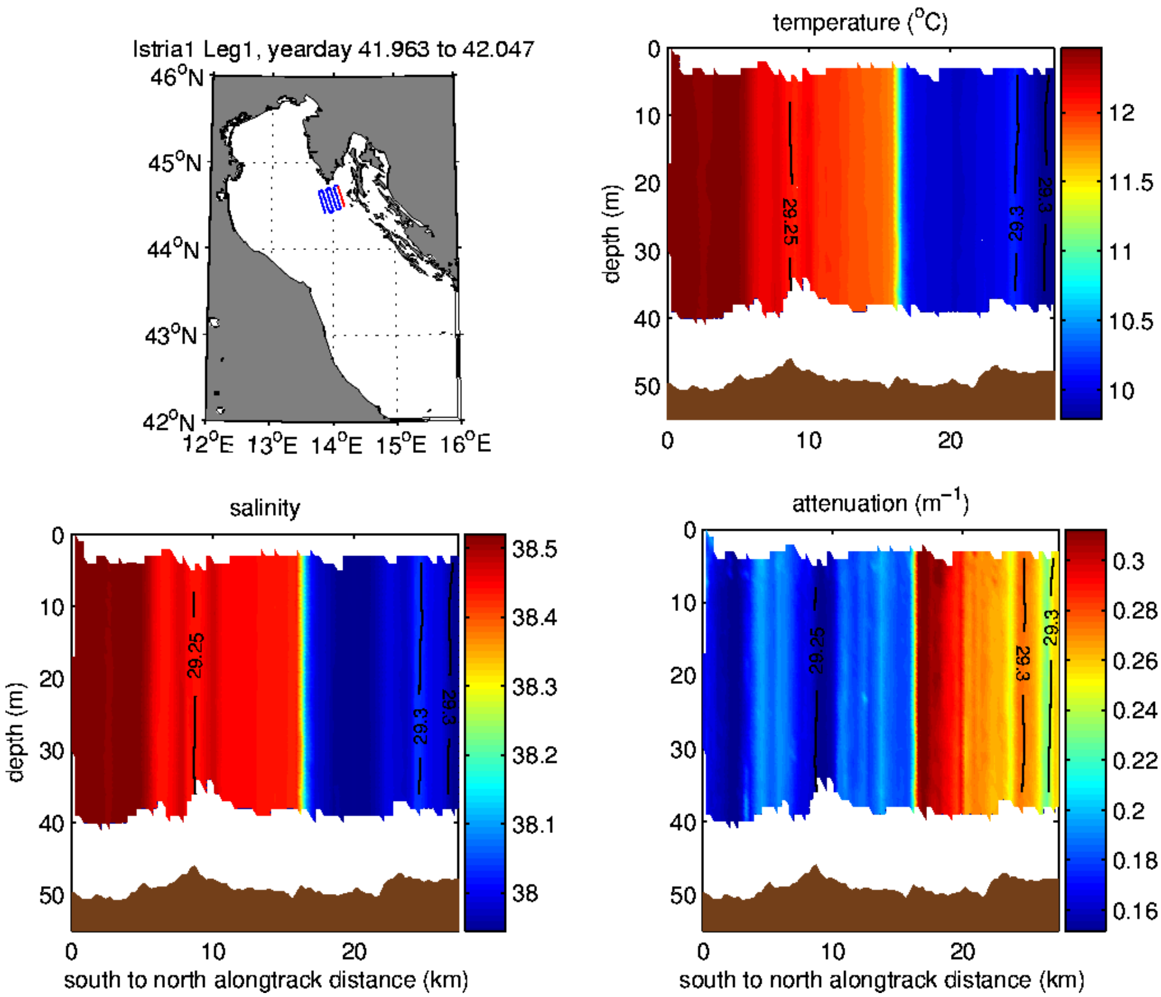


Figure 2.32: Temperature, salinity, and attenuation for Istria1 survey, Leg1 section. Overlaid contours are σ_θ.

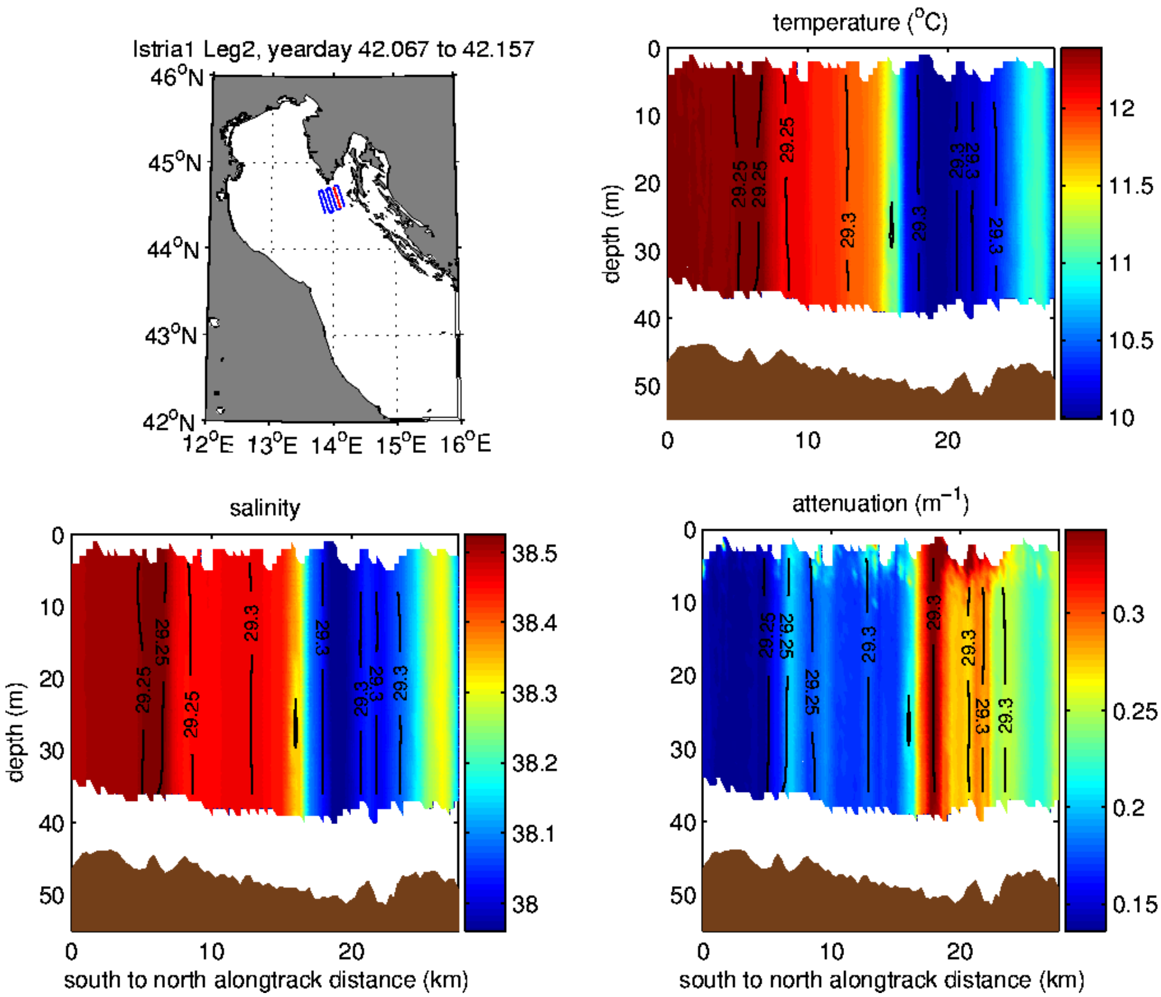


Figure 2.33: Temperature, salinity, and attenuation for Istria1 survey, Leg2 section. Overlaid contours are σ_θ.

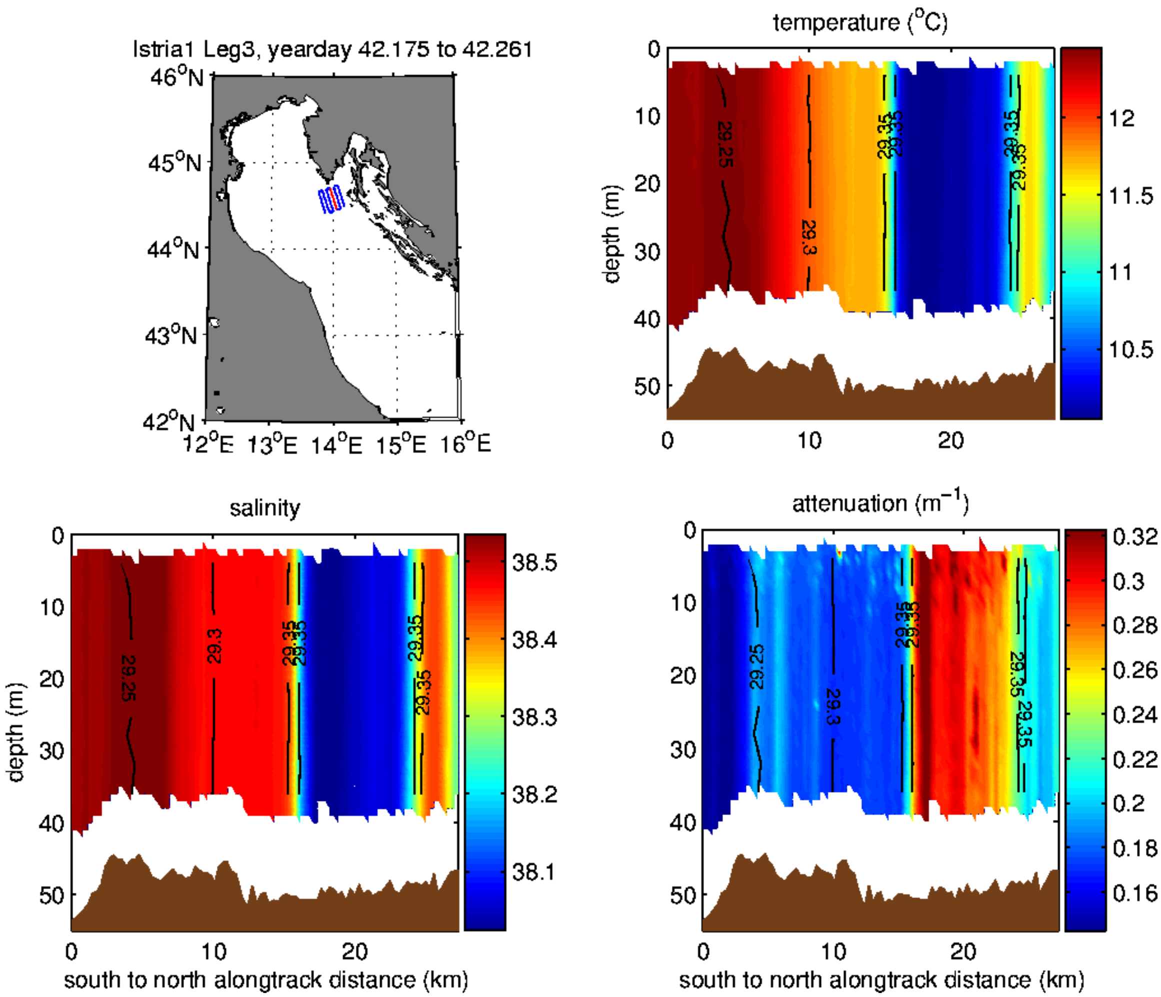


Figure 2.34: Temperature, salinity, and attenuation for Istria1 survey, Leg3 section. Overlaid contours are σ_θ.

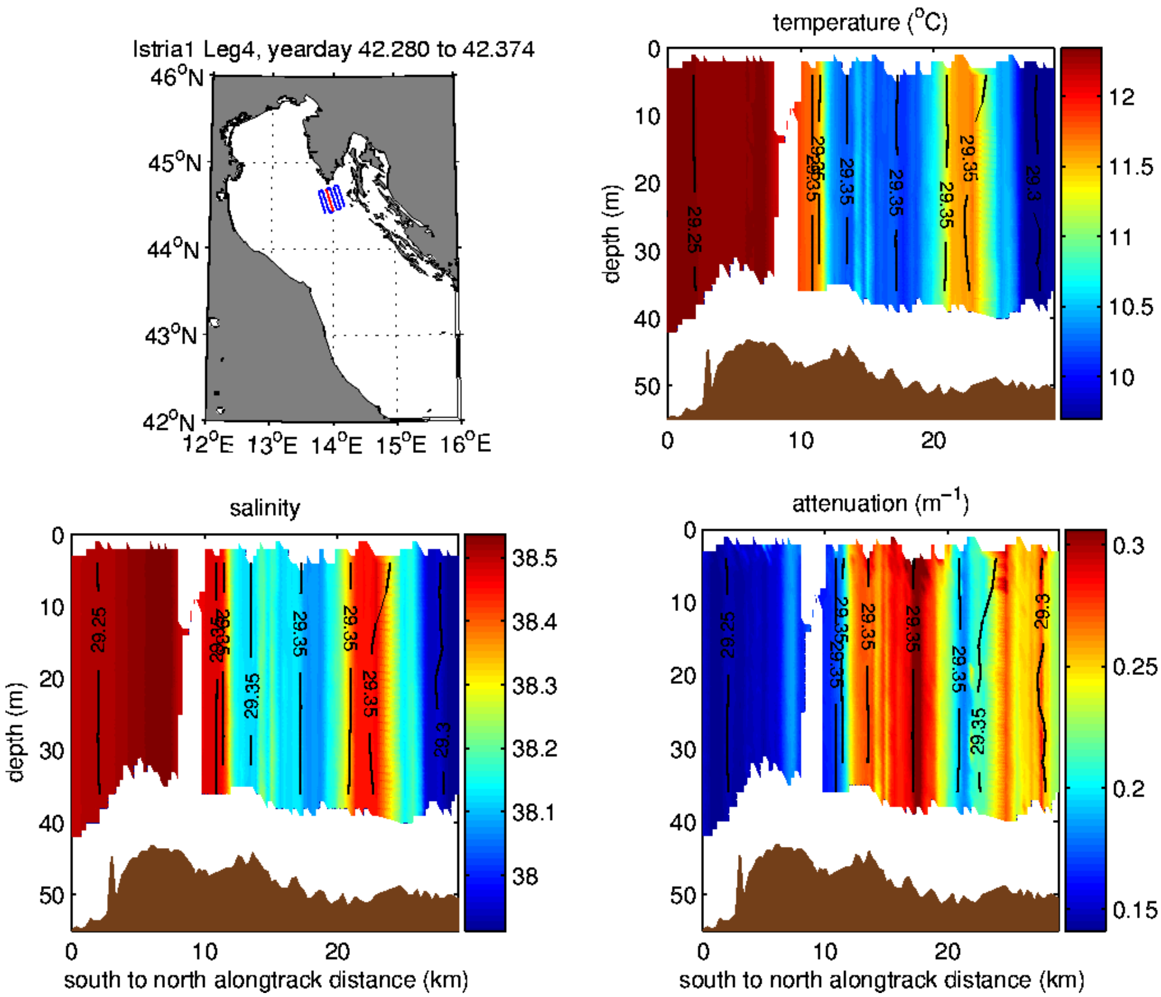


Figure 2.35: Temperature, salinity, and attenuation for Istria1 survey, Leg4 section. Overlaid contours are σ_θ.

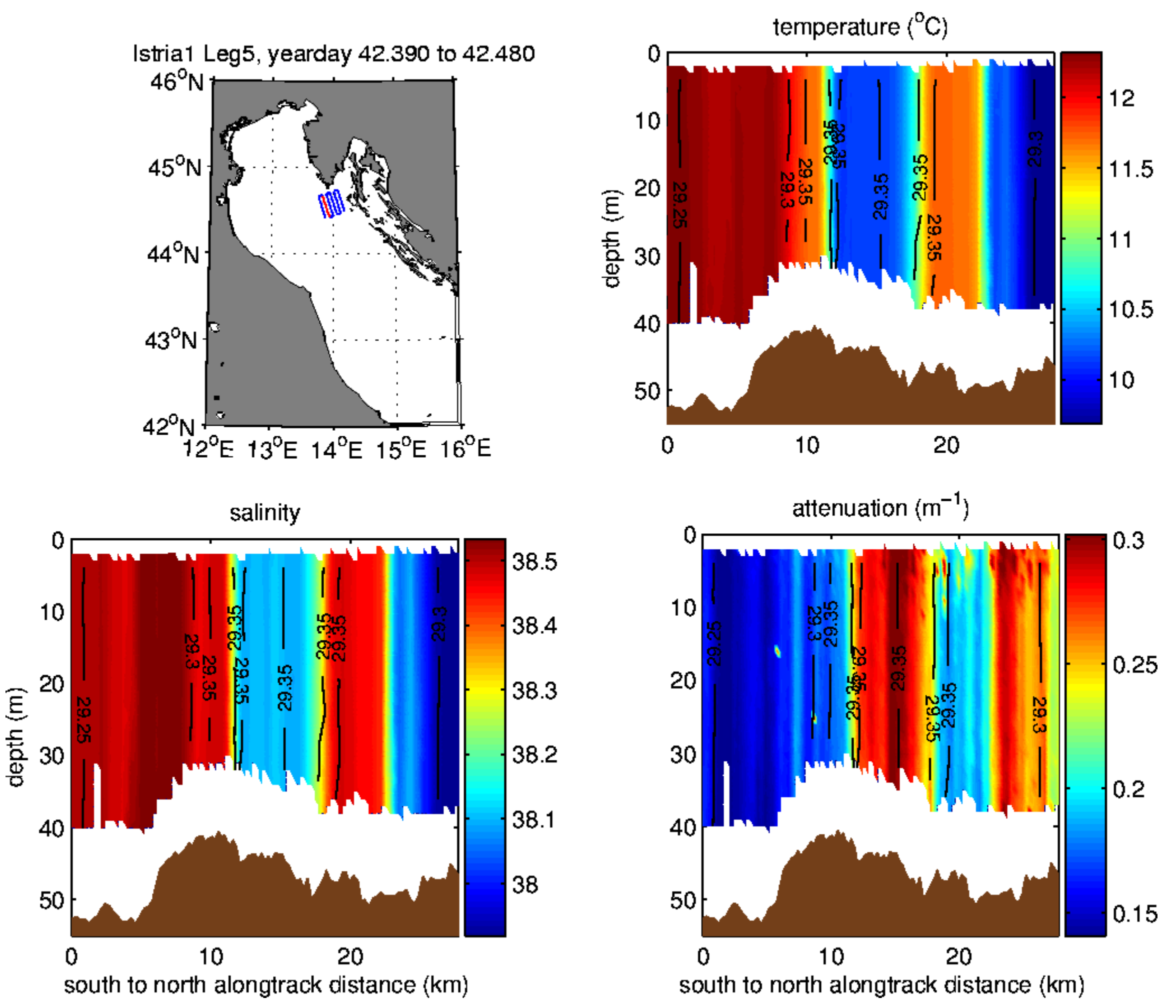


Figure 2.36: Temperature, salinity, and attenuation for Istria1 survey, Leg5 section. Overlaid contours are σ_θ.

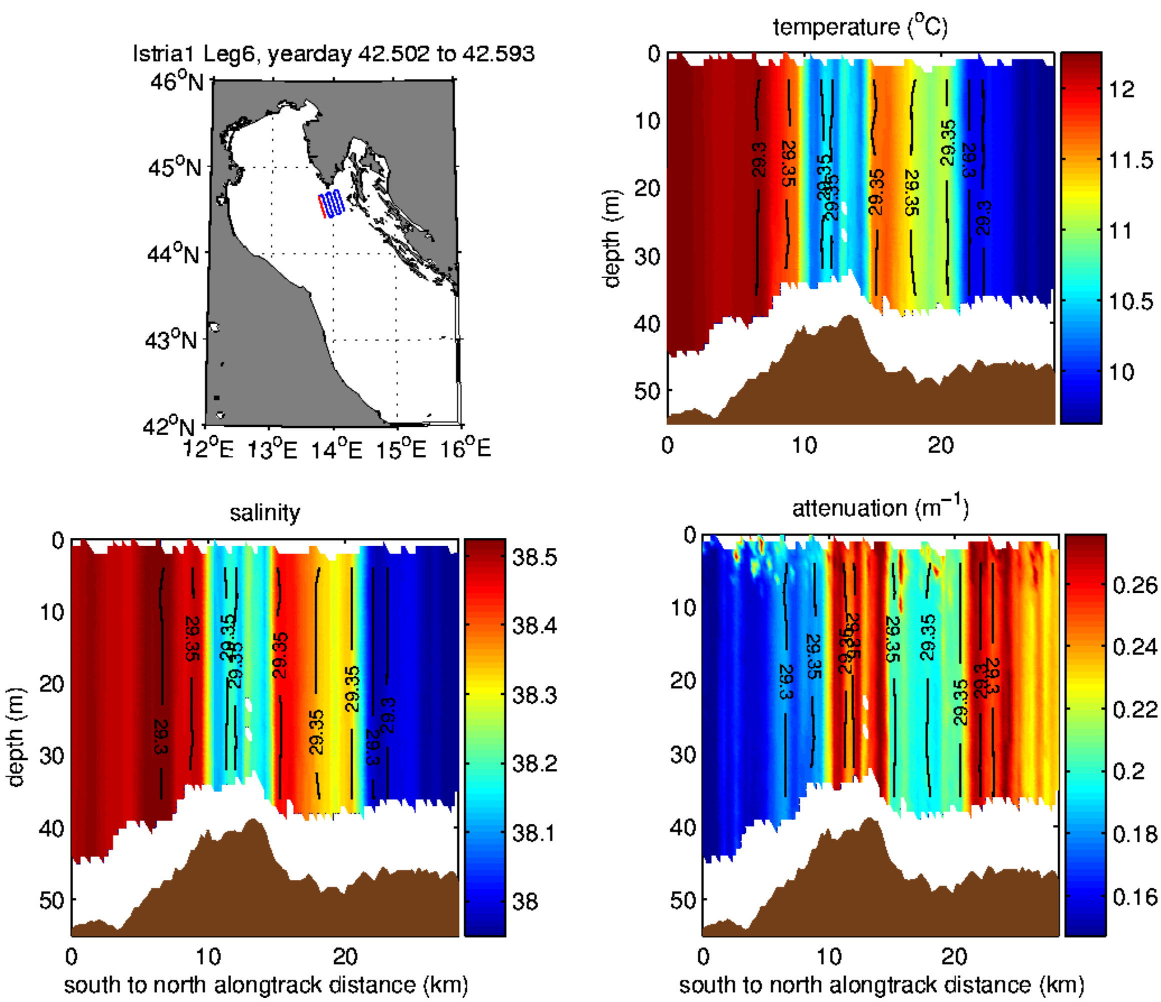


Figure 2.37: Temperature, salinity, and attenuation for Istria1 survey, Leg6 section. Overlaid contours are σ_θ.

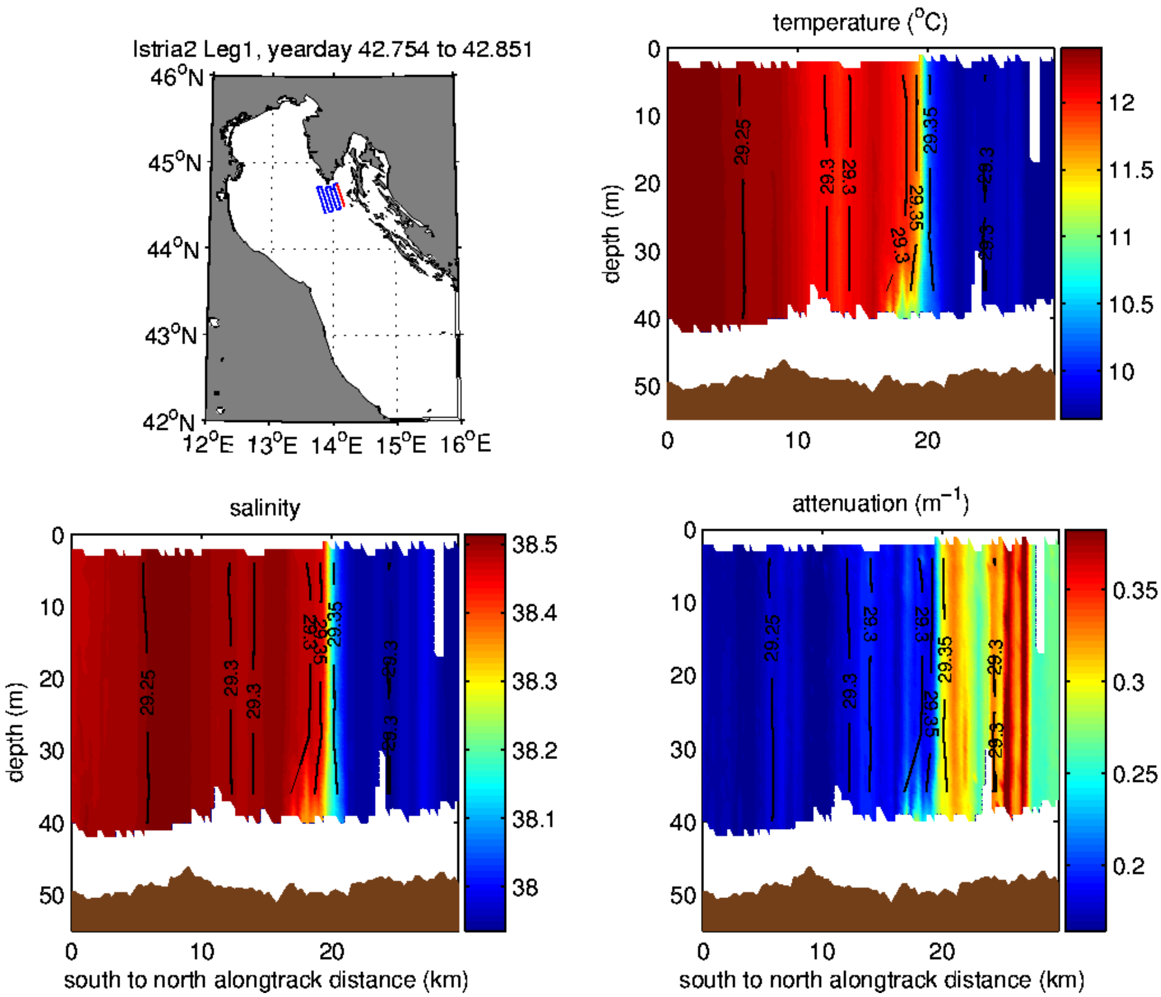


Figure 2.38: Temperature, salinity, and attenuation for Istria2 survey, Leg1 section. Overlaid contours are σ_θ.

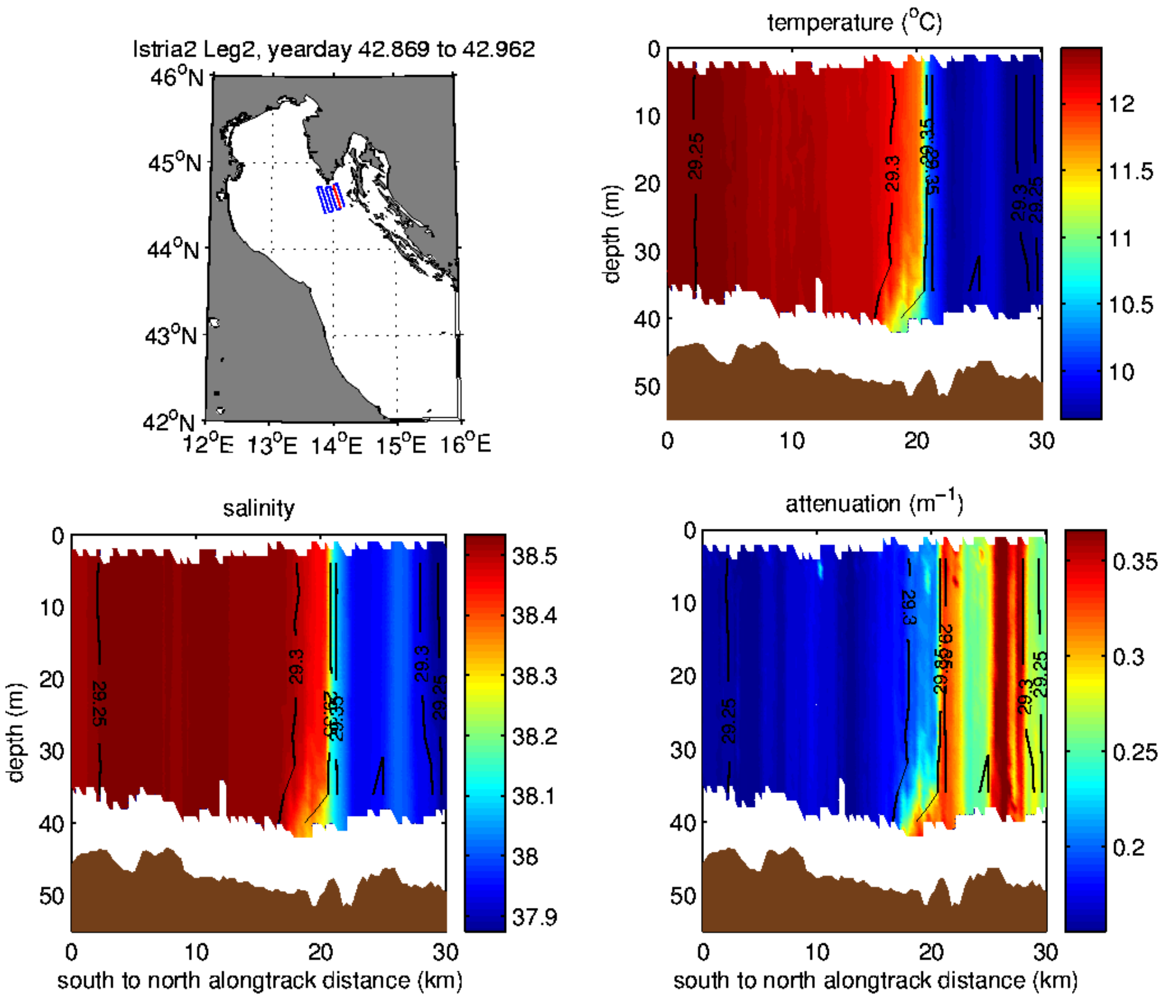


Figure 2.39: Temperature, salinity, and attenuation for Istria2 survey, Leg2 section. Overlaid contours are σ_θ.

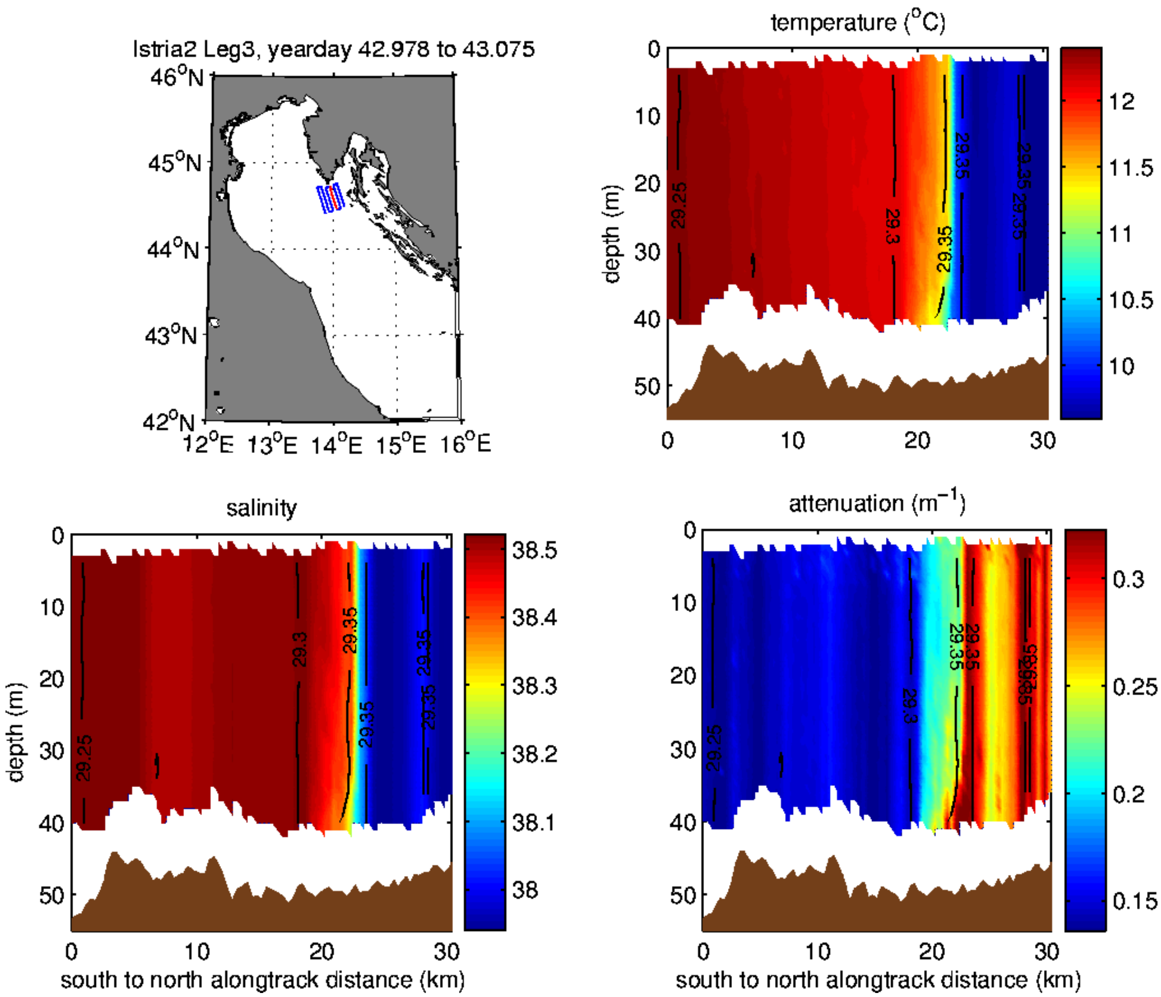


Figure 2.40: Temperature, salinity, and attenuation for Istria2 survey, Leg3 section. Overlaid contours are σ_θ.

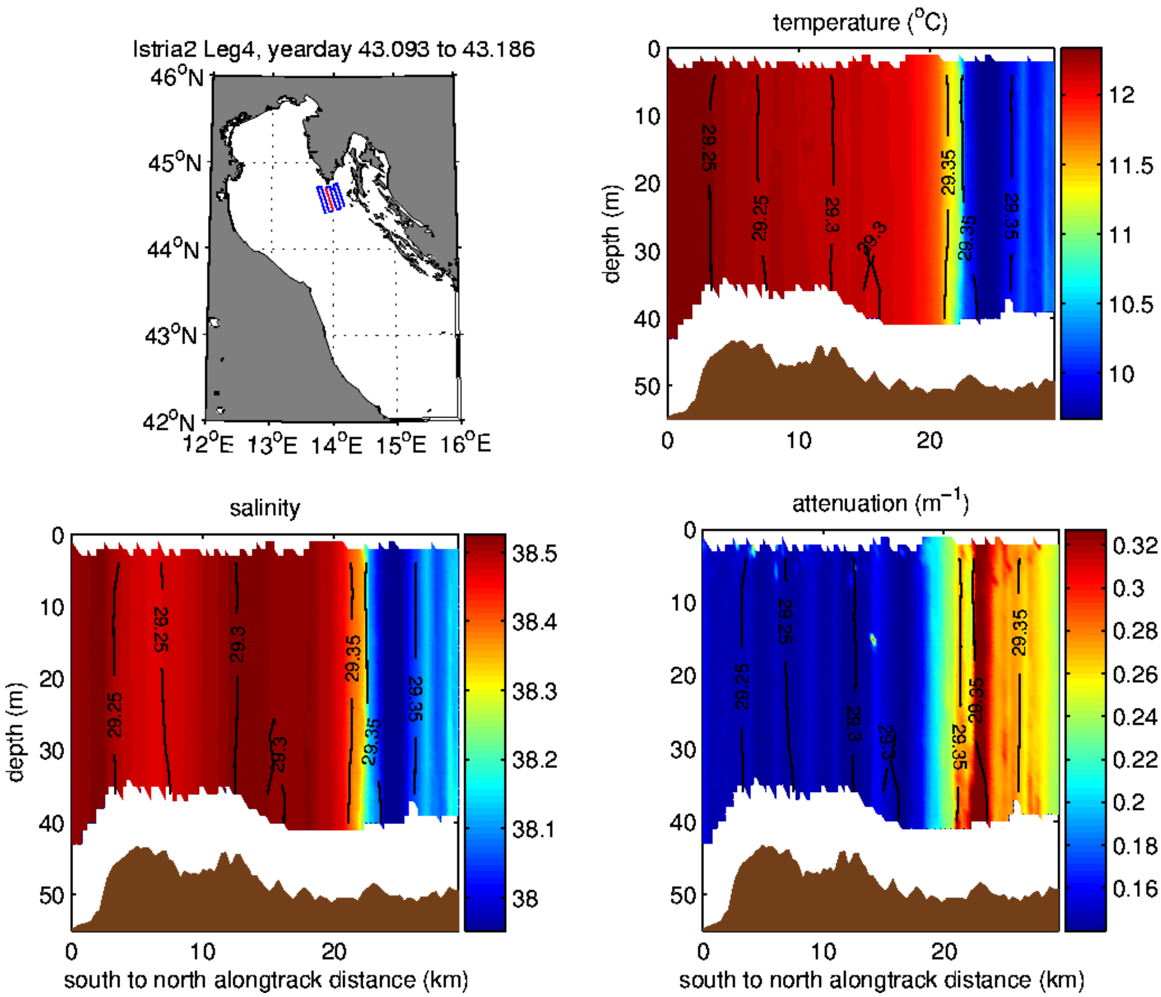


Figure 2.41: Temperature, salinity, and attenuation for Istria2 survey, Leg4 section. Overlaid contours are σ_θ.

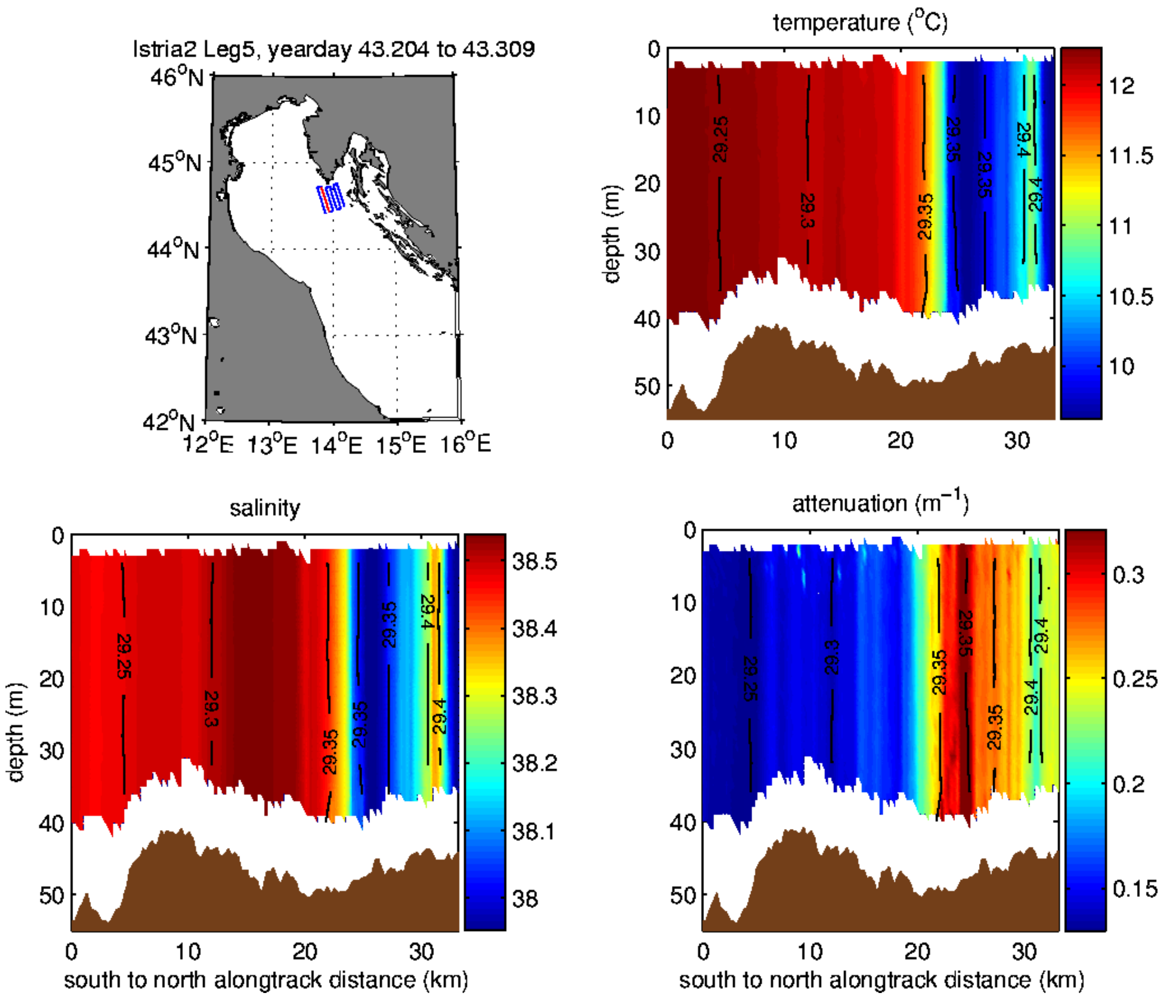


Figure 2.42: Temperature, salinity, and attenuation for Istria2 survey, Leg5 section. Overlaid contours are σ_θ.

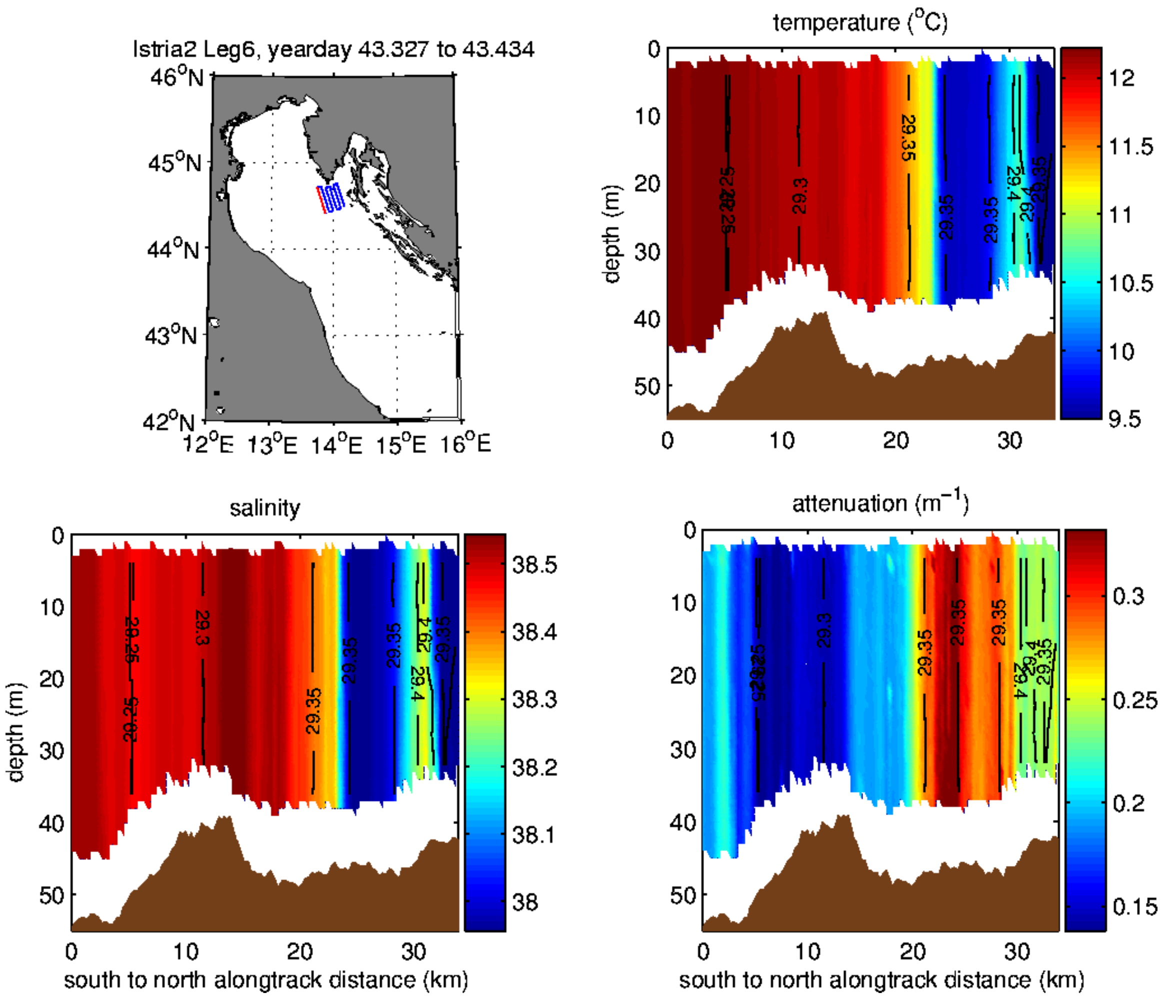


Figure 2.43: Temperature, salinity, and attenuation for Istria2 survey, Leg6 section. Overlaid contours are σ_θ.

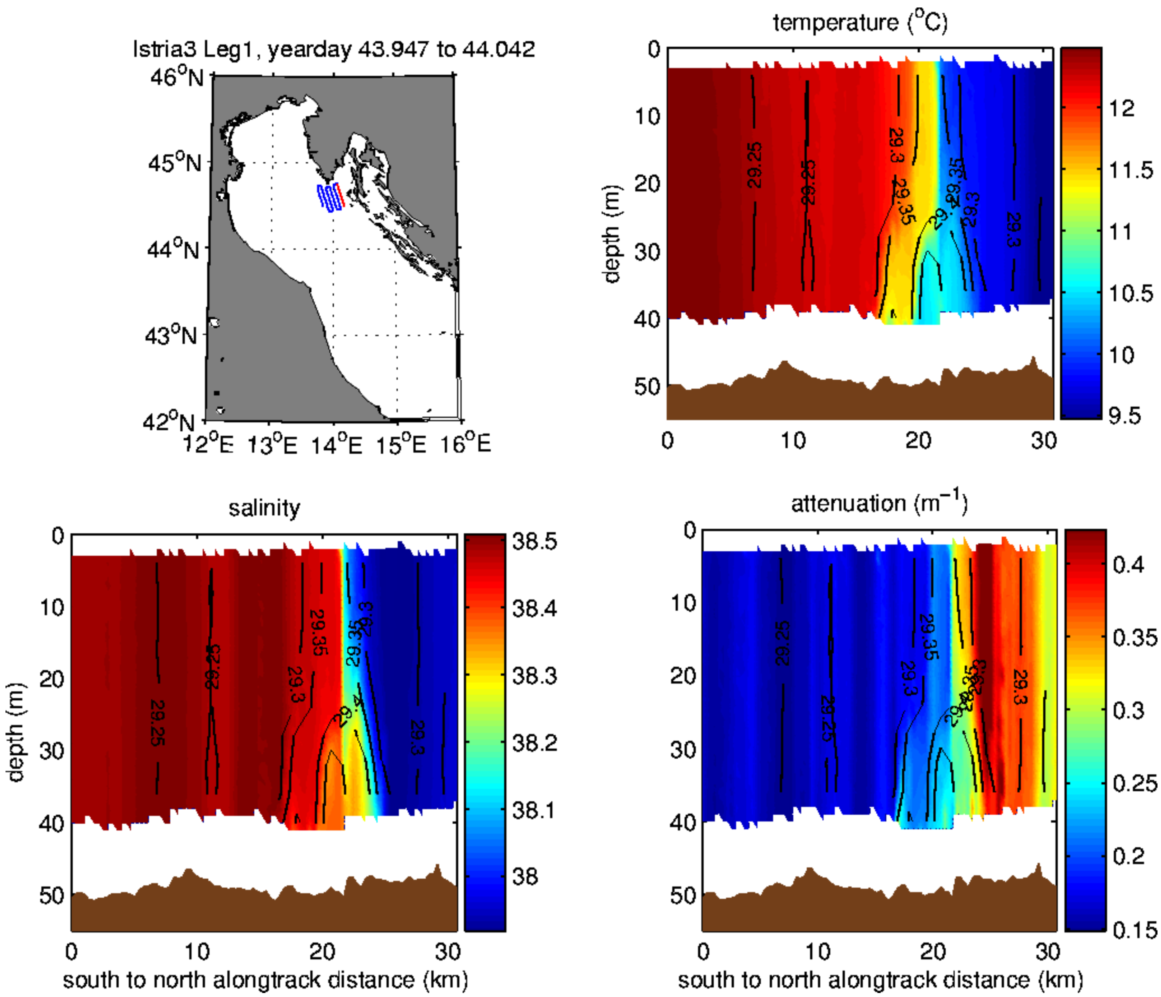


Figure 2.44: Temperature, salinity, and attenuation for Istria3 survey, Leg1 section. Overlaid contours are σ_θ.

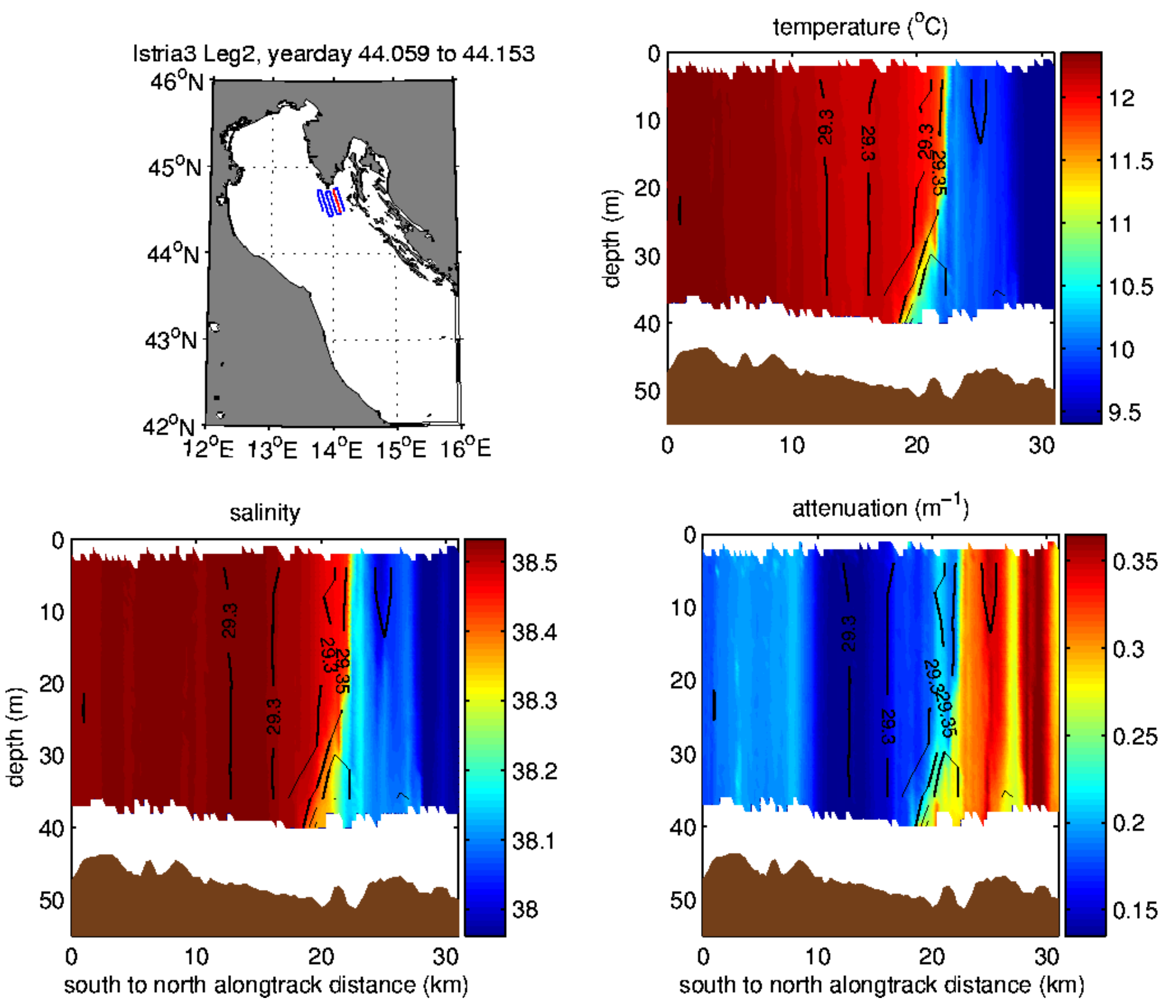


Figure 2.45: Temperature, salinity, and attenuation for Istria3 survey, Leg2 section. Overlaid contours are σ_θ.

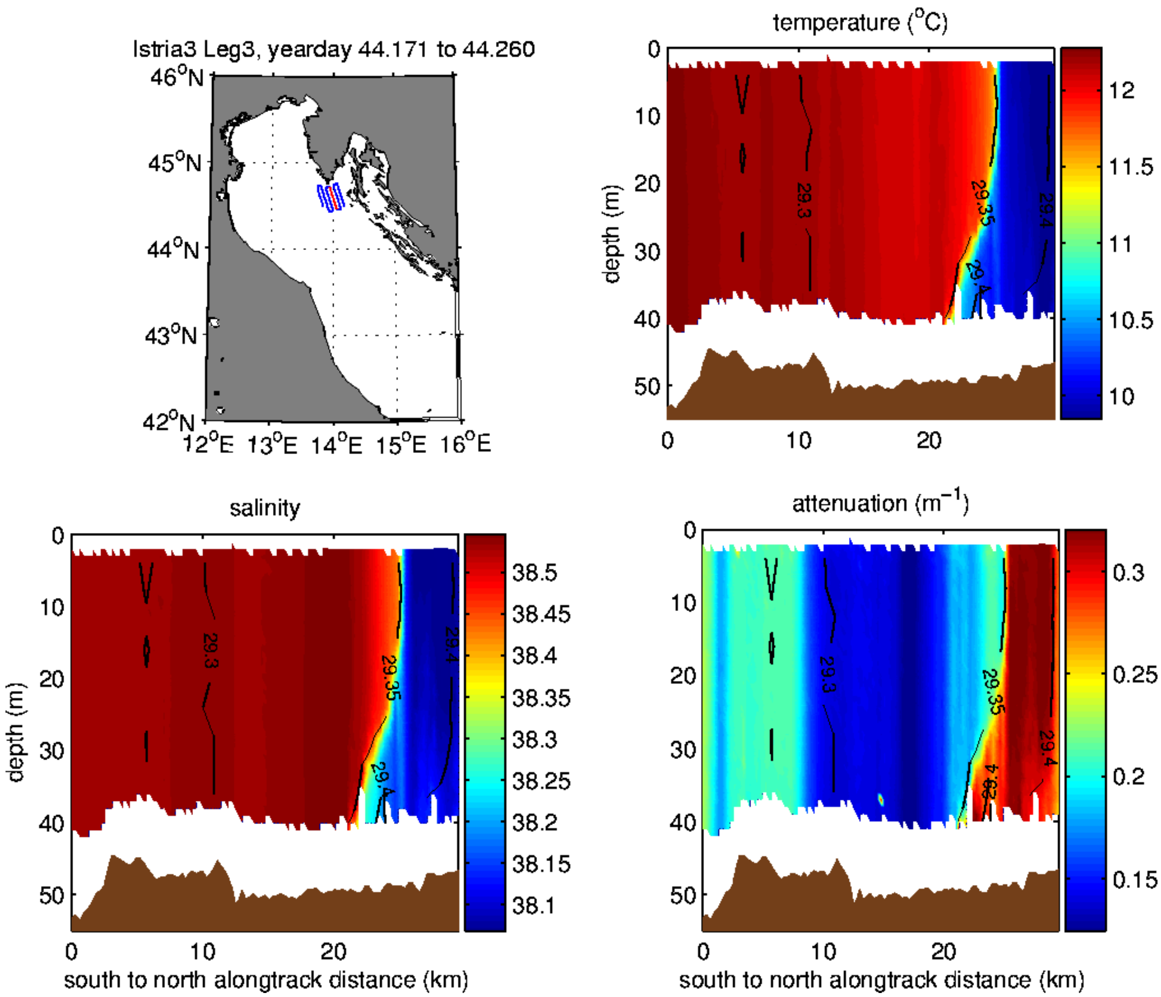


Figure 2.46: Temperature, salinity, and attenuation for Istria3 survey, Leg3 section. Overlaid contours are σ_θ.

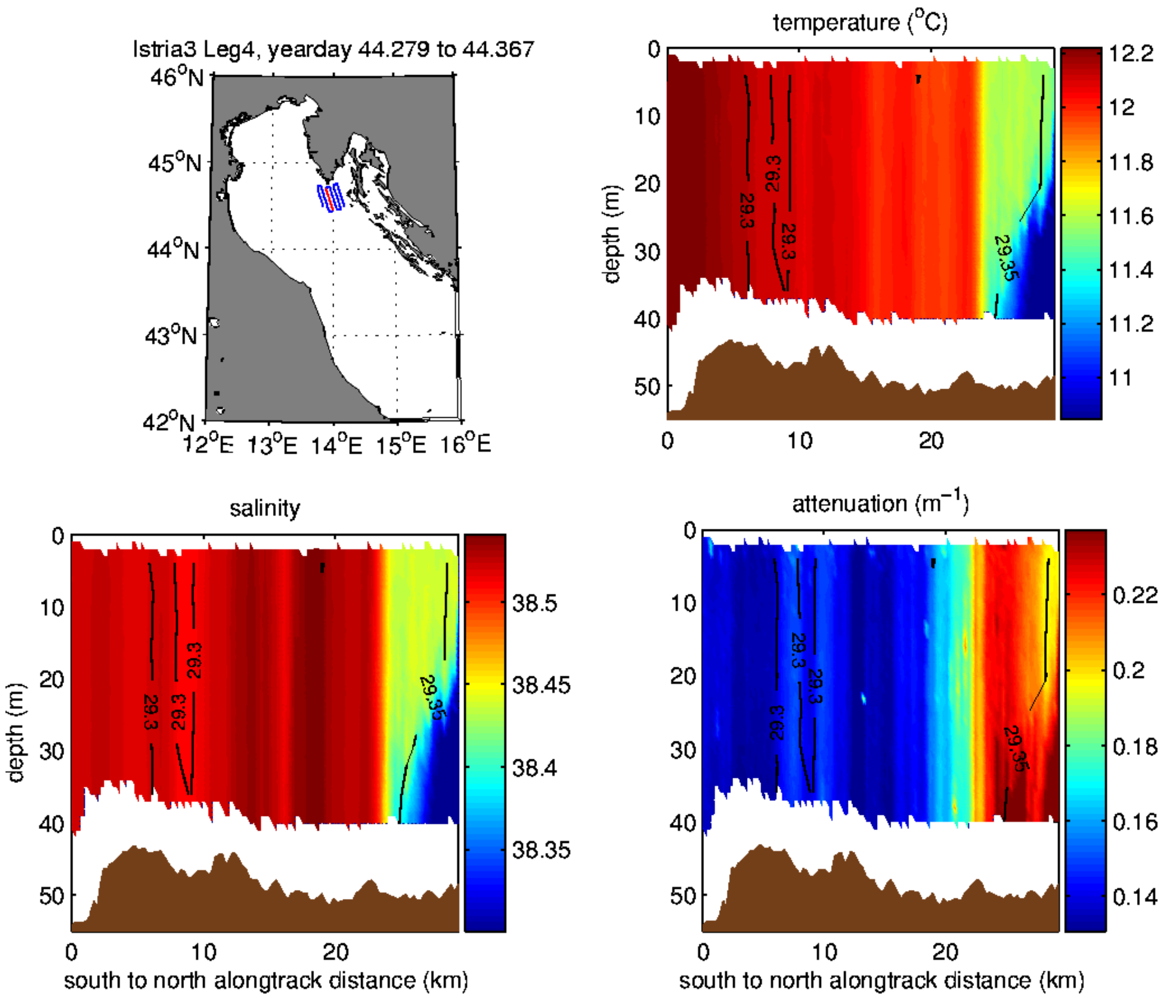


Figure 2.47: Temperature, salinity, and attenuation for Istria3 survey, Leg4 section. Overlaid contours are σ_θ.

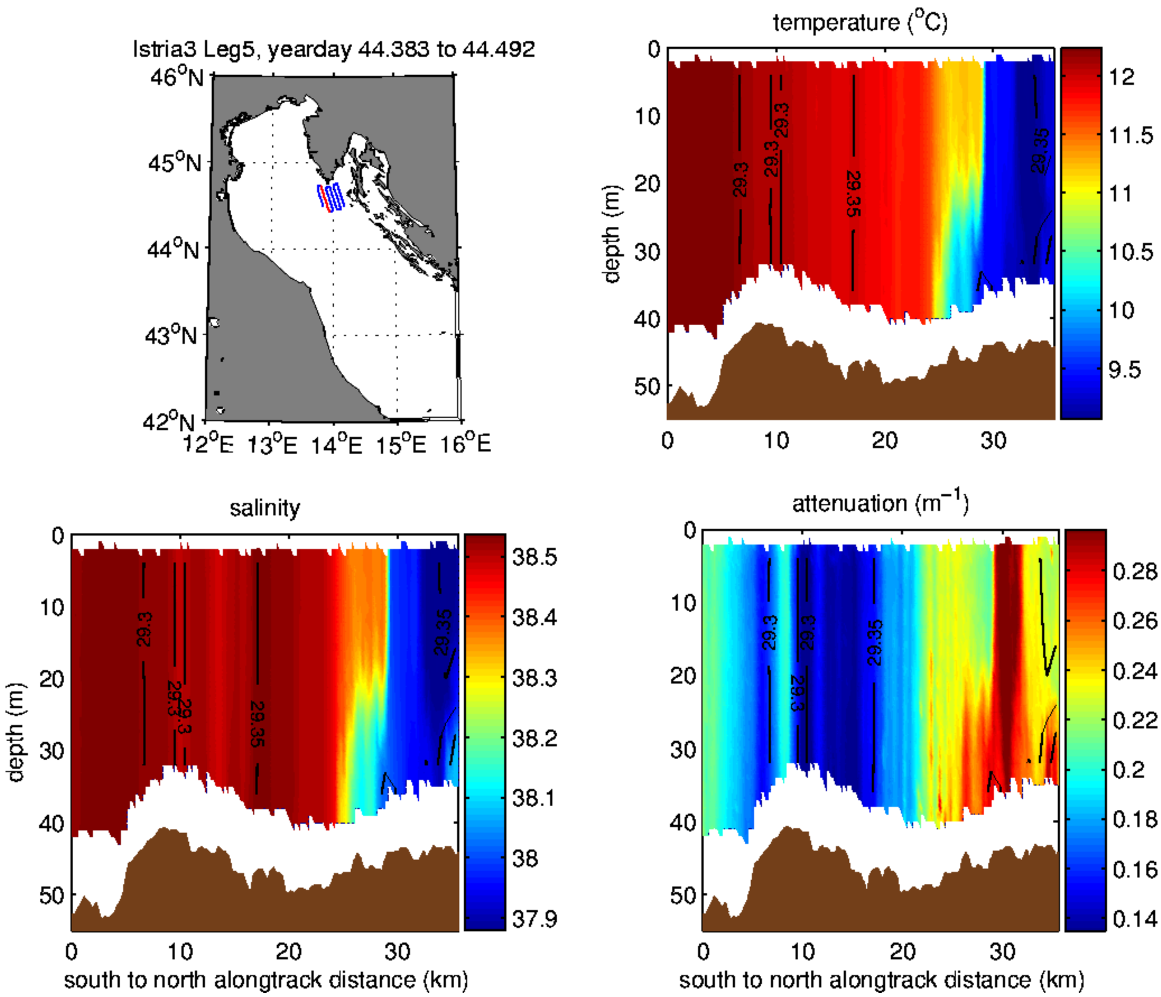


Figure 2.48: Temperature, salinity, and attenuation for Istria3 survey, Leg5 section. Overlaid contours are σ_θ.

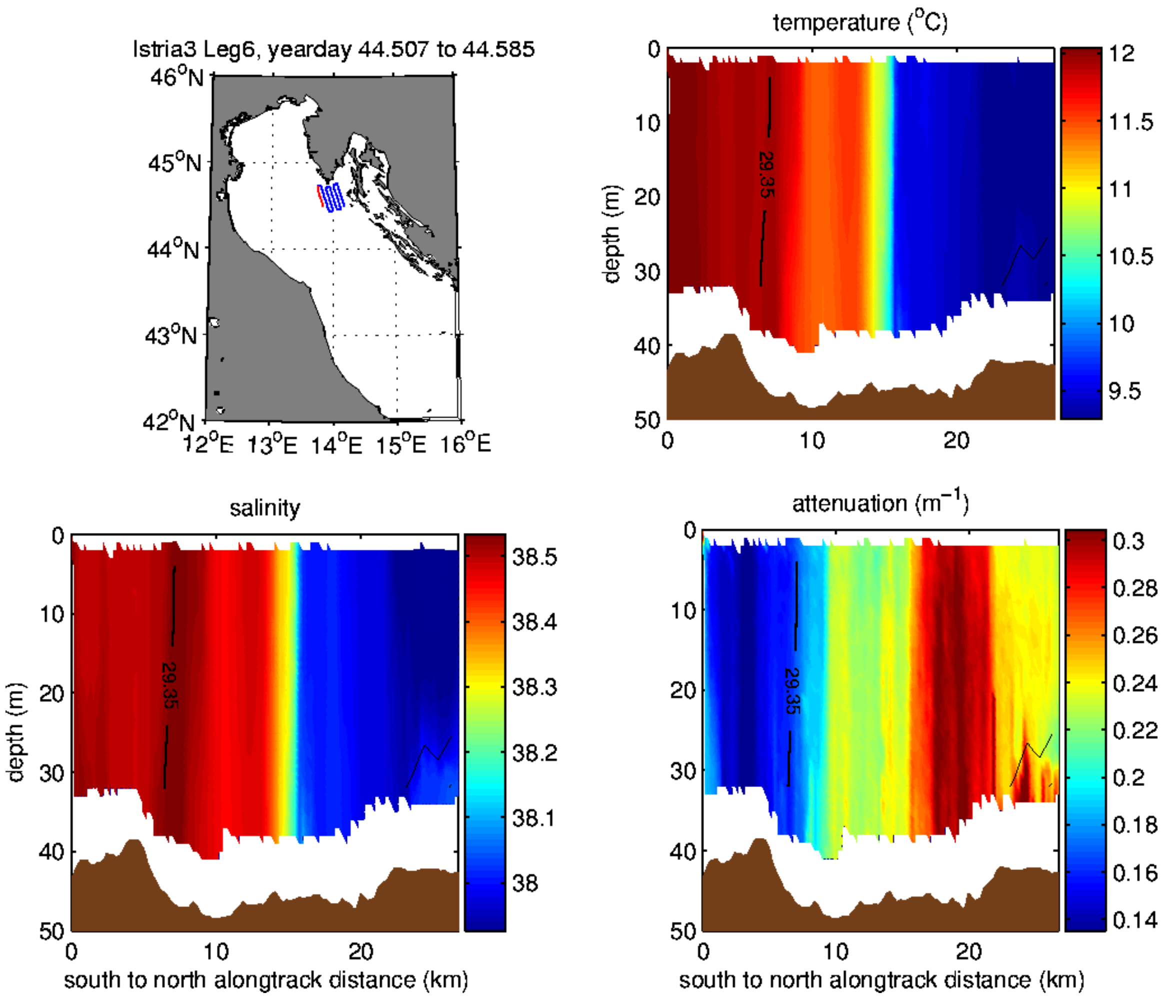


Figure 2.49: Temperature, salinity, and attenuation for Istria3 survey, Leg6 section. Overlaid contours are σ_θ.

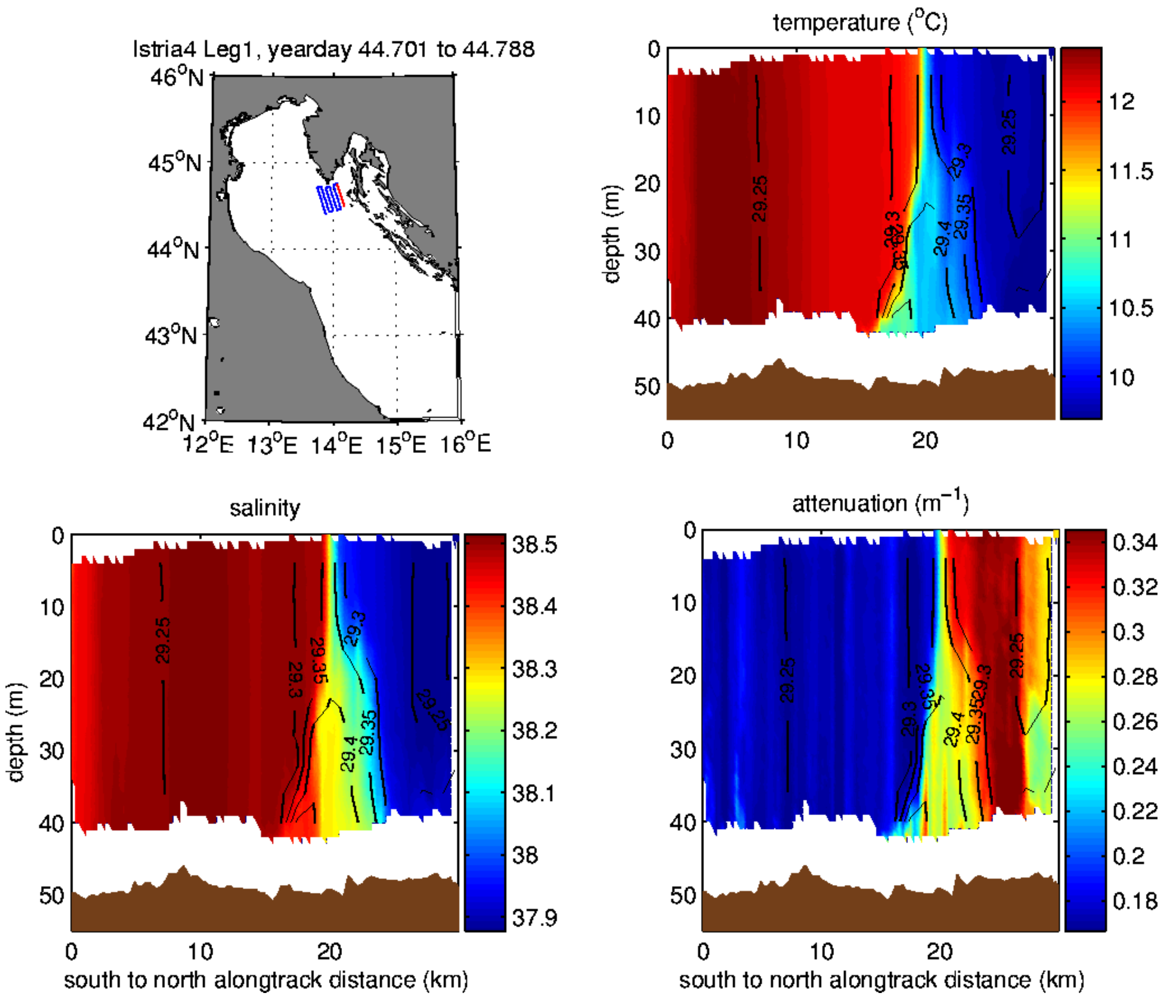


Figure 2.50: Temperature, salinity, and attenuation for Istria4 survey, Leg1 section. Overlaid contours are σ_θ.

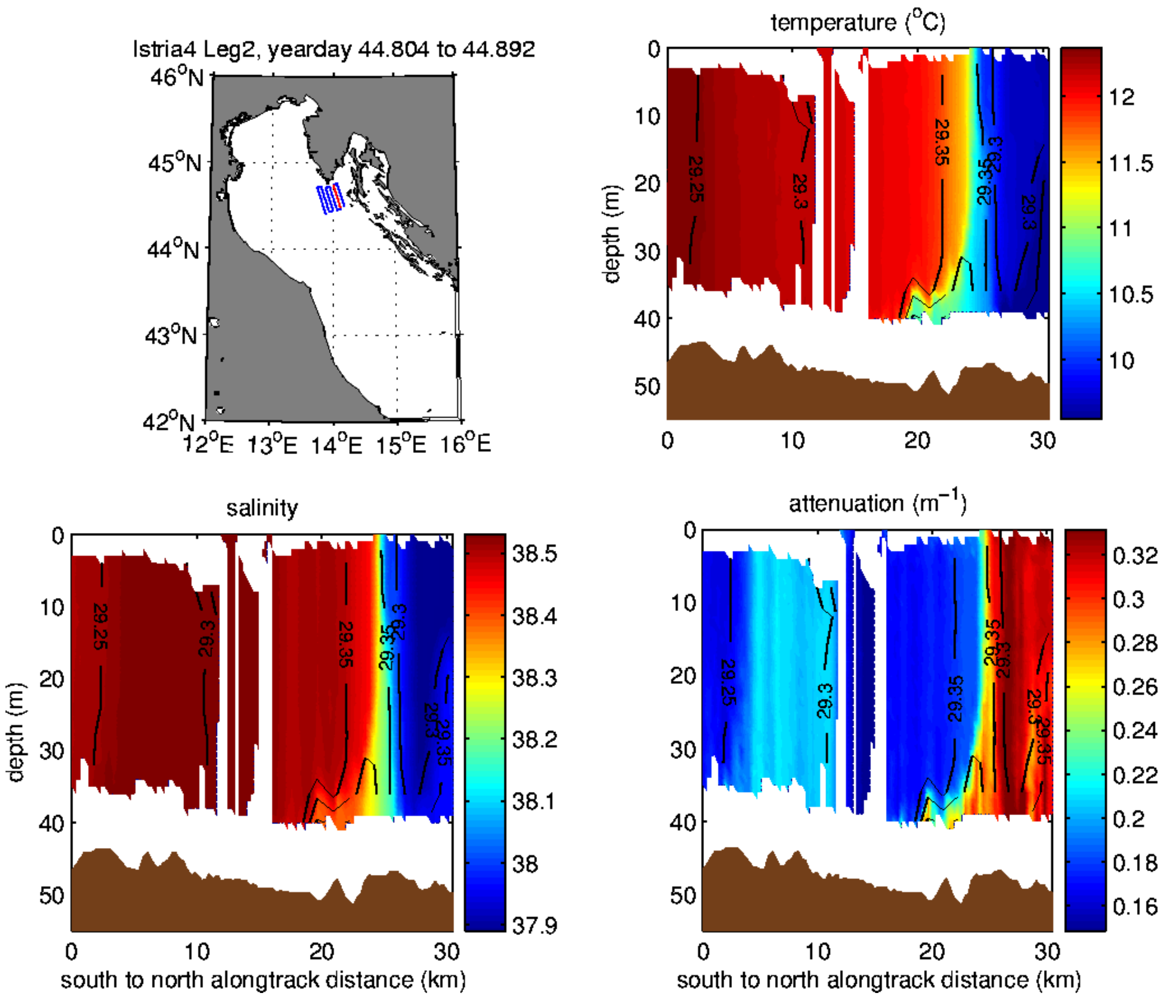


Figure 2.51: Temperature, salinity, and attenuation for Istria4 survey, Leg2 section. Overlaid contours are σ_θ.

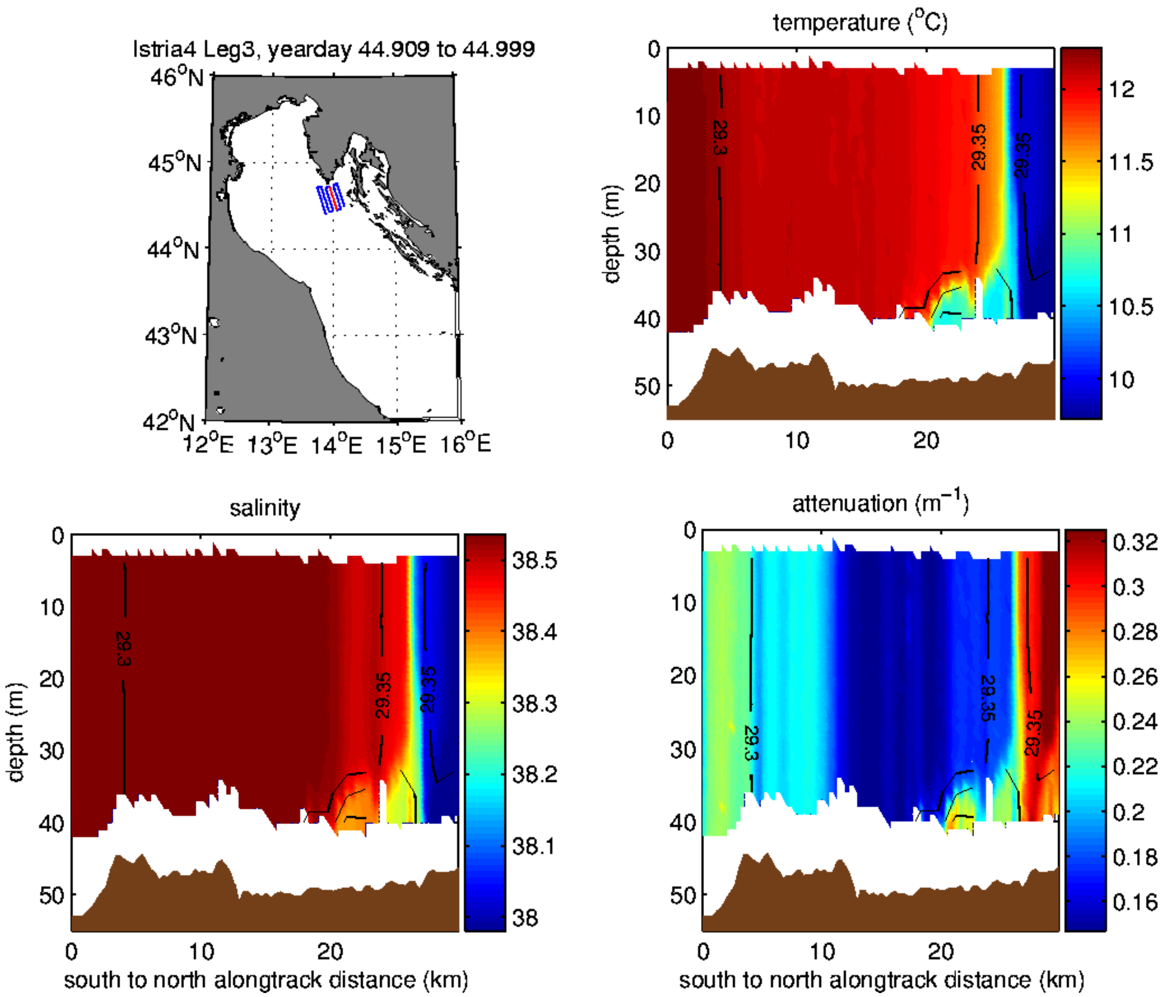


Figure 2.52: Temperature, salinity, and attenuation for Istria4 survey, Leg3 section. Overlaid contours are σ_θ.

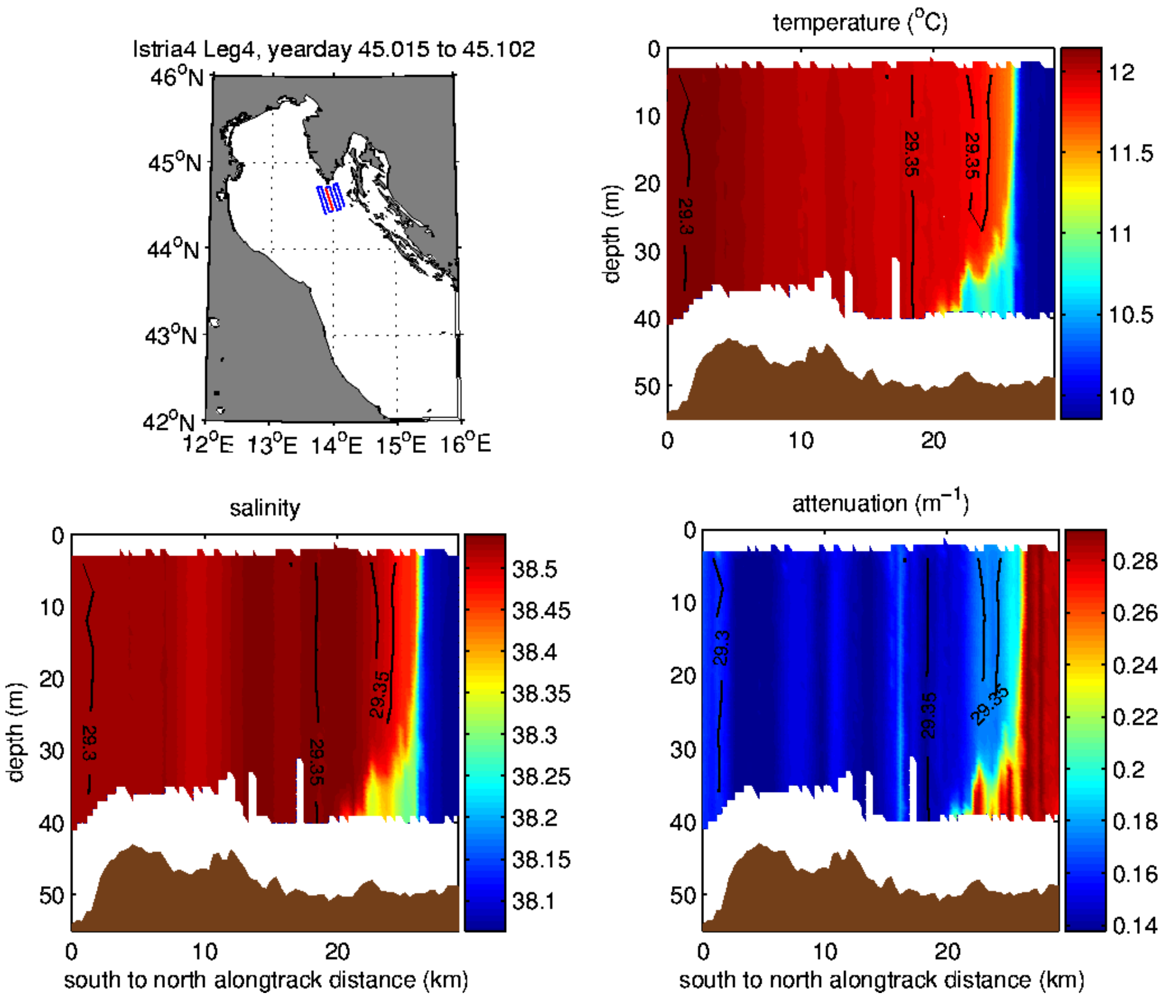


Figure 2.53: Temperature, salinity, and attenuation for Istria4 survey, Leg4 section. Overlaid contours are σ_θ.

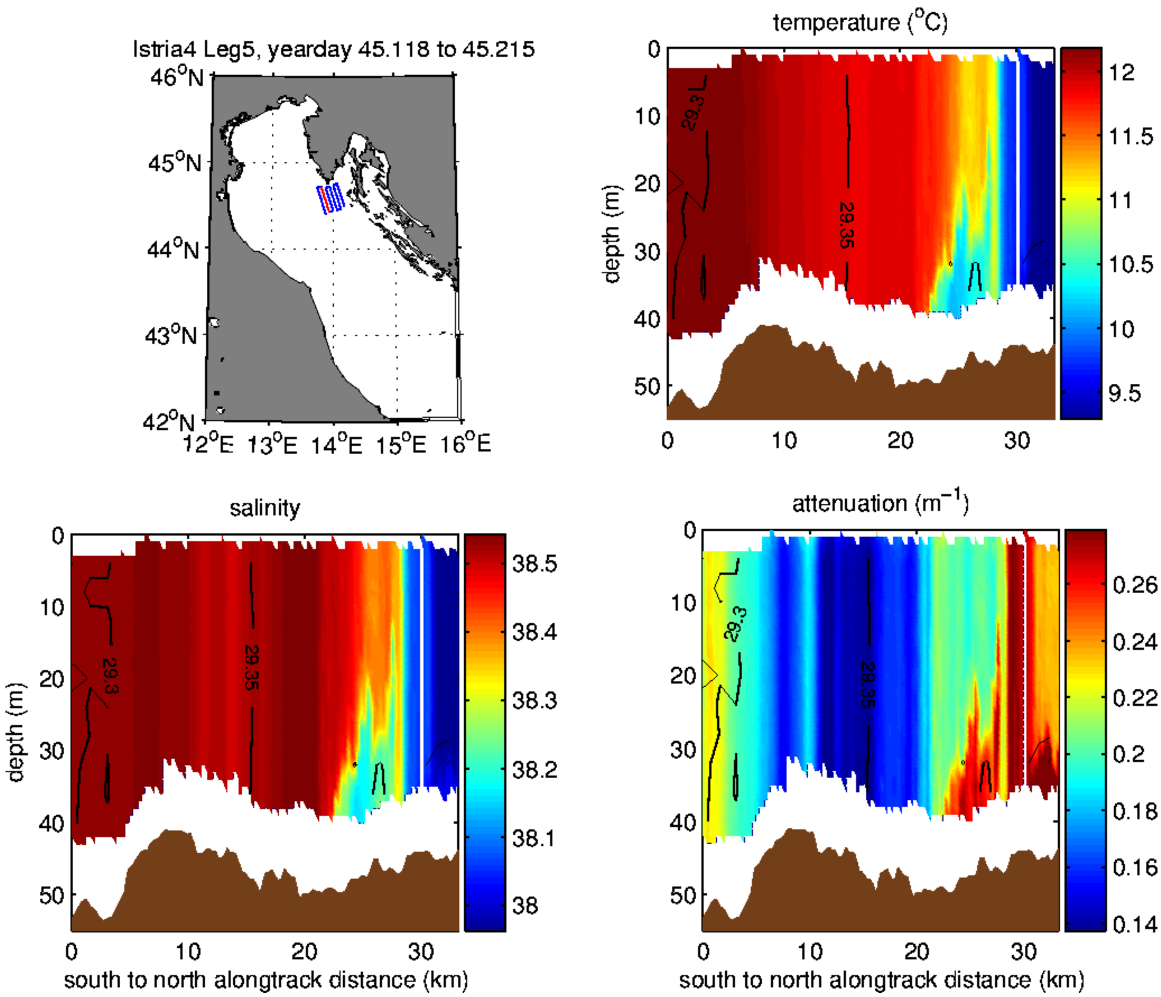


Figure 2.54: Temperature, salinity, and attenuation for Istria4 survey, Leg5 section. Overlaid contours are σ_θ.

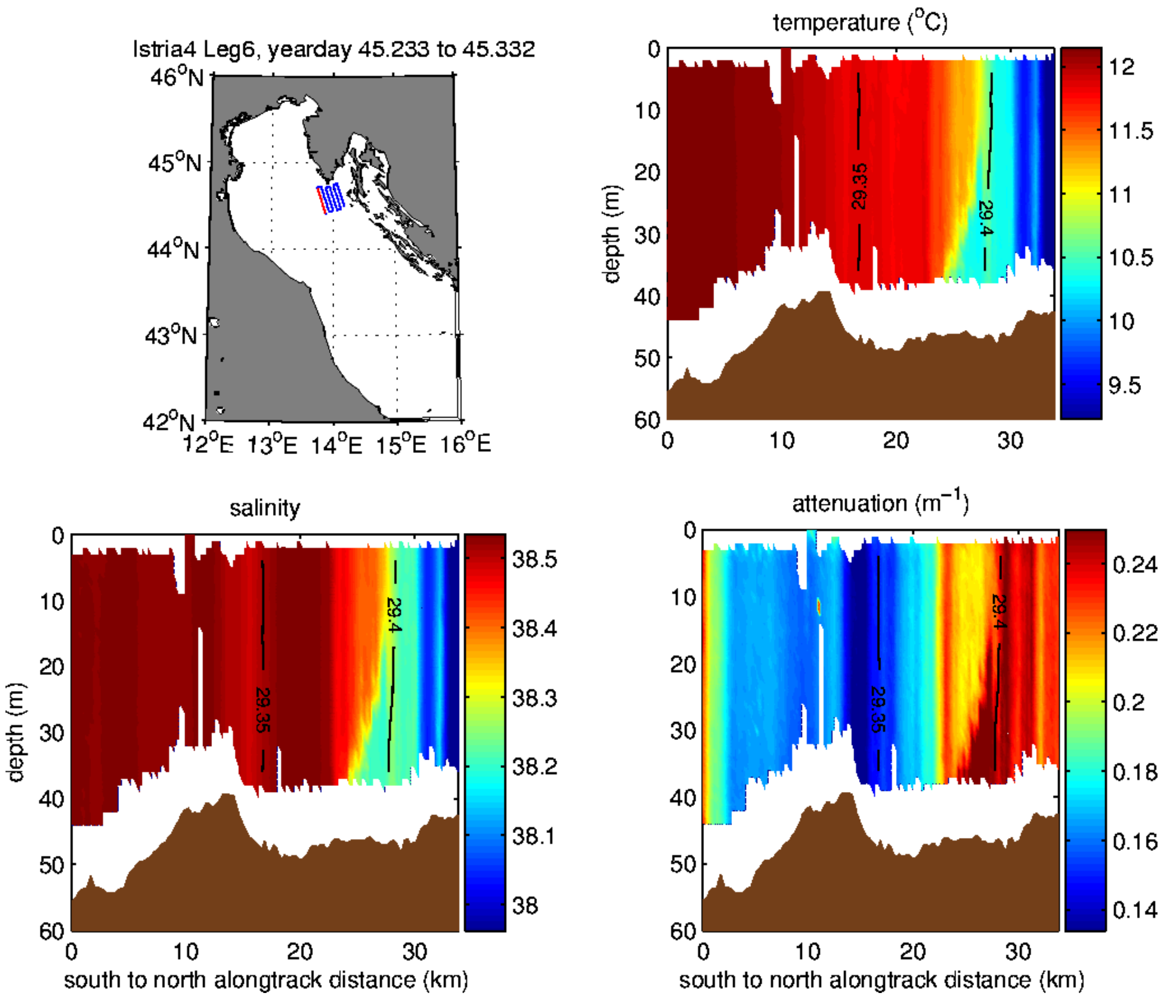


Figure 2.55: Temperature, salinity, and attenuation for Istria4 survey, Leg6 section. Overlaid contours are σ_θ.

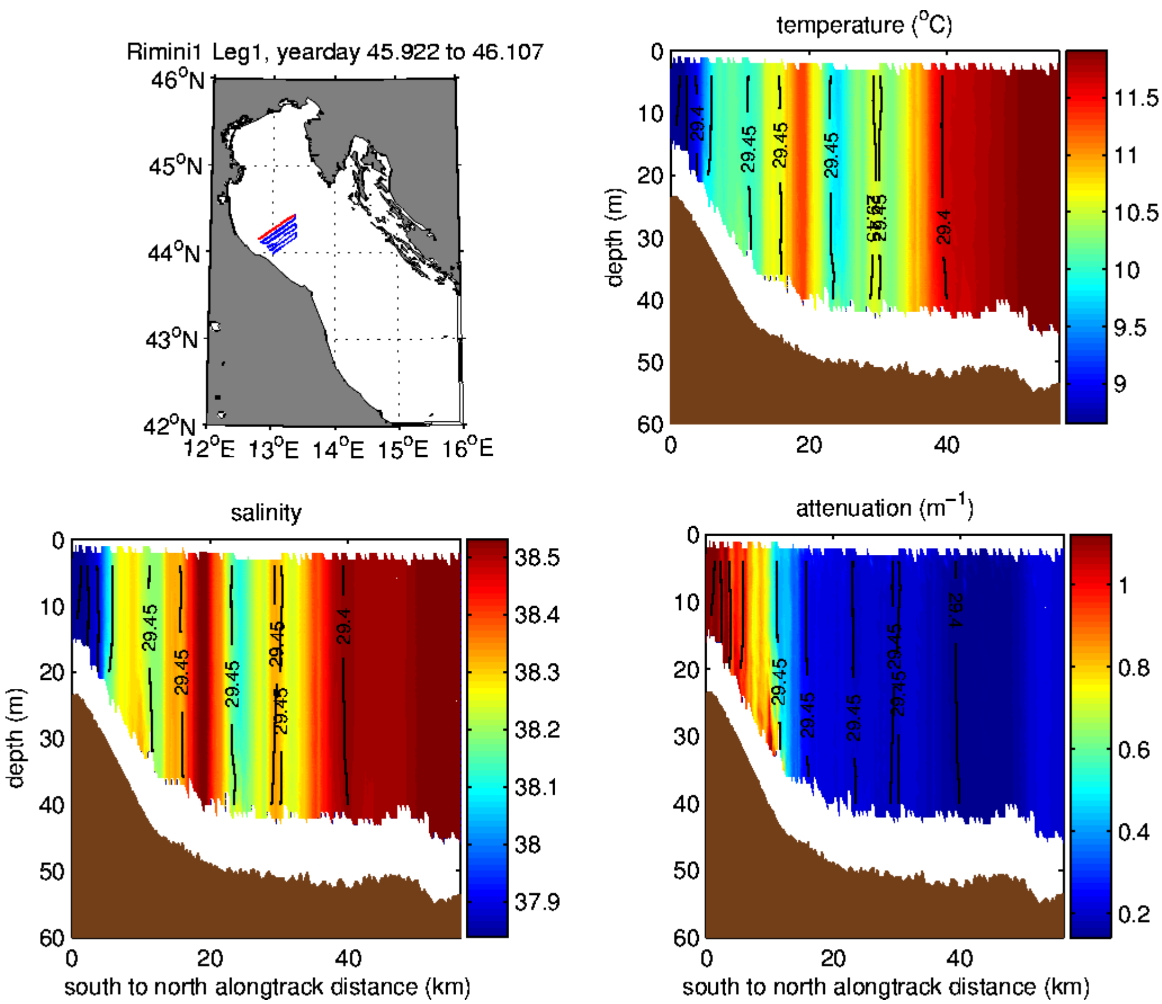


Figure 2.56: Temperature, salinity, and attenuation for Rimini1 survey, Leg1 section. Overlaid contours are σ_θ.

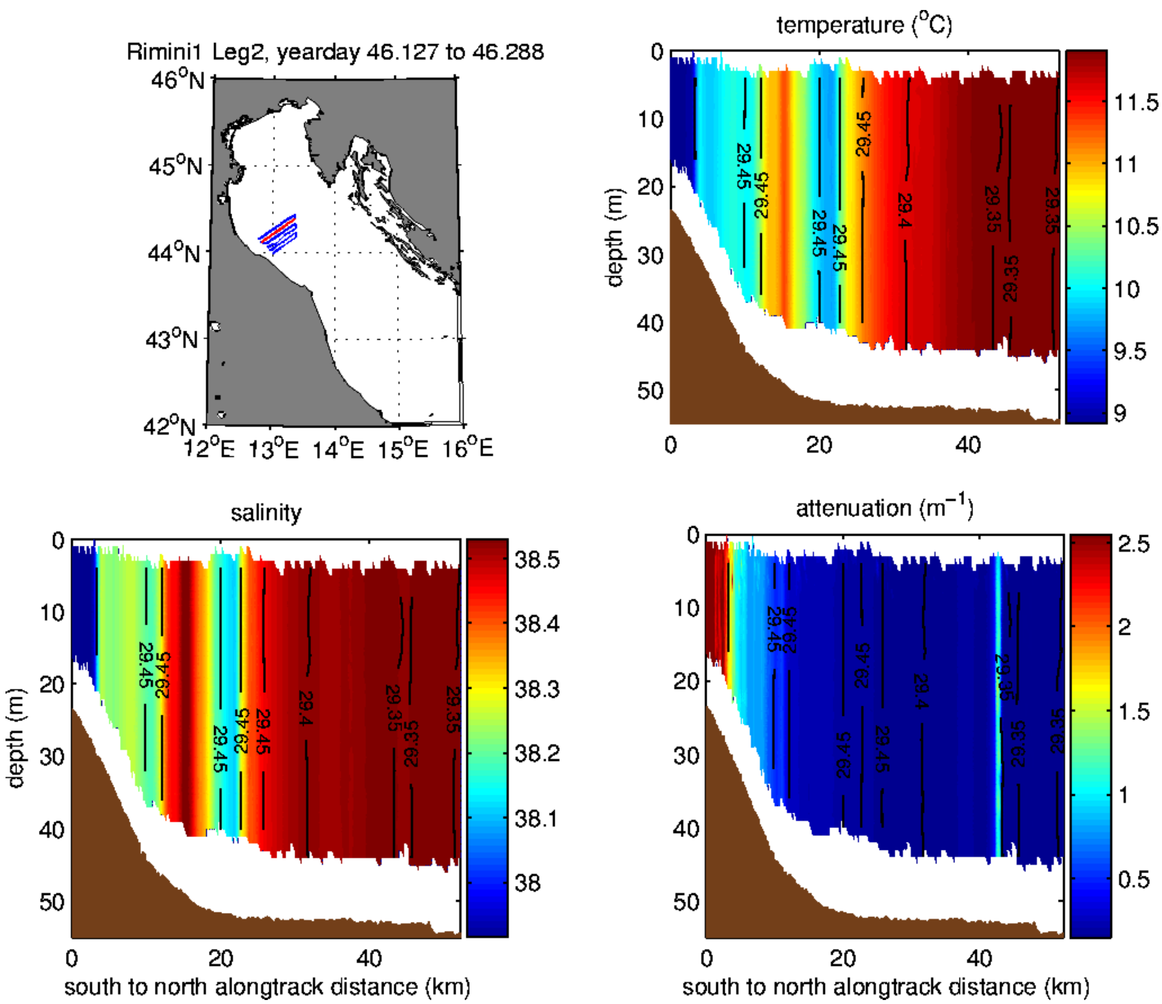


Figure 2.57: Temperature, salinity, and attenuation for Rimini1 survey, Leg2 section. Overlaid contours are σ_θ.

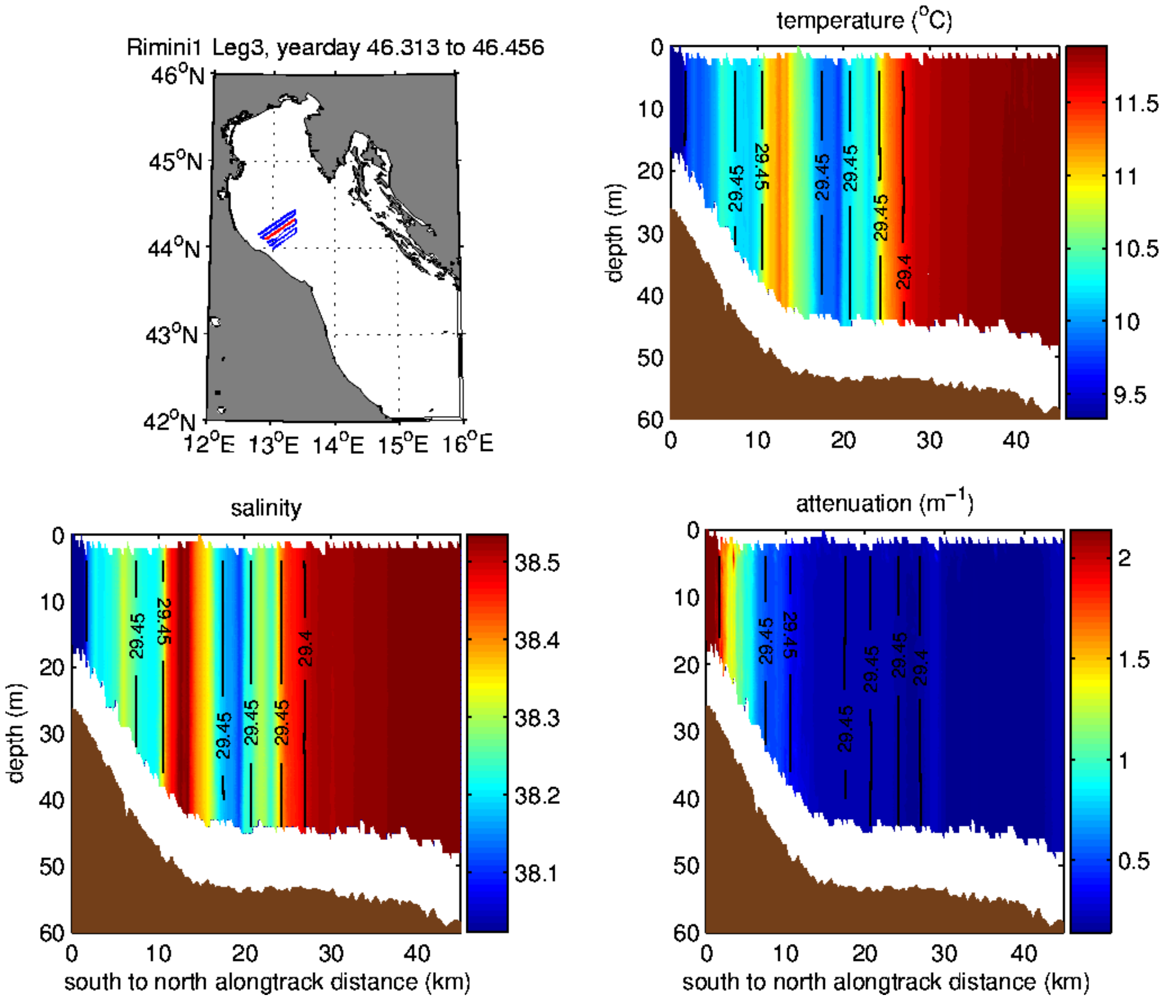


Figure 2.58: Temperature, salinity, and attenuation for Rimini1 survey, Leg3 section. Overlaid contours are σ_θ.

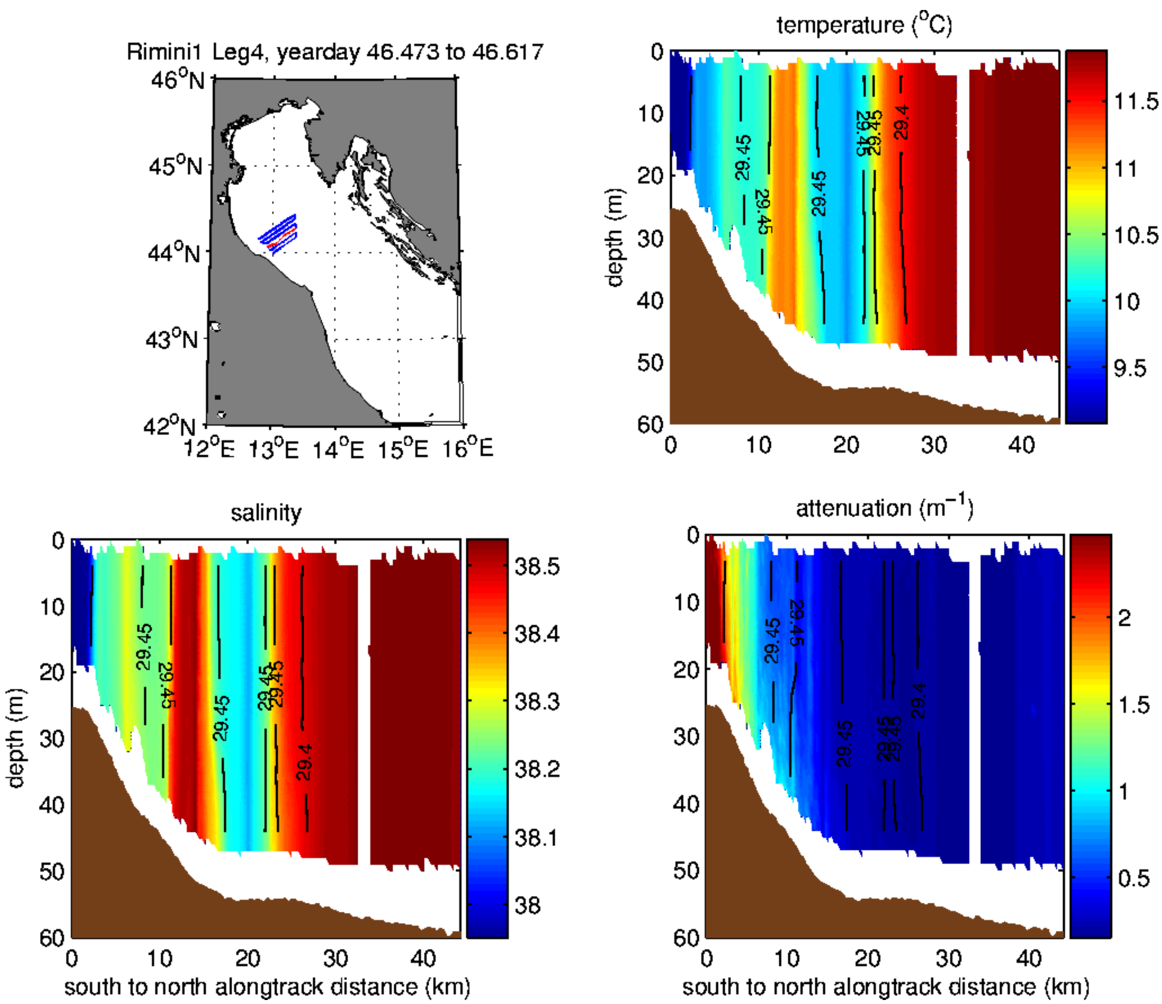


Figure 2.59: Temperature, salinity, and attenuation for Rimini1 survey, Leg4 section. Overlaid contours are σ_θ.

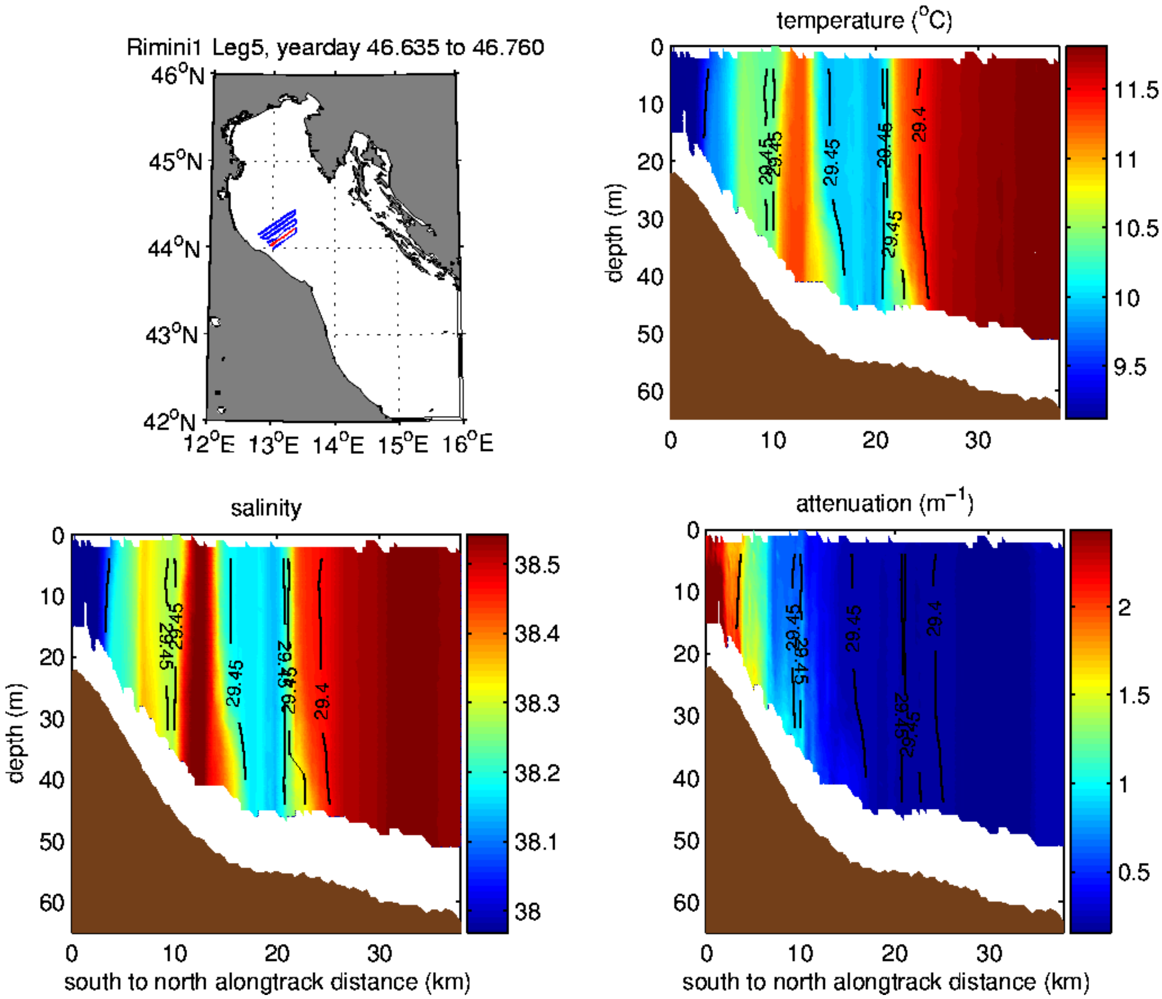


Figure 2.60: Temperature, salinity, and attenuation for Rimini1 survey, Leg5 section. Overlaid contours are σ_θ.

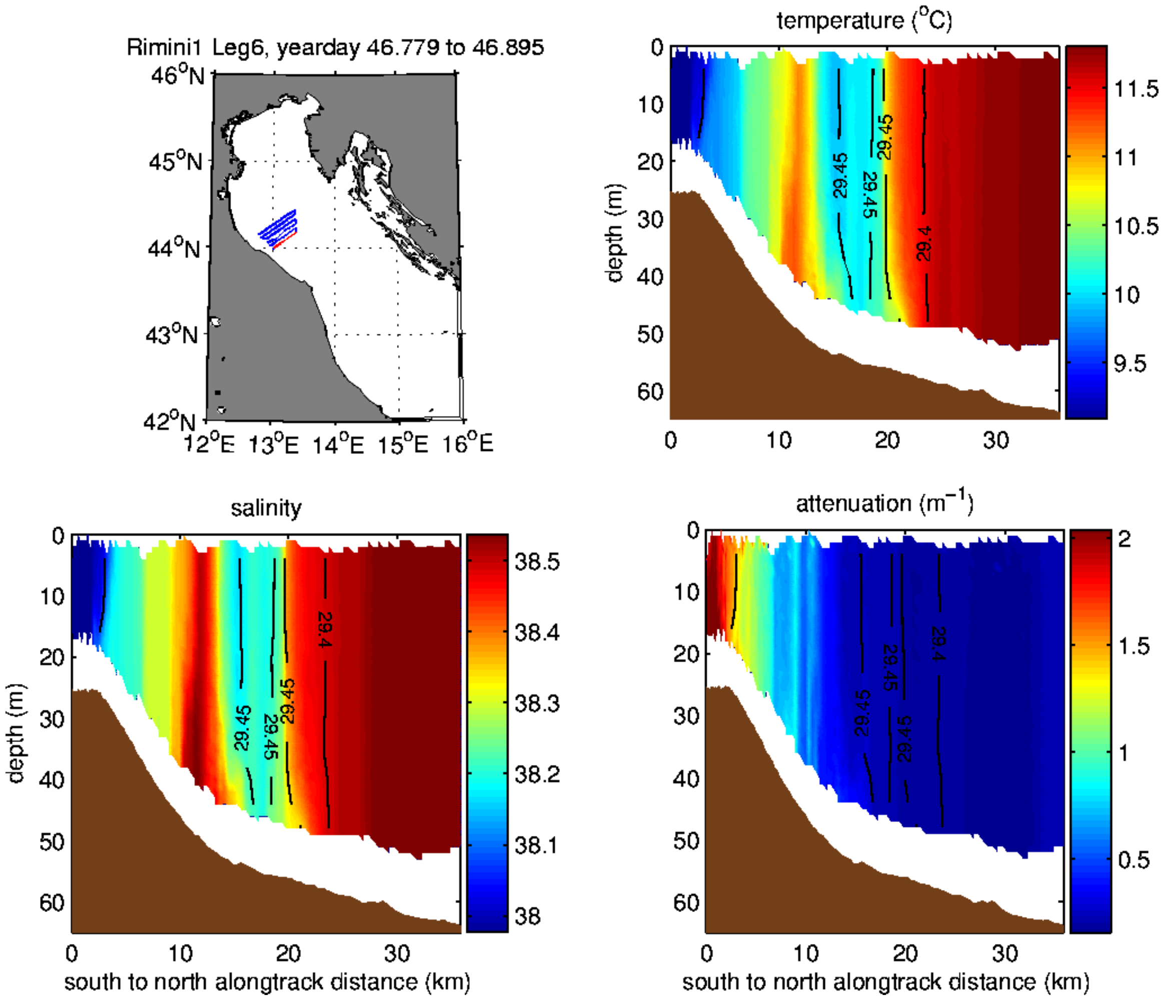


Figure 2.61: Temperature, salinity, and attenuation for Rimini1 survey, Leg6 section. Overlaid contours are σ_θ.

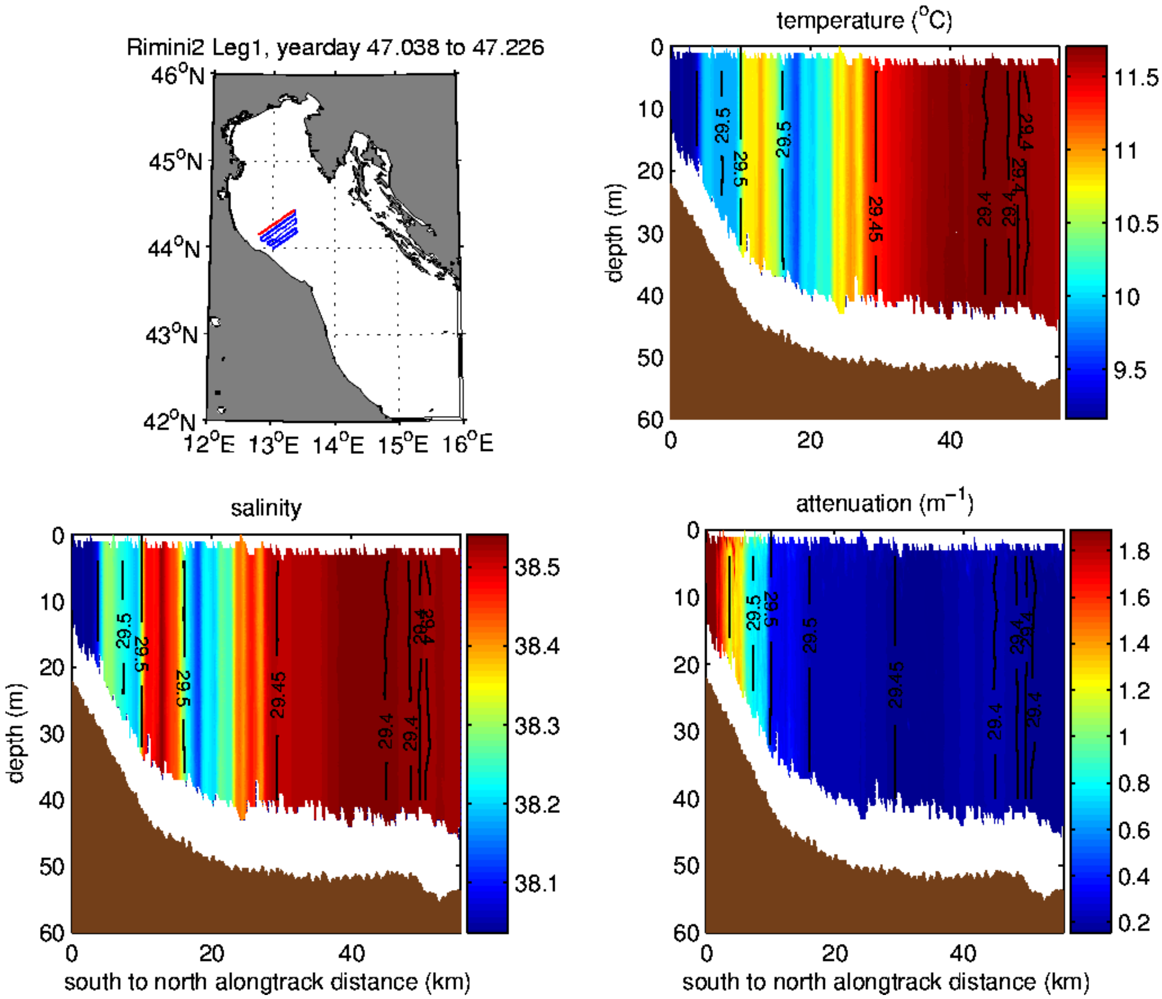


Figure 2.62: Temperature, salinity, and attenuation for Rimini2 survey, Leg1 section. Overlaid contours are σ_θ.

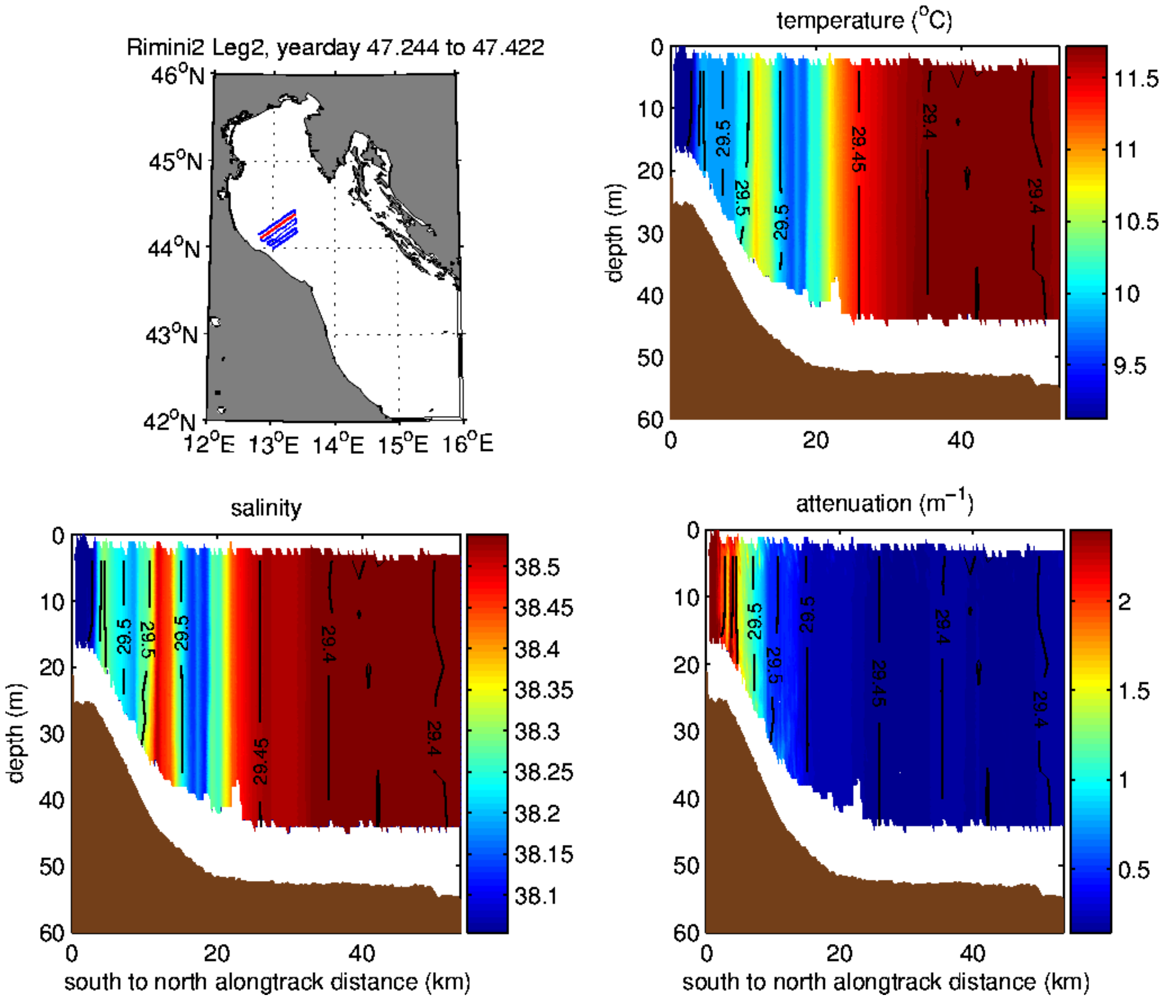


Figure 2.63: Temperature, salinity, and attenuation for Rimini2 survey, Leg2 section. Overlaid contours are σ_θ.

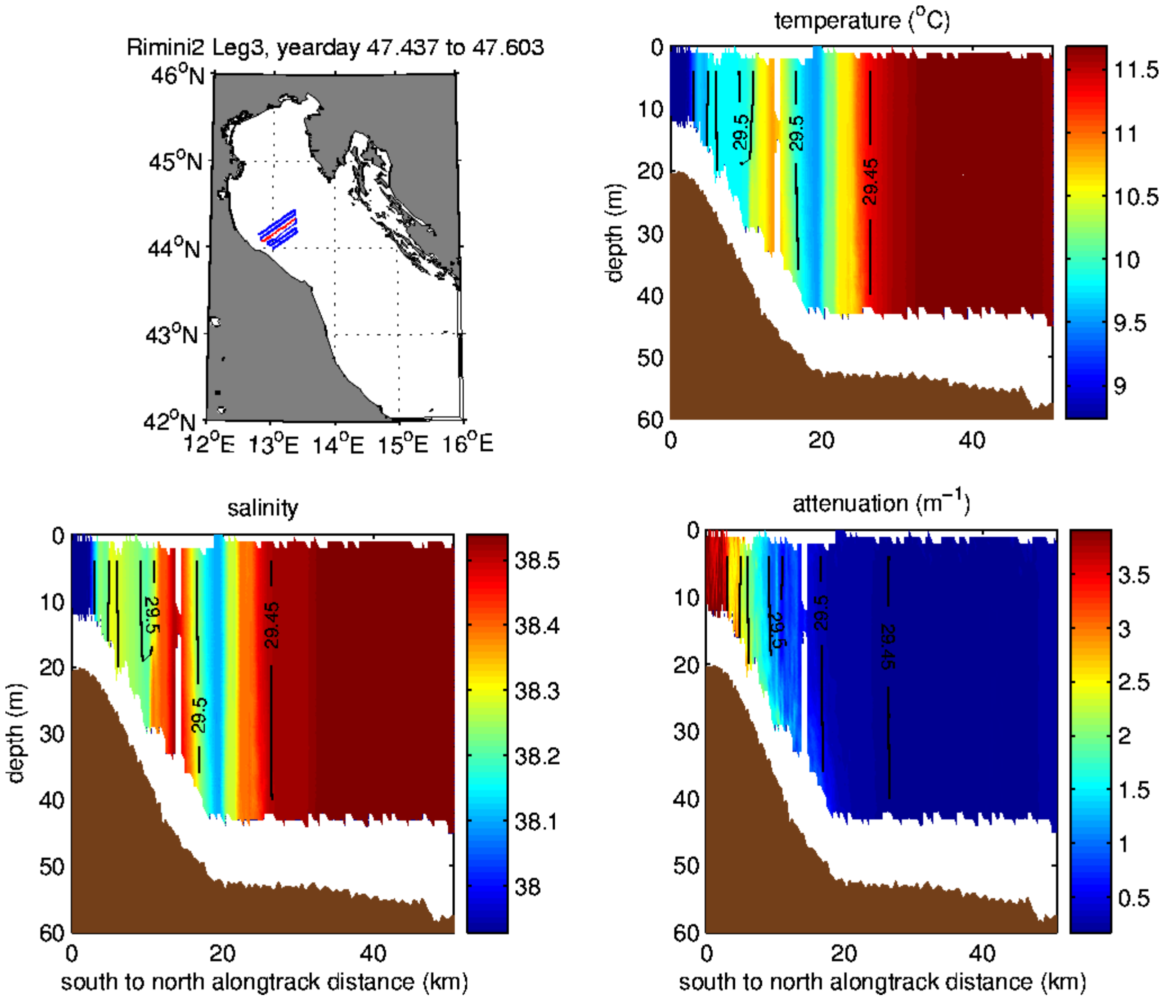


Figure 2.64: Temperature, salinity, and attenuation for Rimini2 survey, Leg3 section. Overlaid contours are σ_θ.

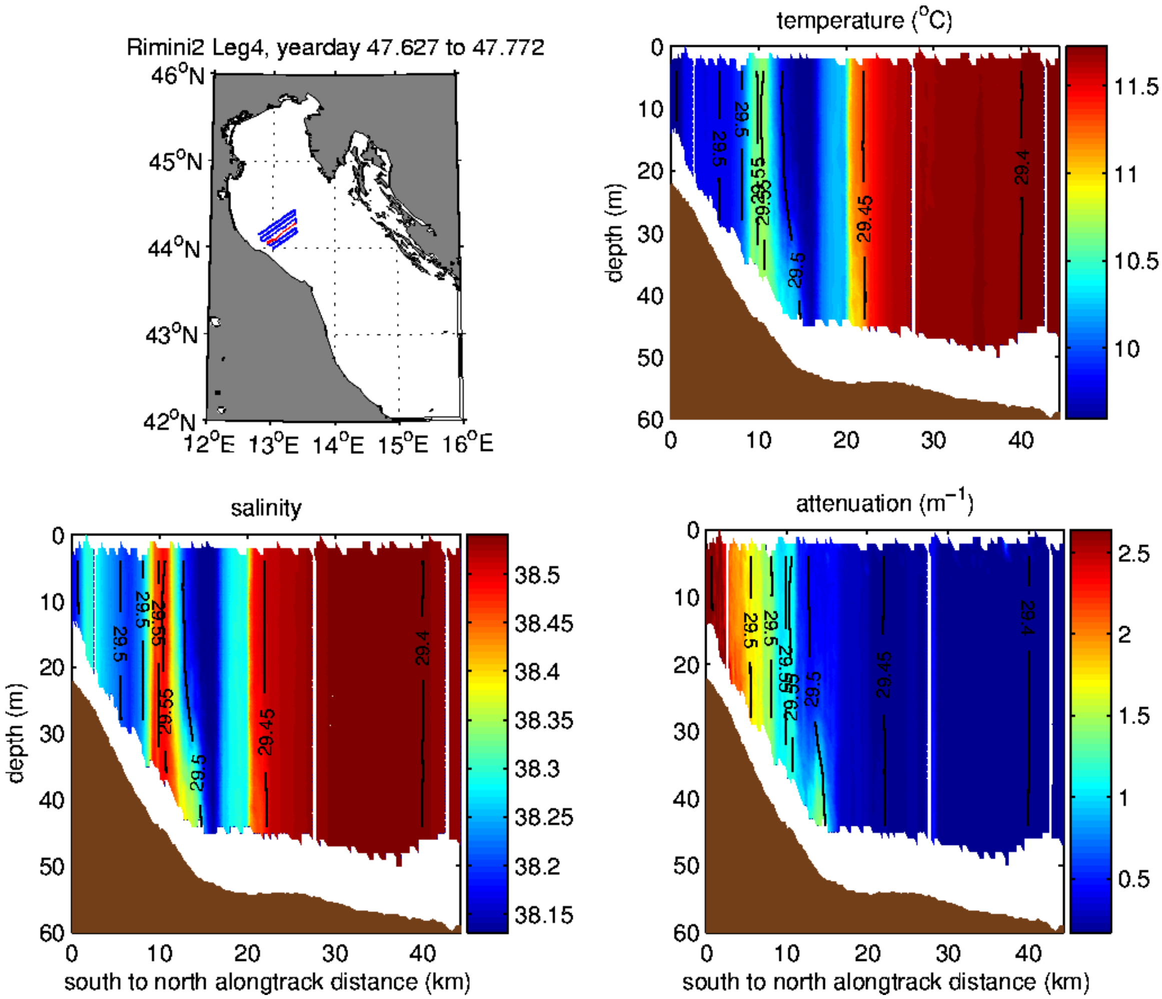


Figure 2.65: Temperature, salinity, and attenuation for Rimini2 survey, Leg4 section. Overlaid contours are σ_θ.

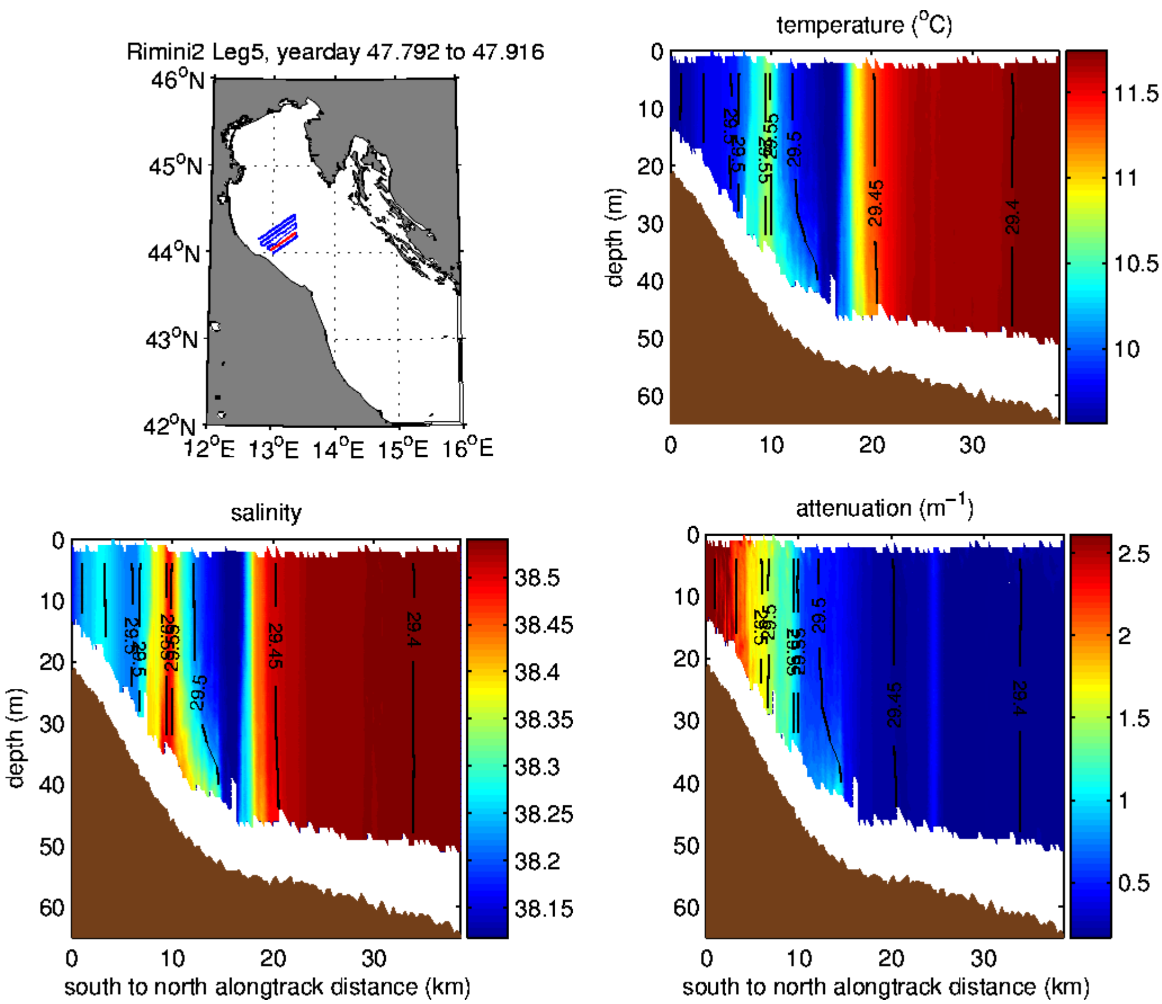


Figure 2.66: Temperature, salinity, and attenuation for Rimini2 survey, Leg5 section. Overlaid contours are σ_θ.

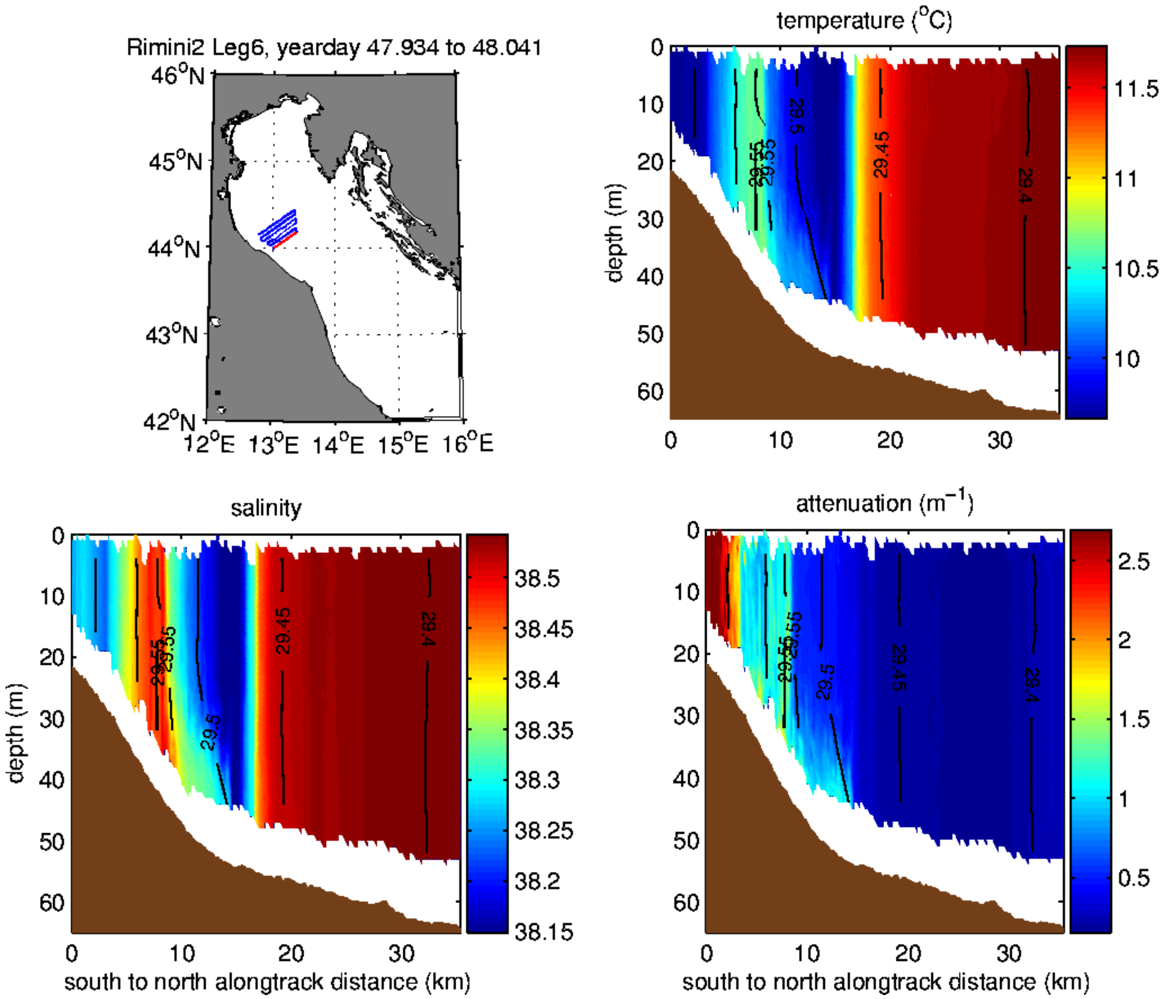


Figure 2.67: Temperature, salinity, and attenuation for Rimini2 survey, Leg6 section. Overlaid contours are σ_θ.

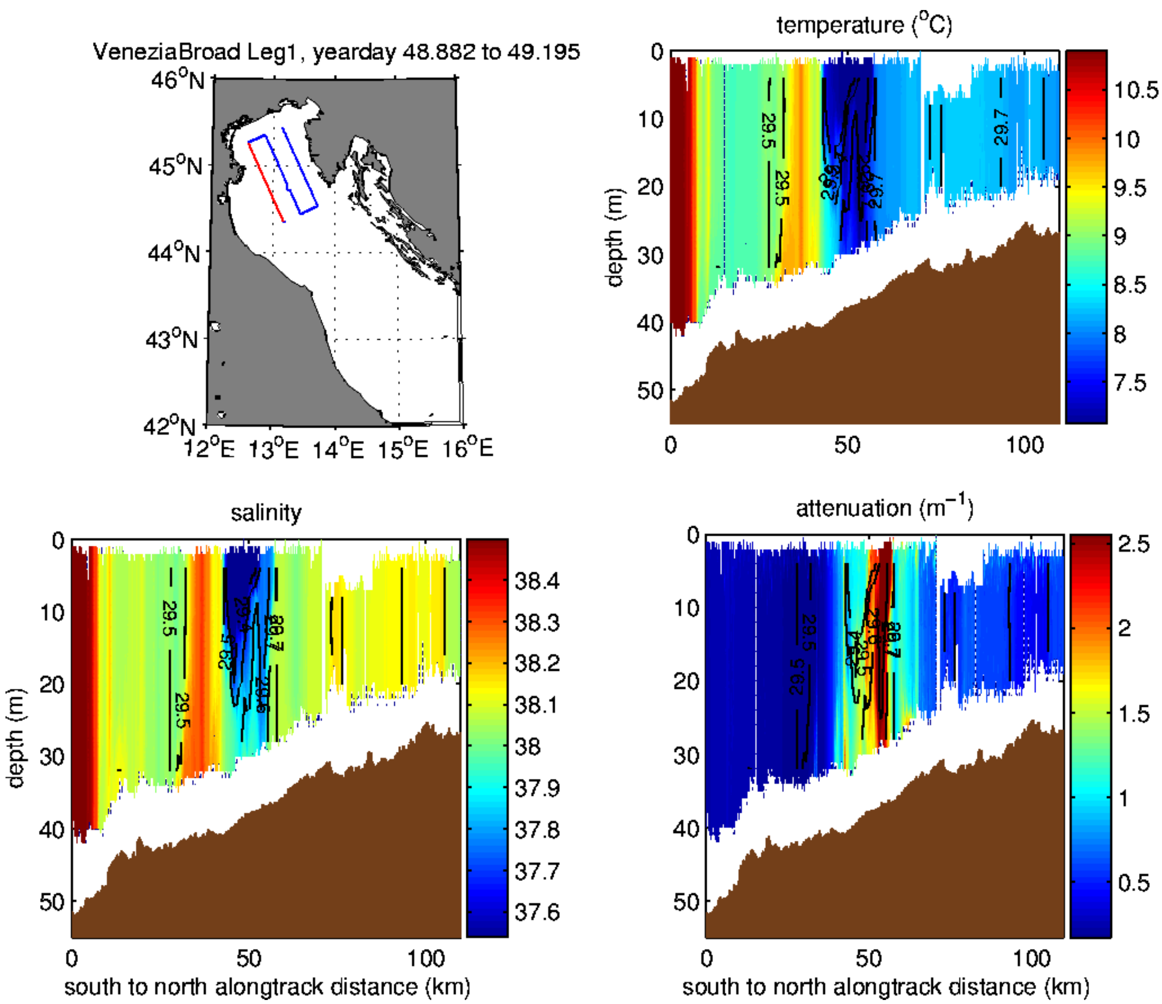


Figure 2.68: Temperature, salinity, and attenuation for VeneziaBroad survey, Leg1 section. Overlaid contours are σ_θ.

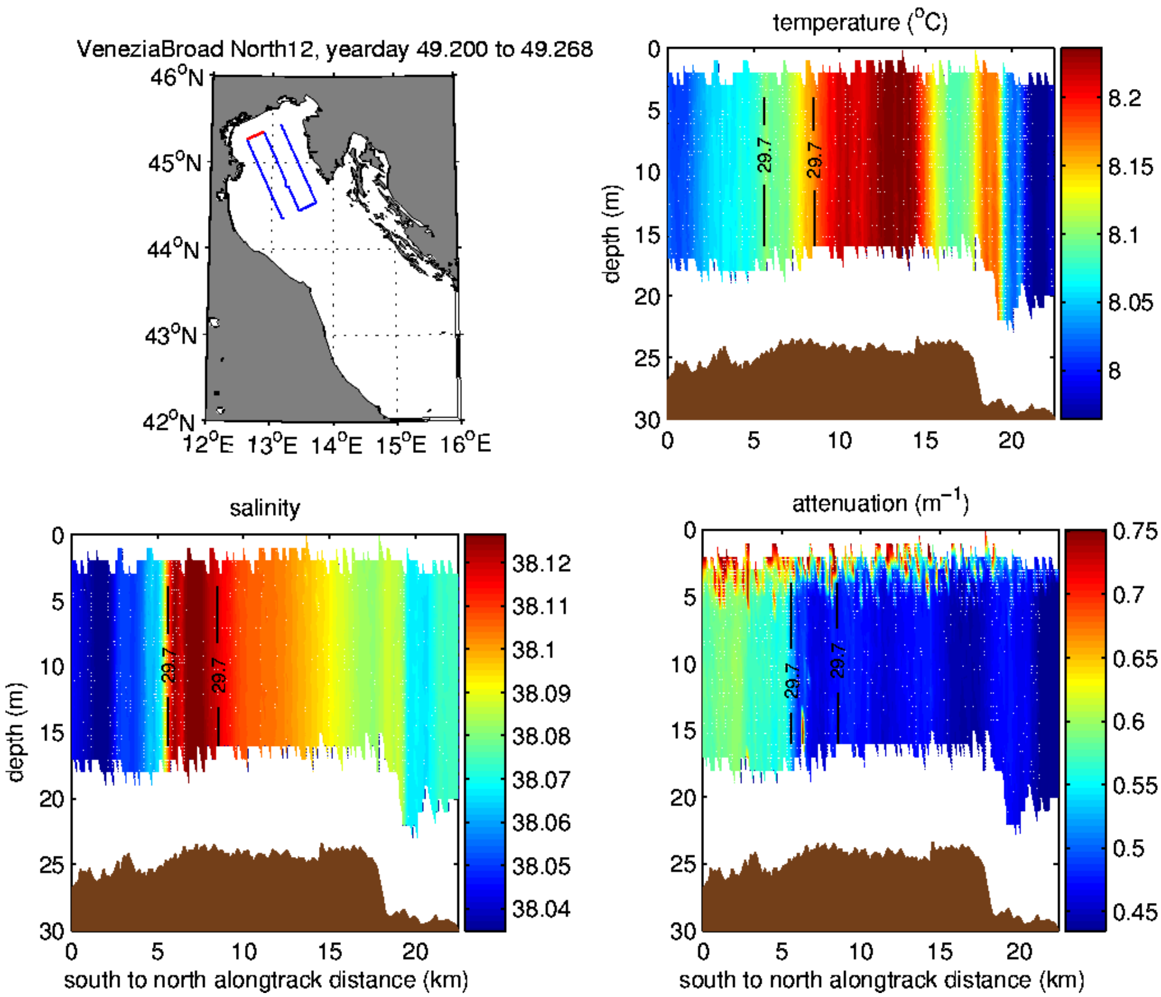


Figure 2.69: Temperature, salinity, and attenuation for VeneziaBroad survey, North12 section. Overlaid contours are σ_θ.

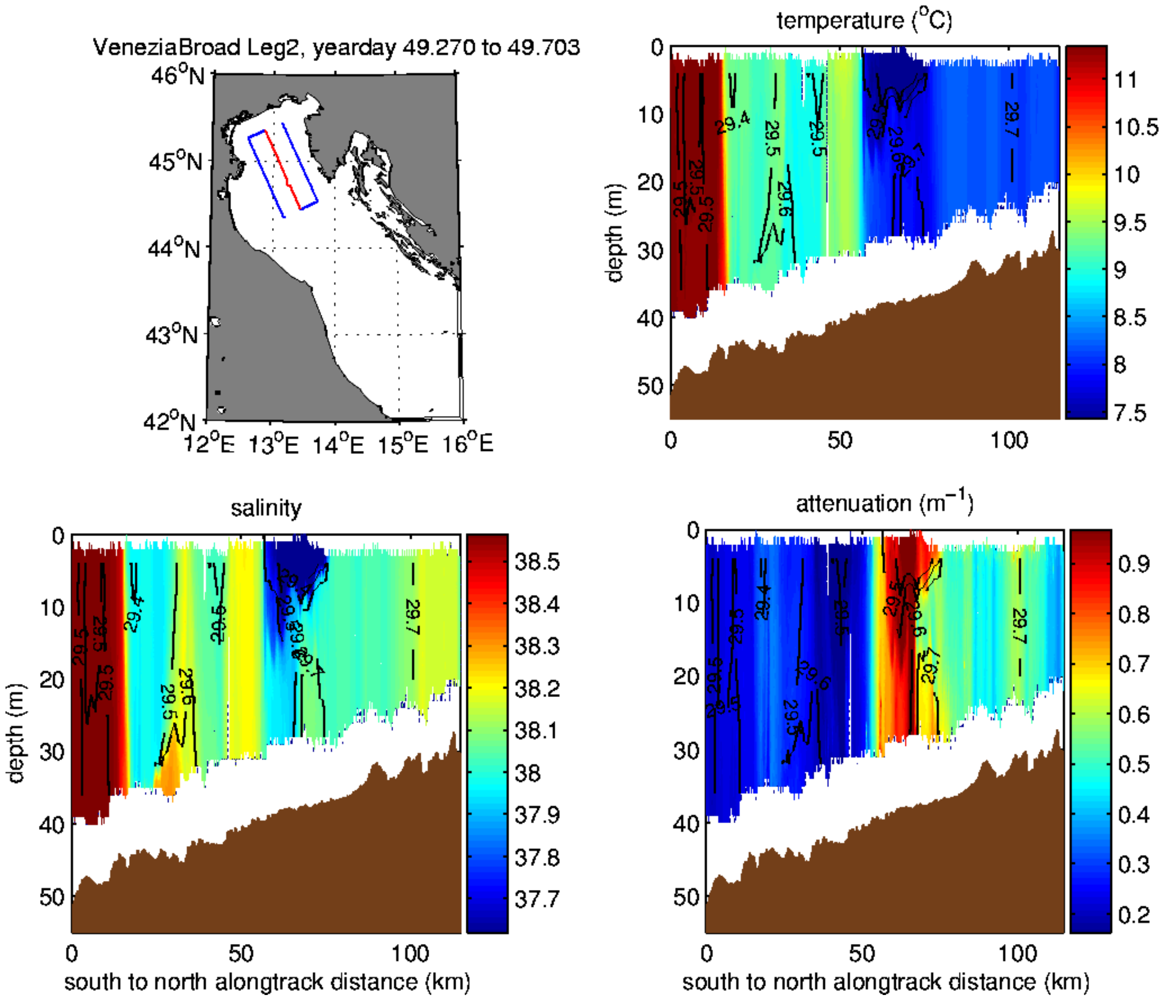


Figure 2.70: Temperature, salinity, and attenuation for VeneziaBroad survey, Leg2 section. Overlaid contours are σ_θ.

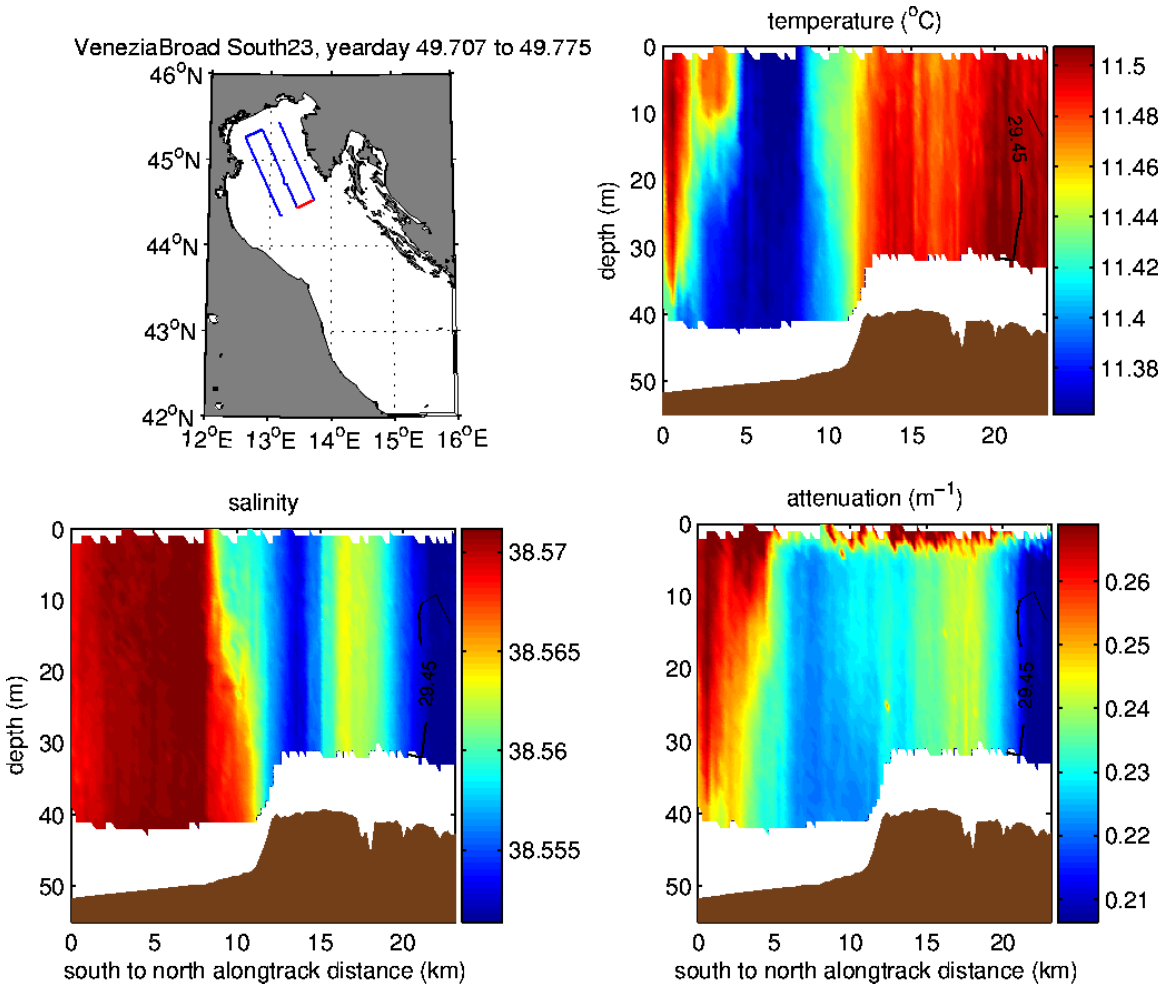


Figure 2.71: Temperature, salinity, and attenuation for VeneziaBroad survey, South23 section. Overlaid contours are σ_θ.

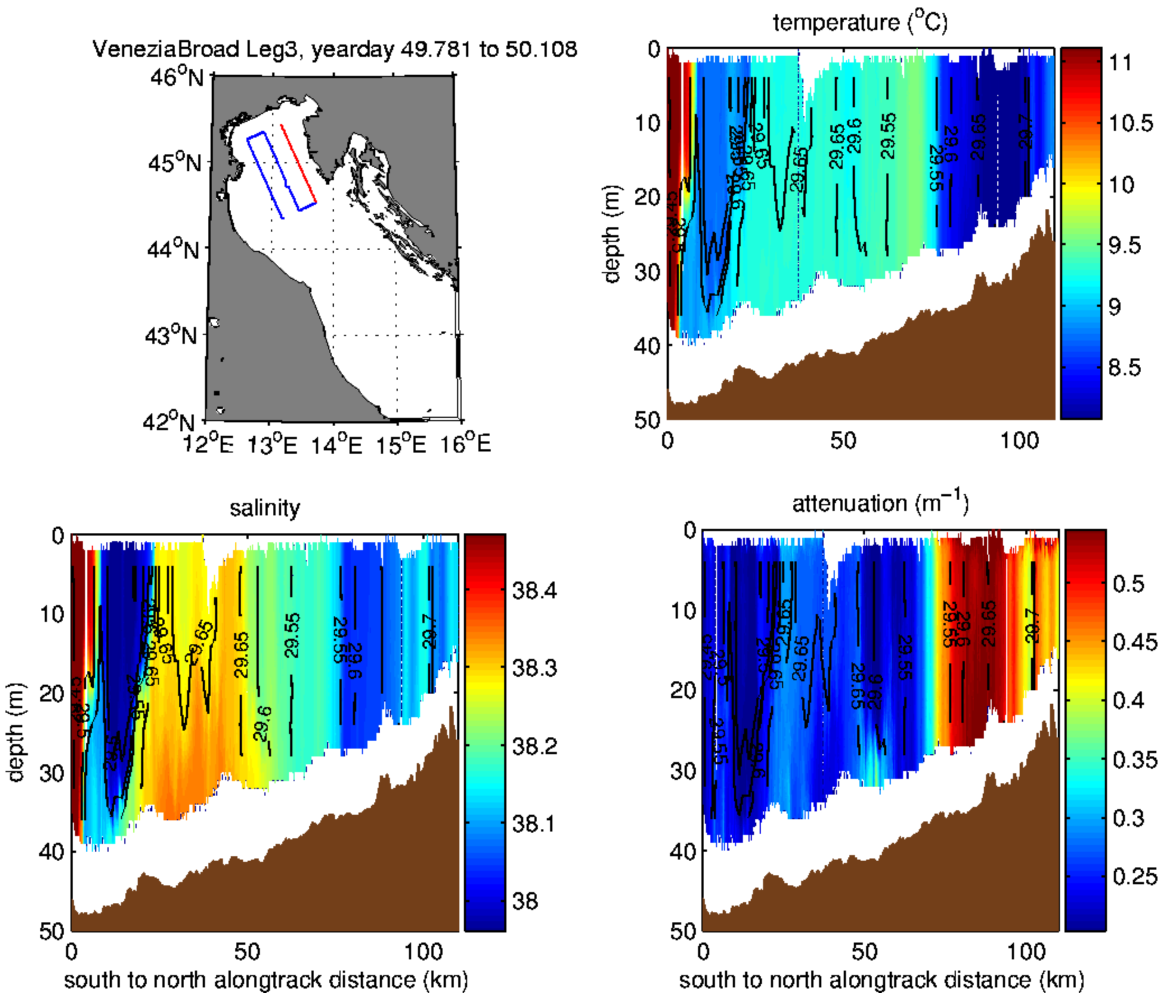


Figure 2.72: Temperature, salinity, and attenuation for VeneziaBroad survey, Leg3 section. Overlaid contours are σ_θ.

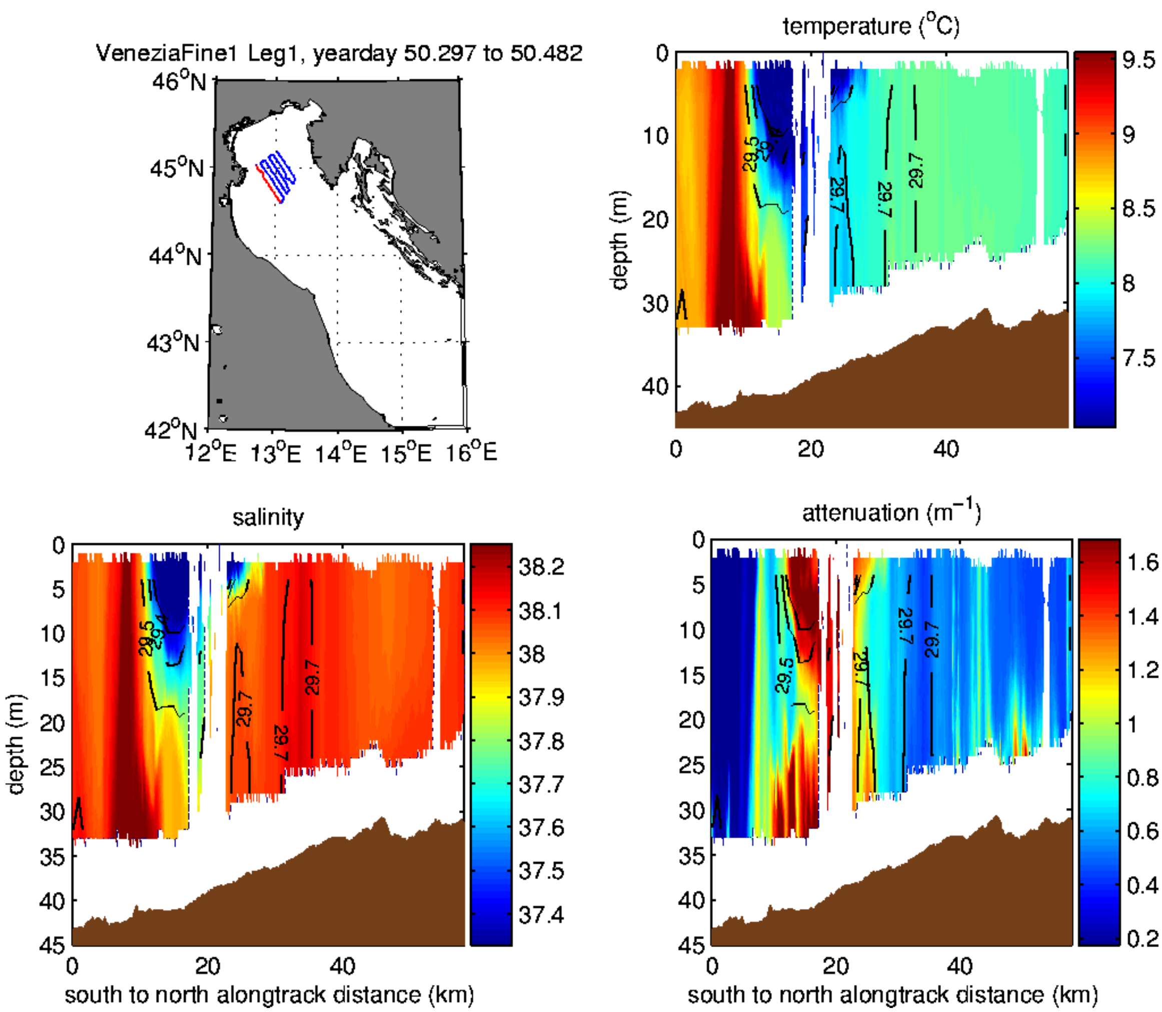


Figure 2.73: Temperature, salinity, and attenuation for VeneziaFine1 survey, Leg1 section. Overlaid contours are σ_θ.

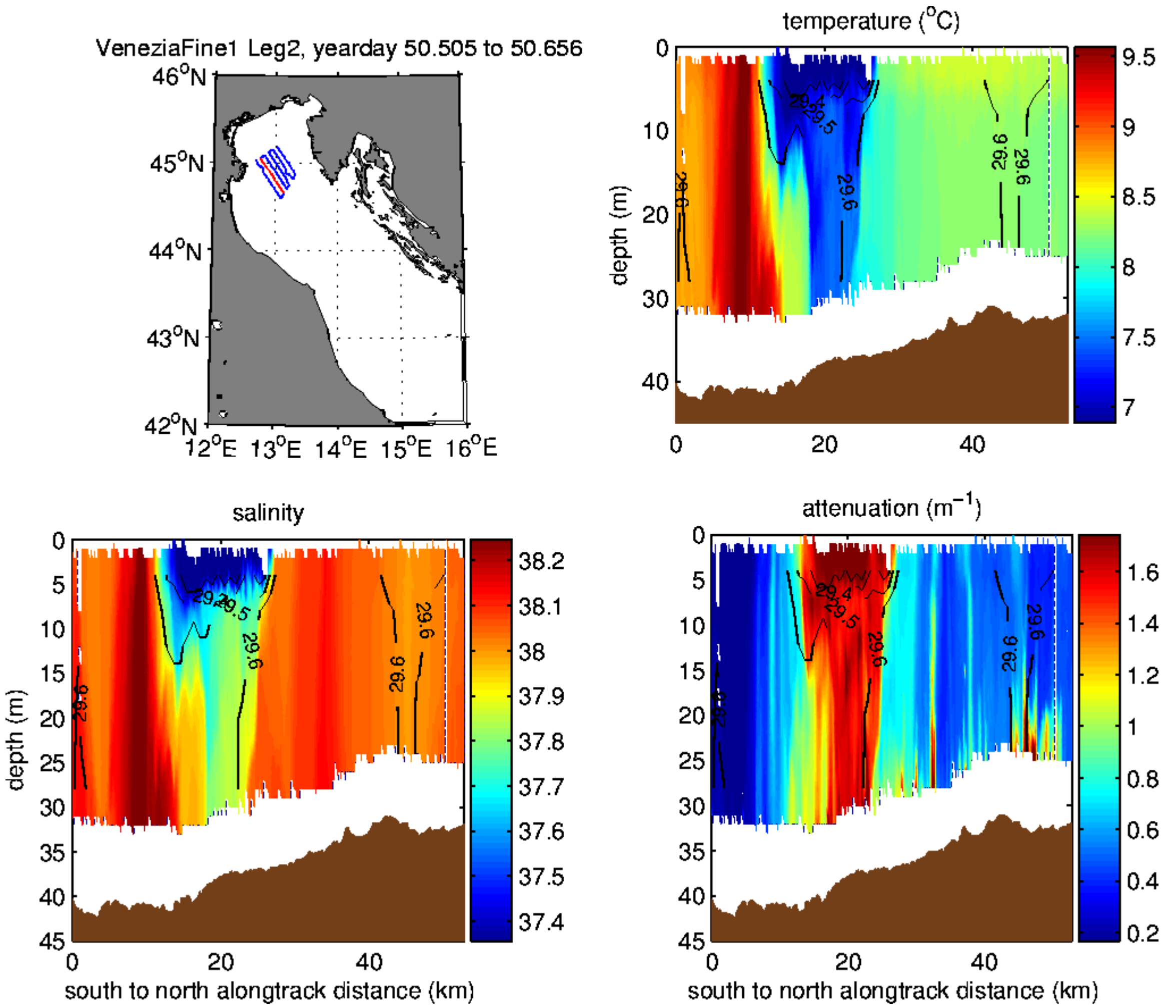


Figure 2.74: Temperature, salinity, and attenuation for VeneziaFine1 survey, Leg2 section. Overlaid contours are σ_θ.

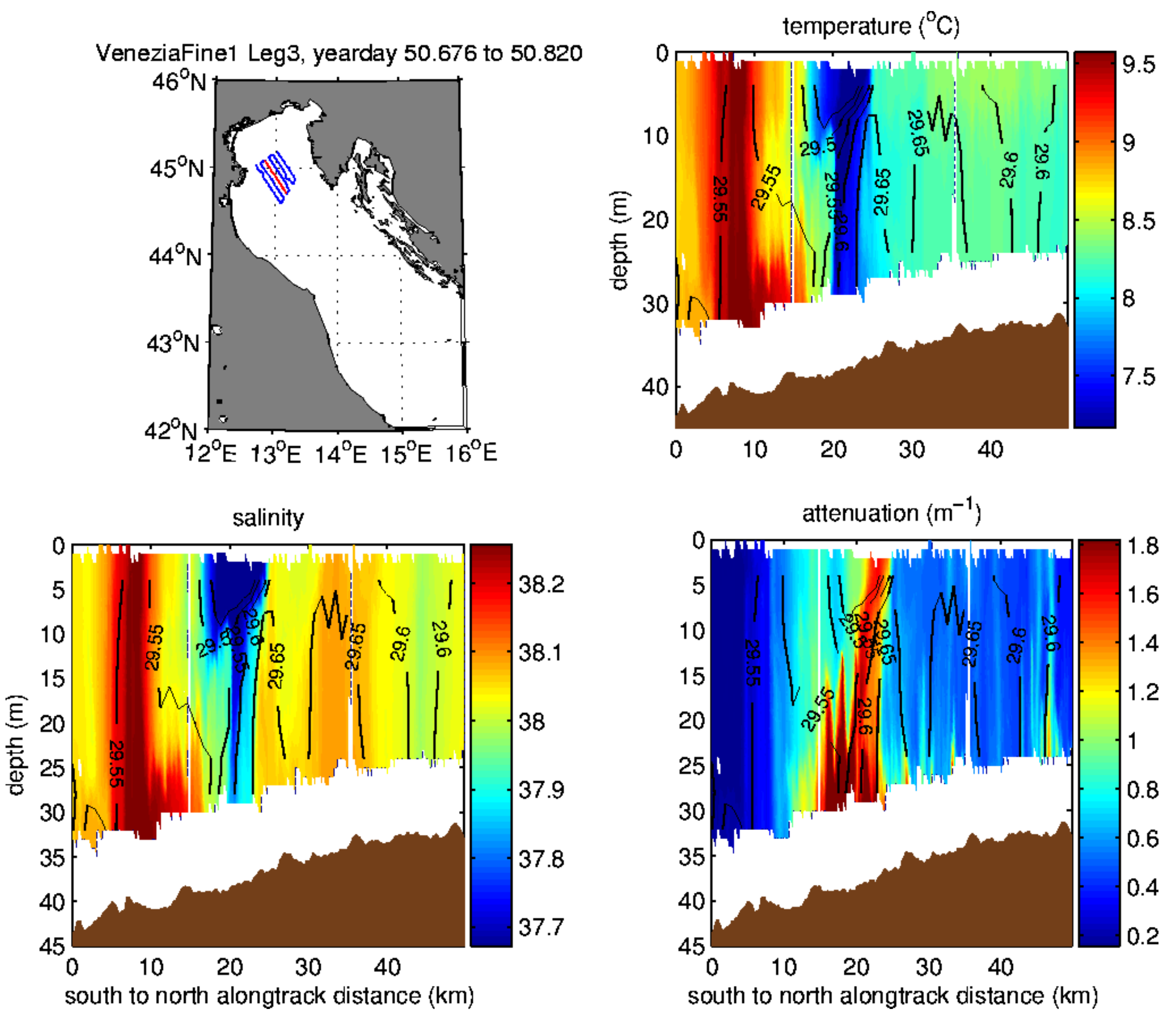


Figure 2.75: Temperature, salinity, and attenuation for VeneziaFine1 survey, Leg3 section. Overlaid contours are σ_θ.

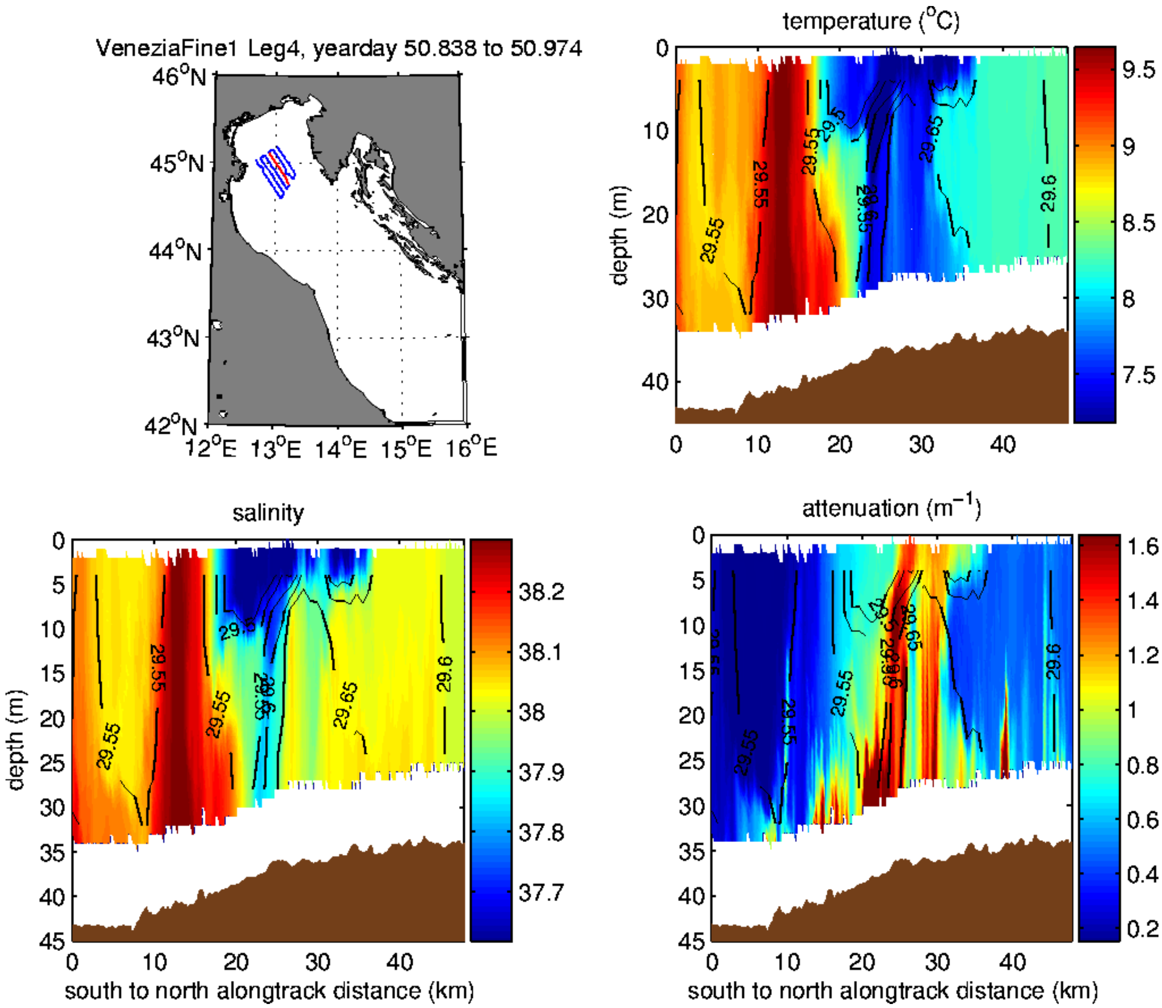


Figure 2.76: Temperature, salinity, and attenuation for VeneziaFine1 survey, Leg4 section. Overlaid contours are σ_θ.

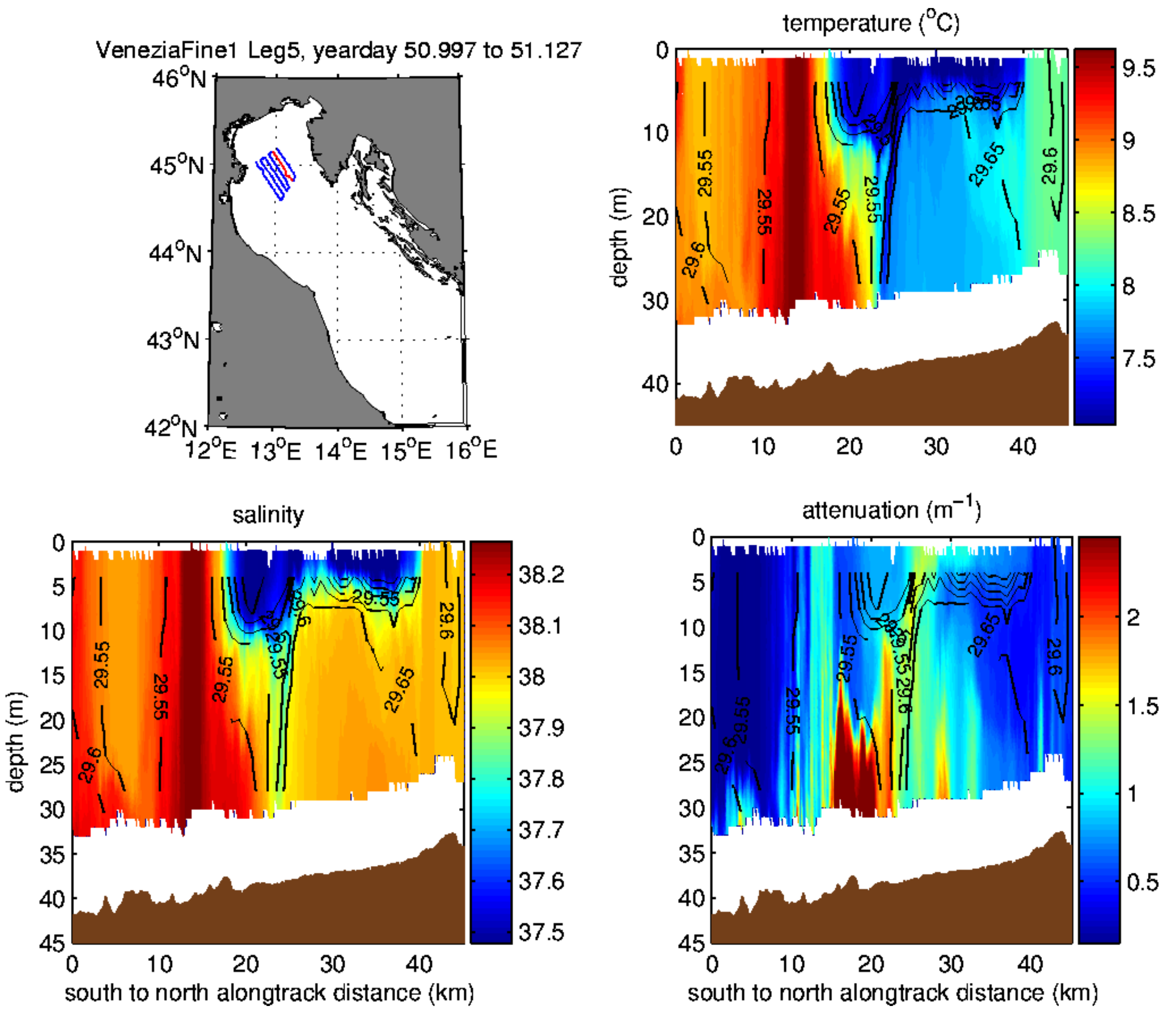


Figure 2.77: Temperature, salinity, and attenuation for VeneziaFine1 survey, Leg5 section. Overlaid contours are σ_θ.

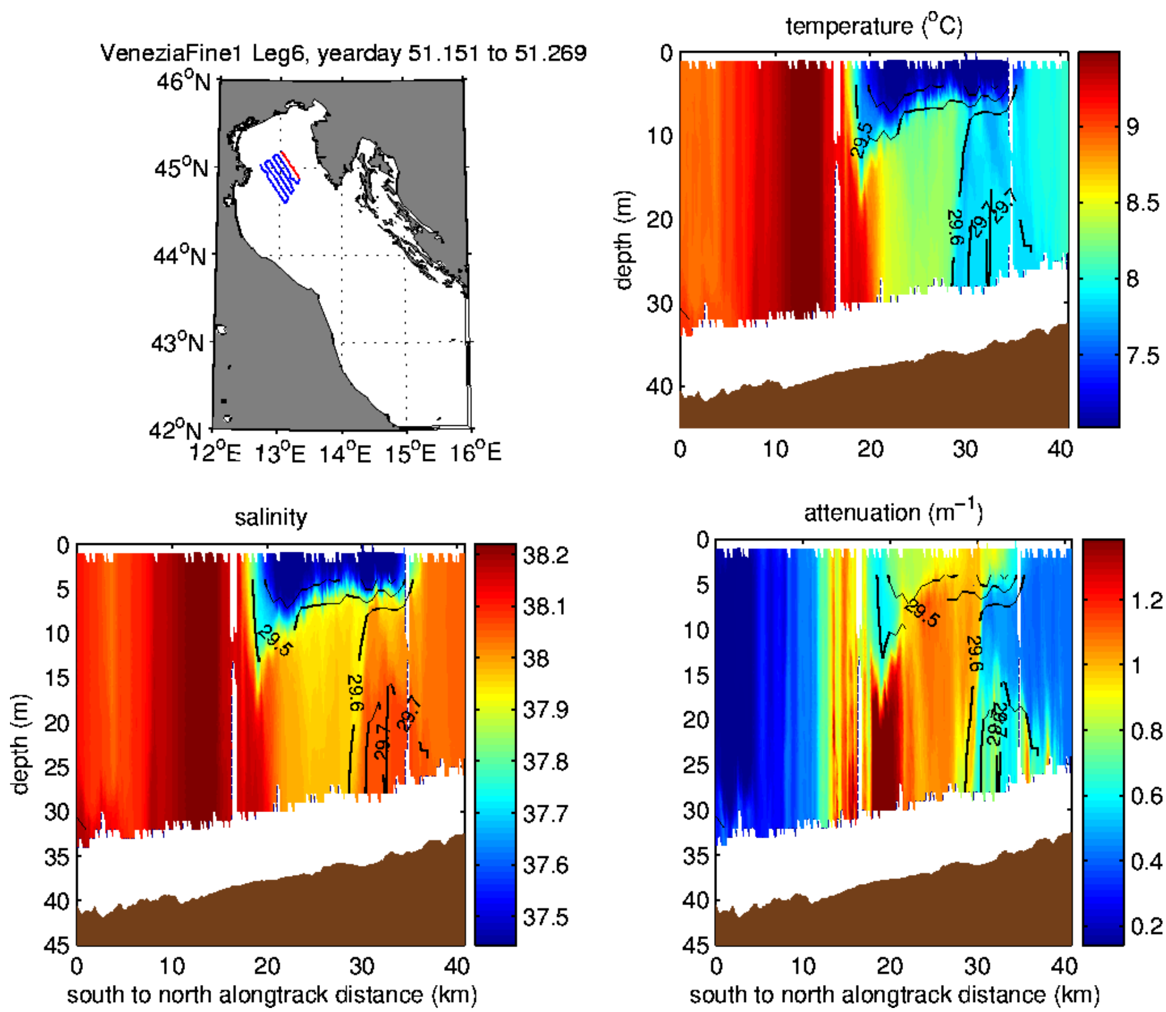


Figure 2.78: Temperature, salinity, and attenuation for VeneziaFine1 survey, Leg6 section. Overlaid contours are σ_θ.

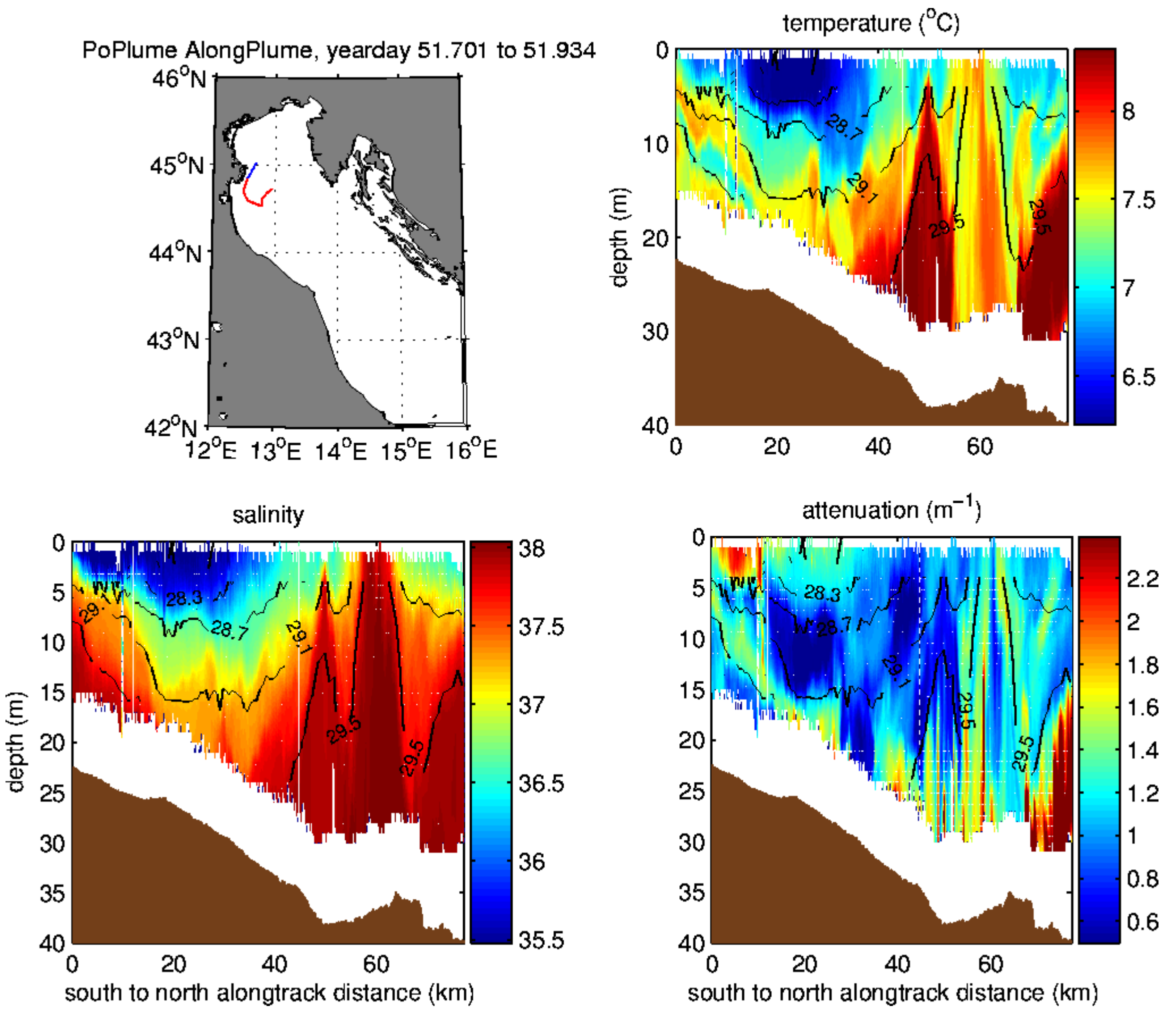


Figure 2.79: Temperature, salinity, and attenuation for PoPlume survey, AlongPlume section. Overlaid contours are σ_θ.

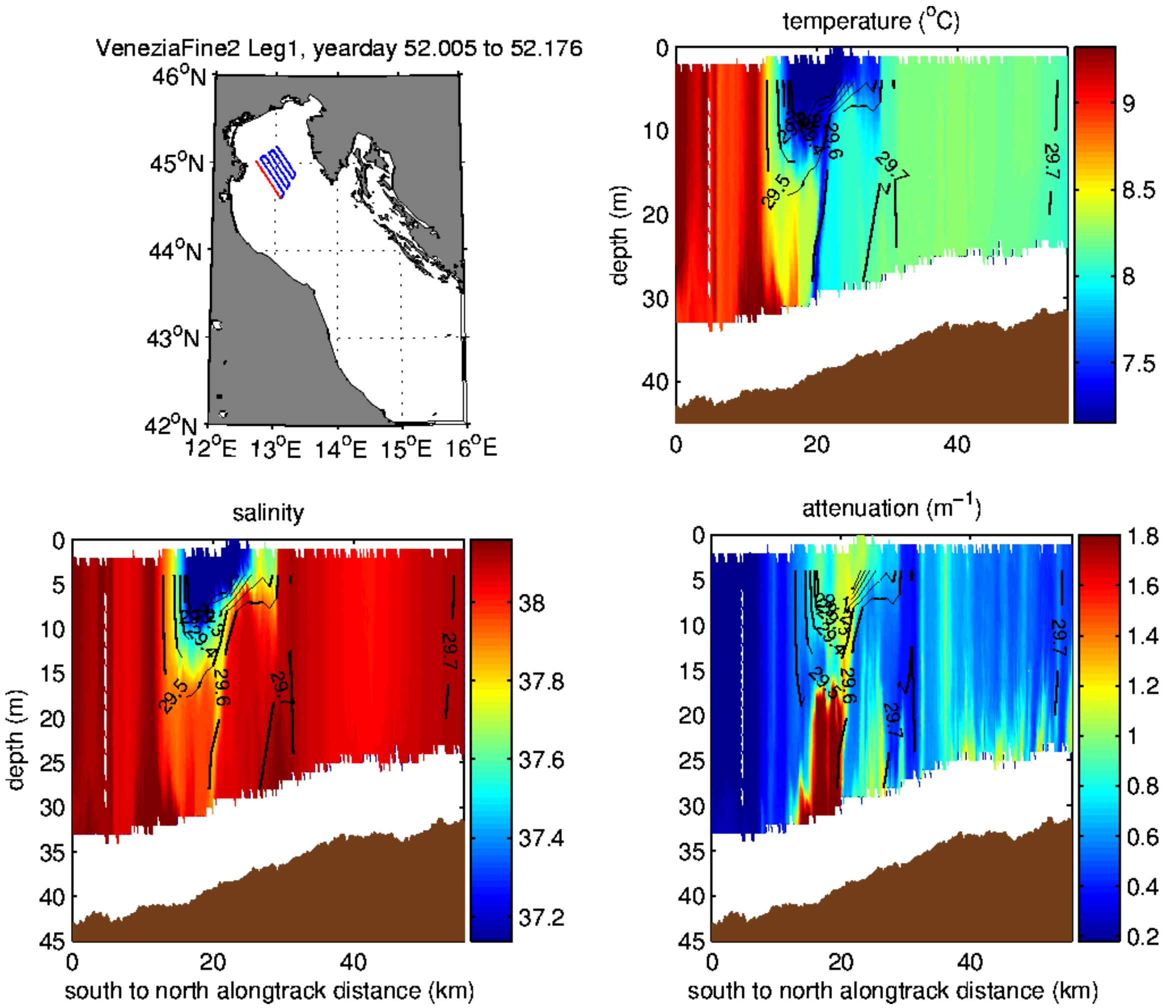


Figure 2.80: Temperature, salinity, and attenuation for VeneziaFine2 survey, Leg1 section. Overlaid contours are σ_θ.

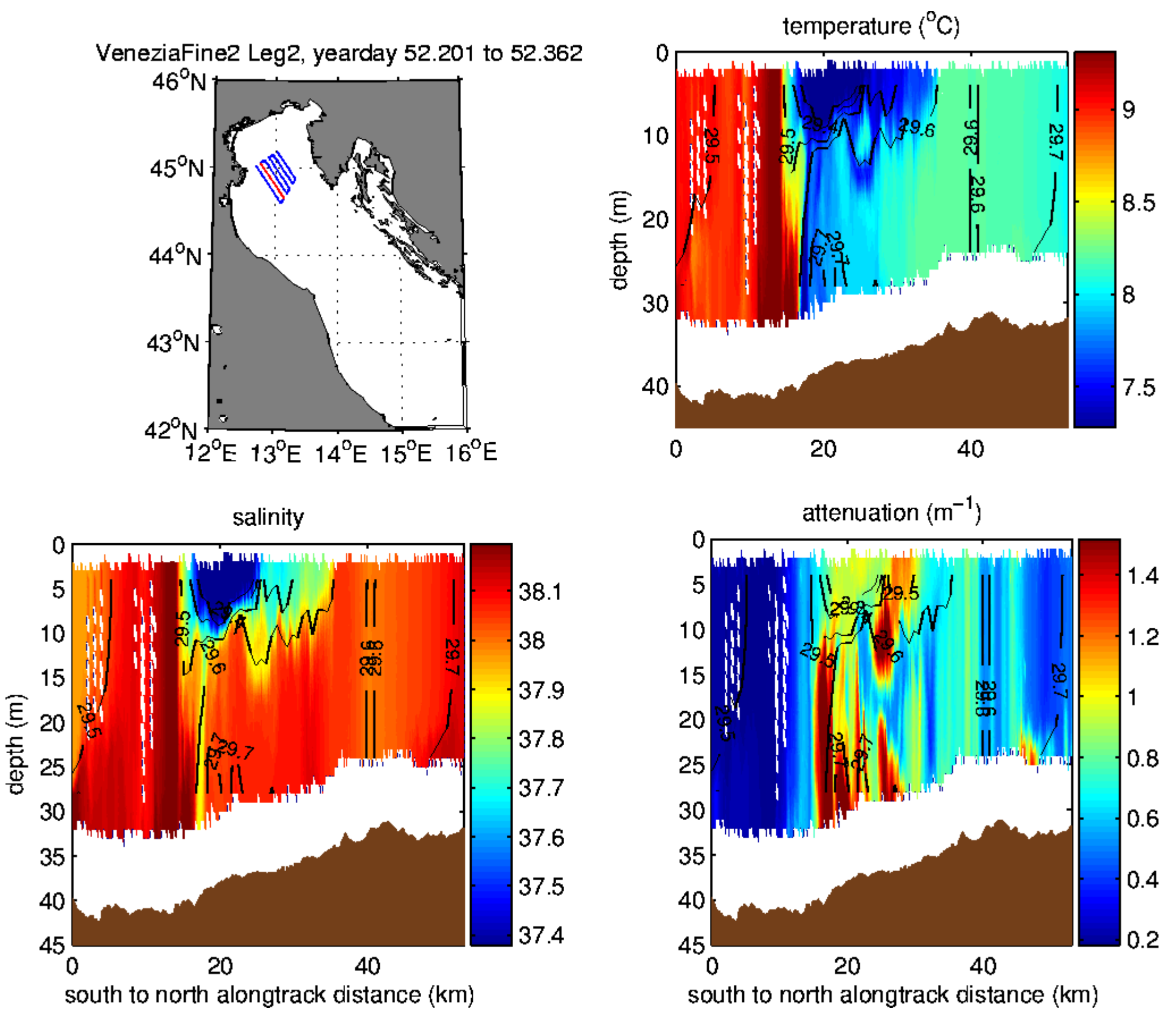


Figure 2.81: Temperature, salinity, and attenuation for VeneziaFine2 survey, Leg2 section. Overlaid contours are σ_θ.

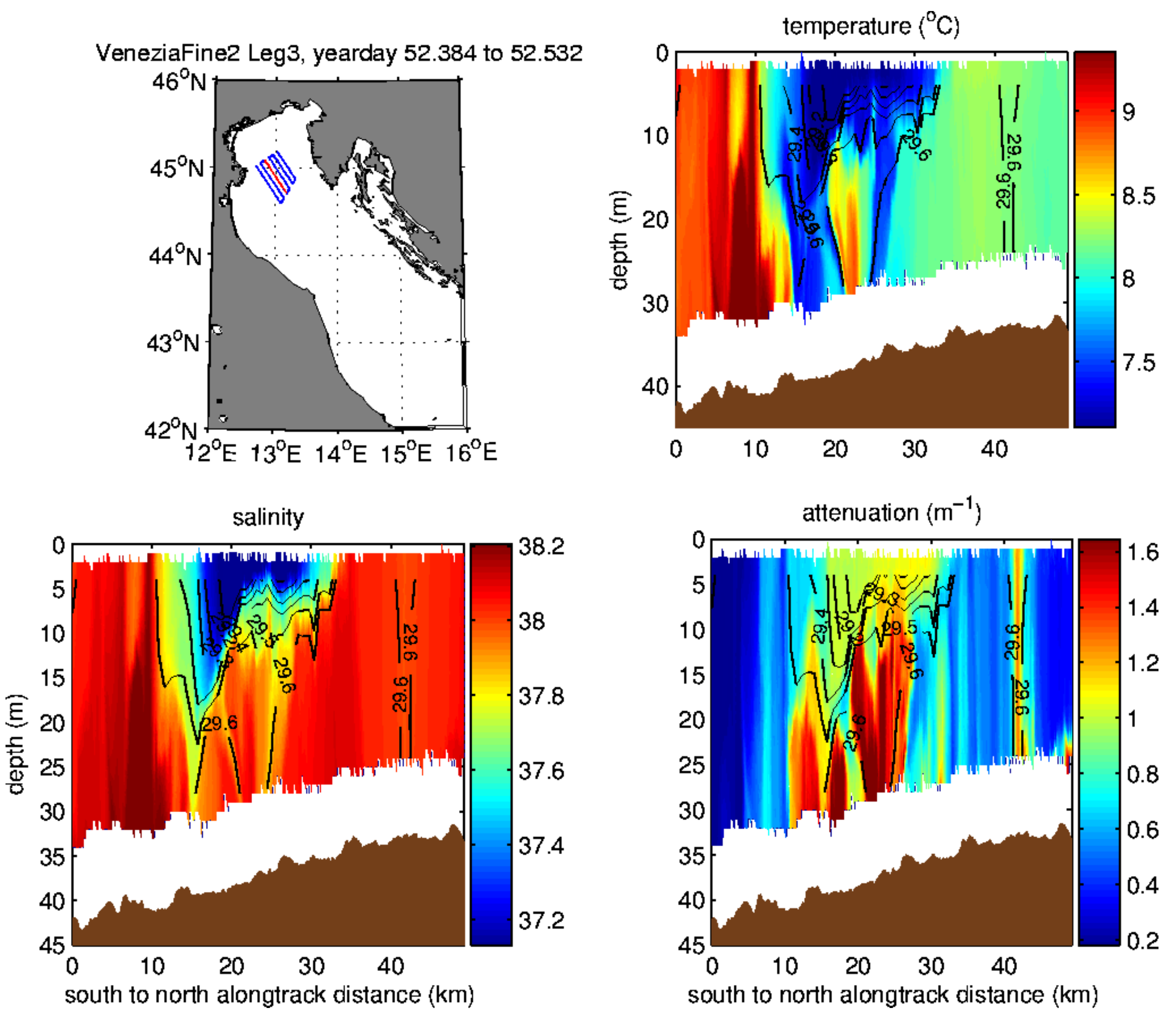


Figure 2.82: Temperature, salinity, and attenuation for VeneziaFine2 survey, Leg3 section. Overlaid contours are σ_θ.

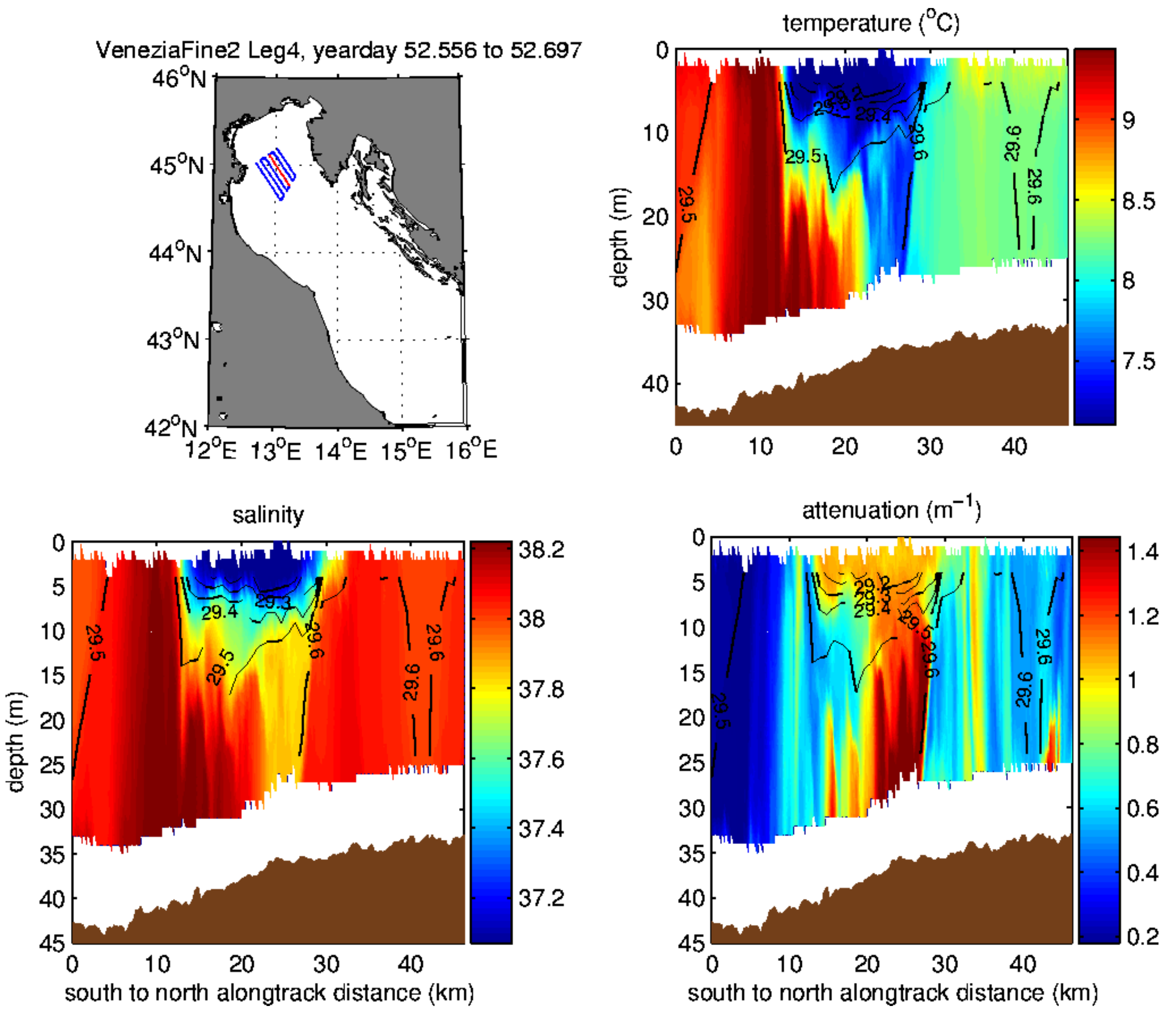


Figure 2.83: Temperature, salinity, and attenuation for VeneziaFine2 survey, Leg4 section. Overlaid contours are σ_θ.

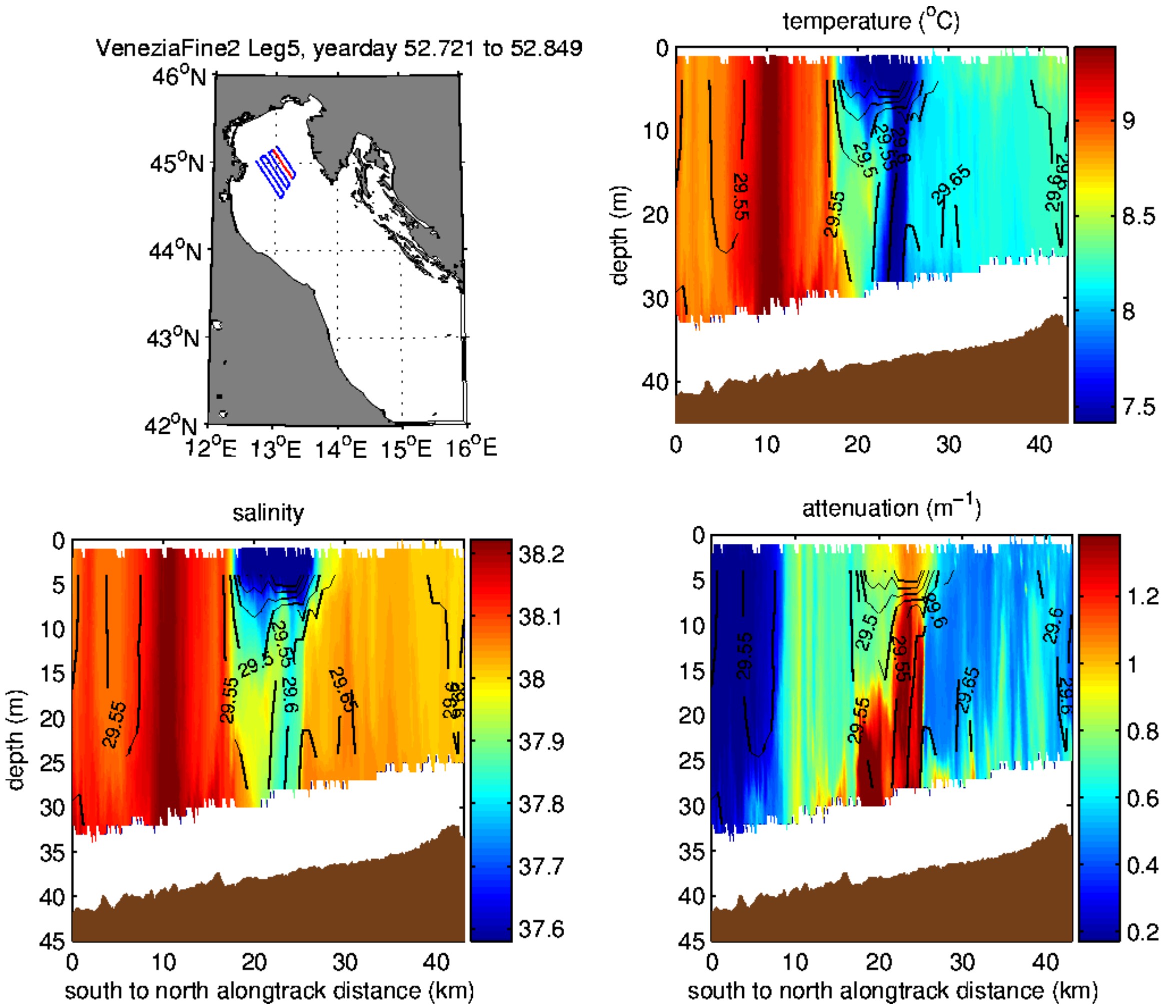


Figure 2.84: Temperature, salinity, and attenuation for VeneziaFine2 survey, Leg5 section. Overlaid contours are σ_θ.

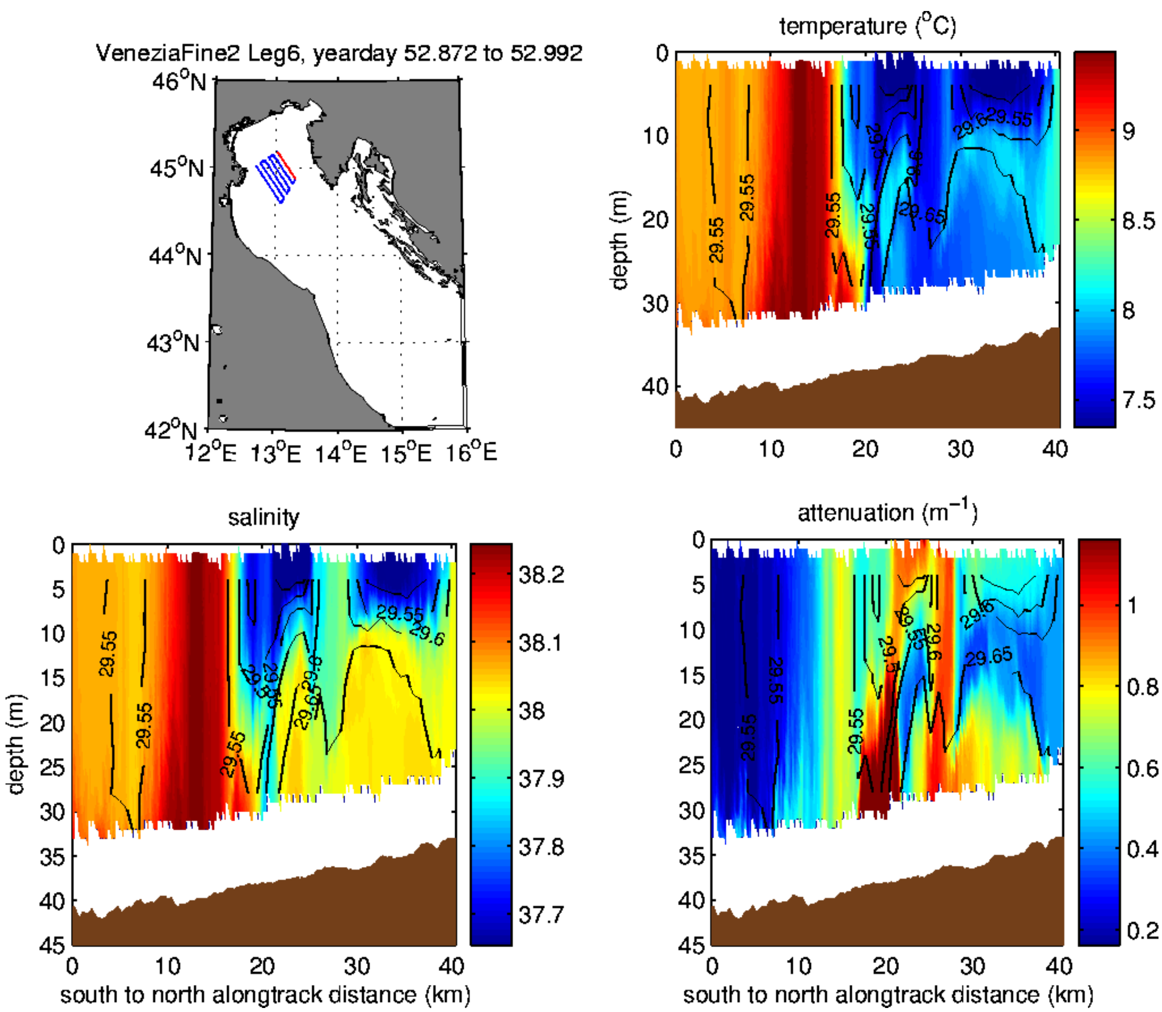


Figure 2.85: Temperature, salinity, and attenuation for VeneziaFine2 survey, Leg6 section. Overlaid contours are σ_θ.

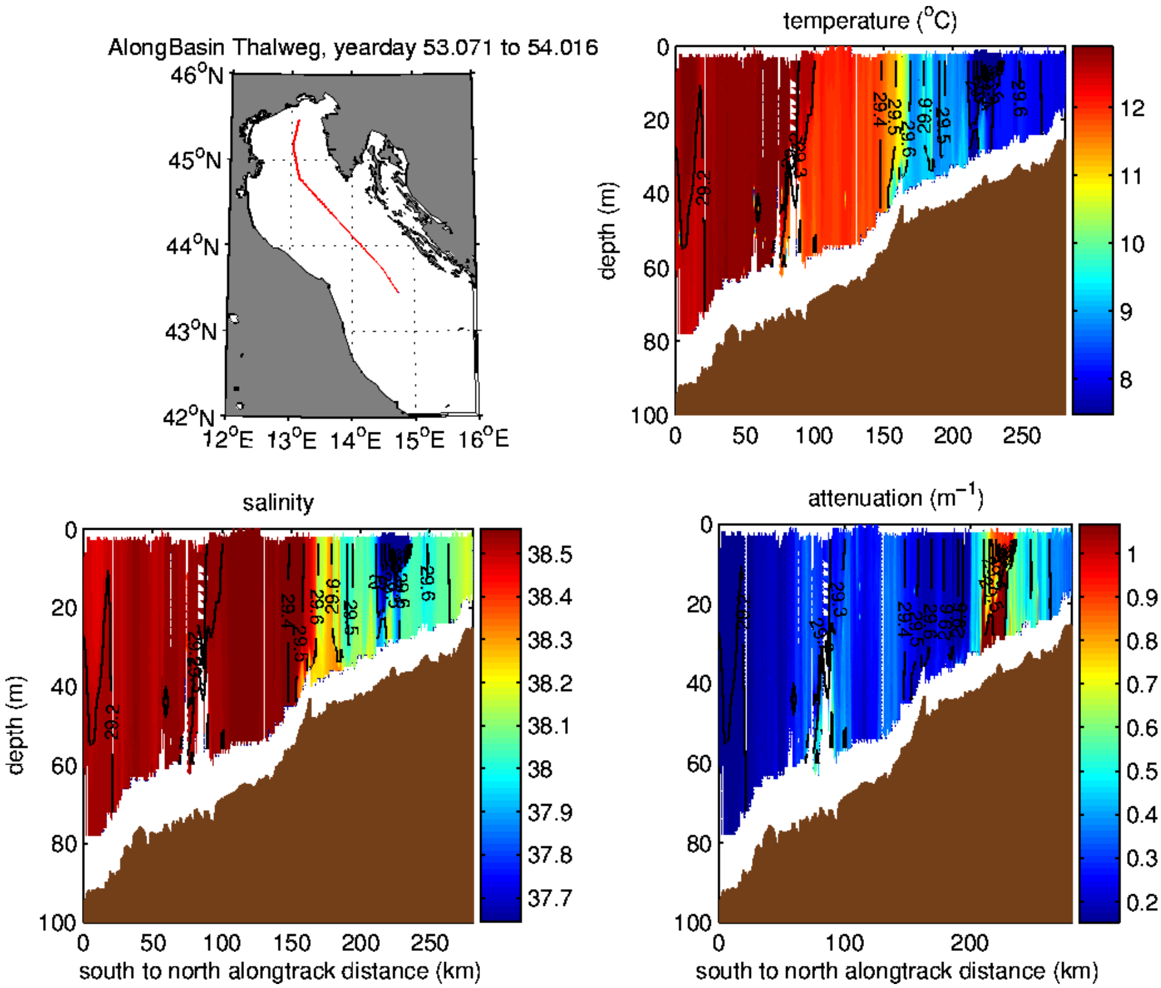


Figure 2.86: Temperature, salinity, and attenuation for AlongBasin survey, Thalweg section. Overlaid contours are σ_θ.

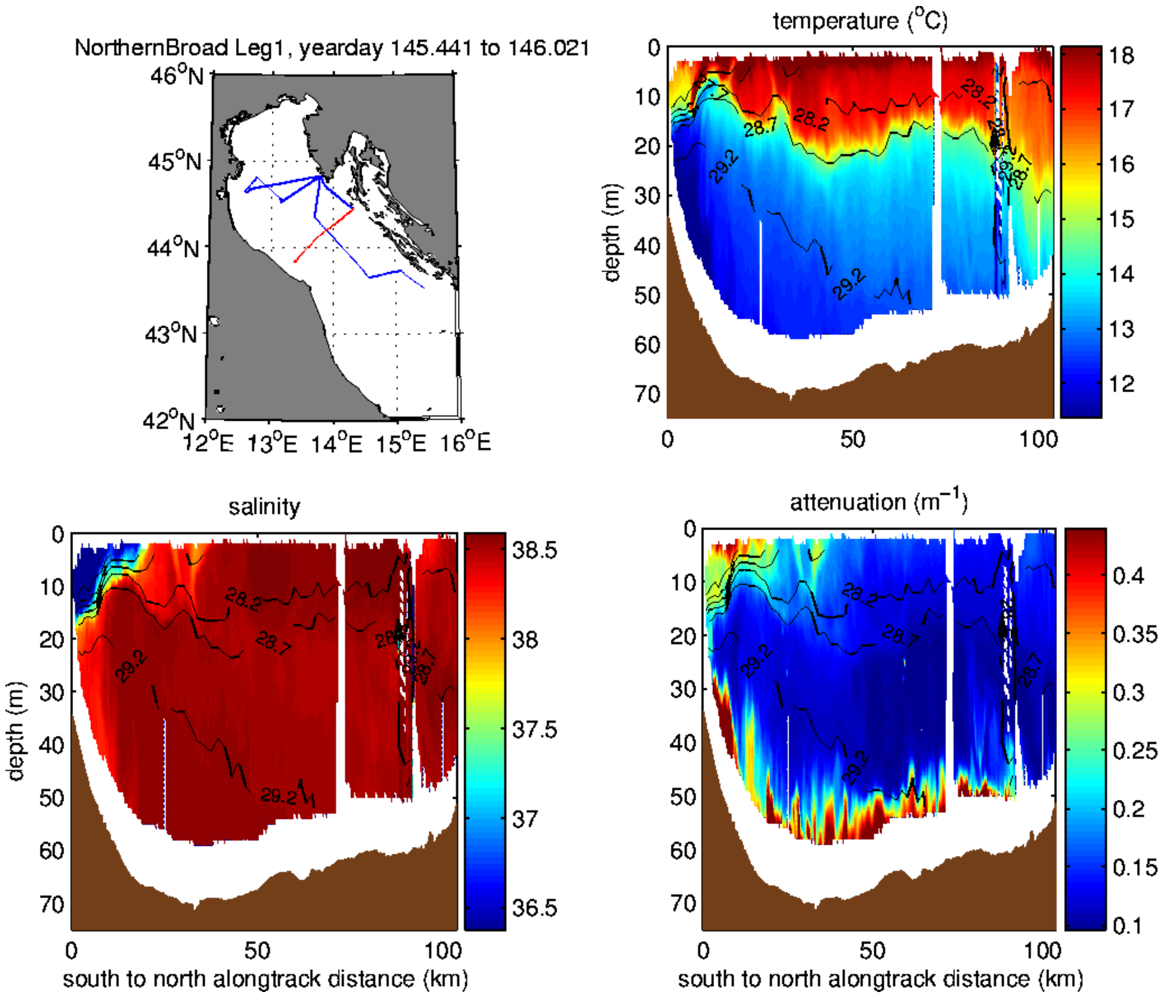


Figure 2.87: Temperature, salinity, and attenuation for NorthernBroad survey, Leg1 section. Overlaid contours are σ_θ.

2.4 DOLCE VITA 2 profile results

Sections for temperature, salinity, and attenuation (from the transmissometer) are shown in Figs. 2.87 through 2.178 for all legs of all surveys. The map in the upper-left panel of each figure shows the location of the leg in the survey. The starting and ending decimal yeardays for each leg are indicated in the title of the map panel.

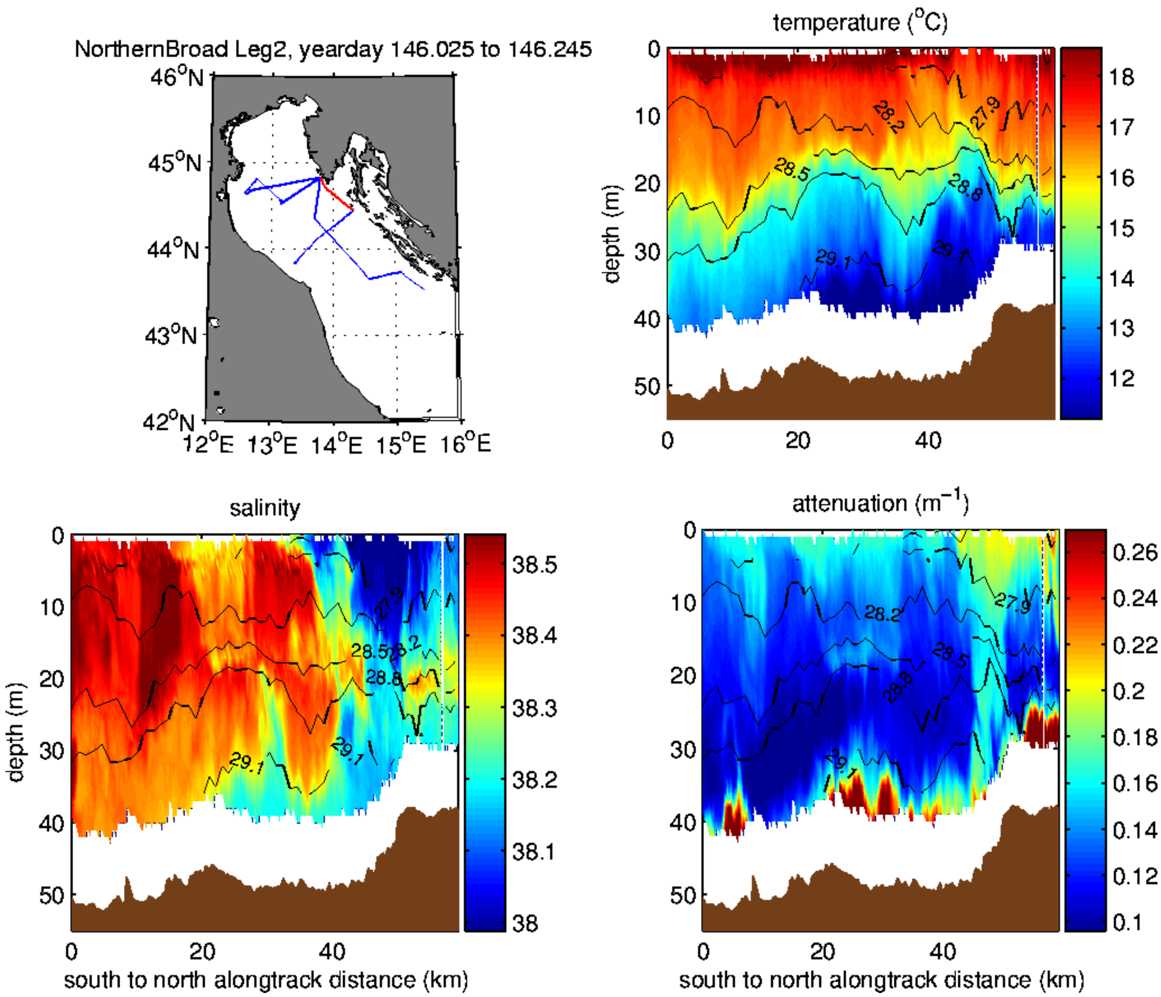


Figure 2.88: Temperature, salinity, and attenuation for NorthernBroad survey, Leg2 section. Overlaid contours are σ_θ.

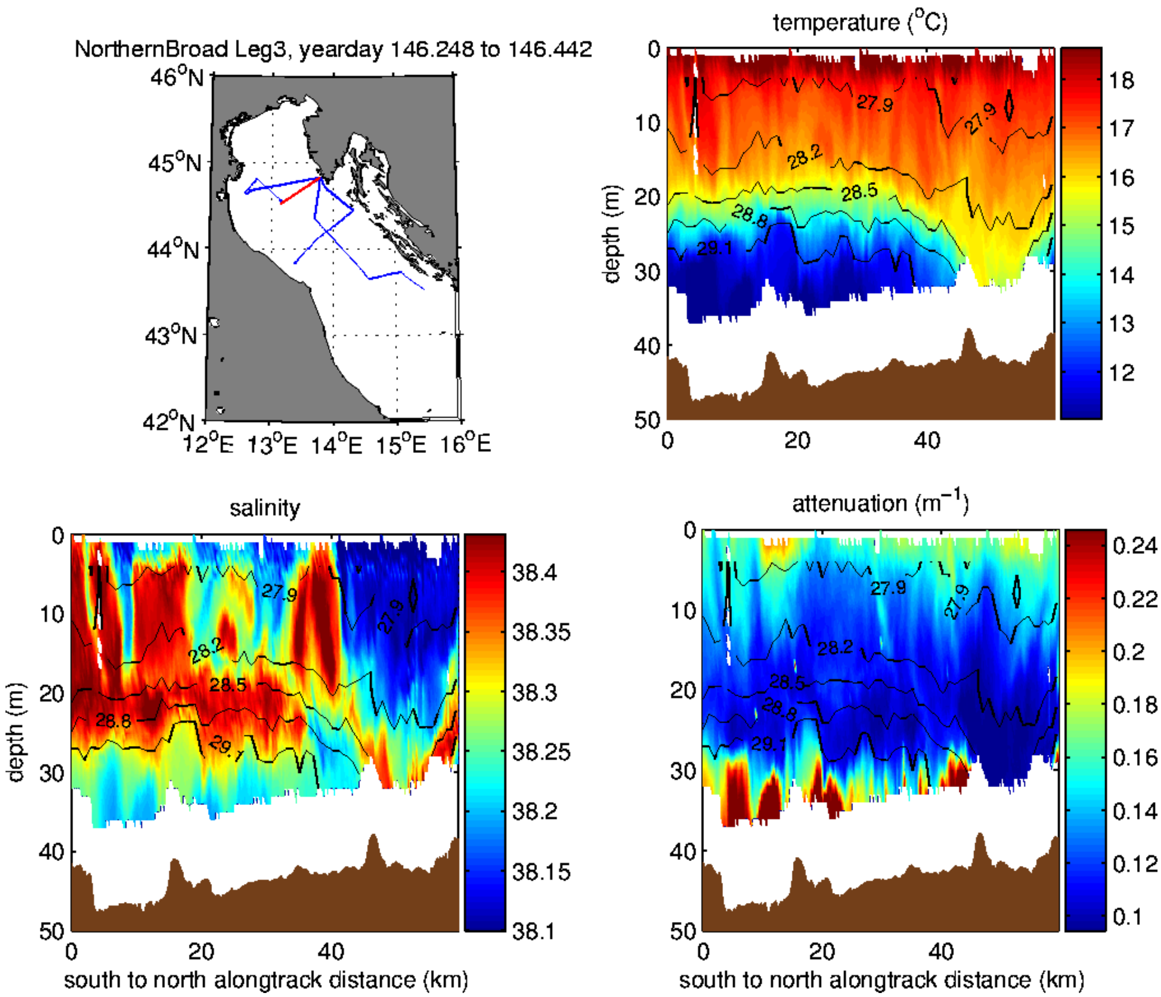


Figure 2.89: Temperature, salinity, and attenuation for NorthernBroad survey, Leg3 section. Overlaid contours are σ_θ.

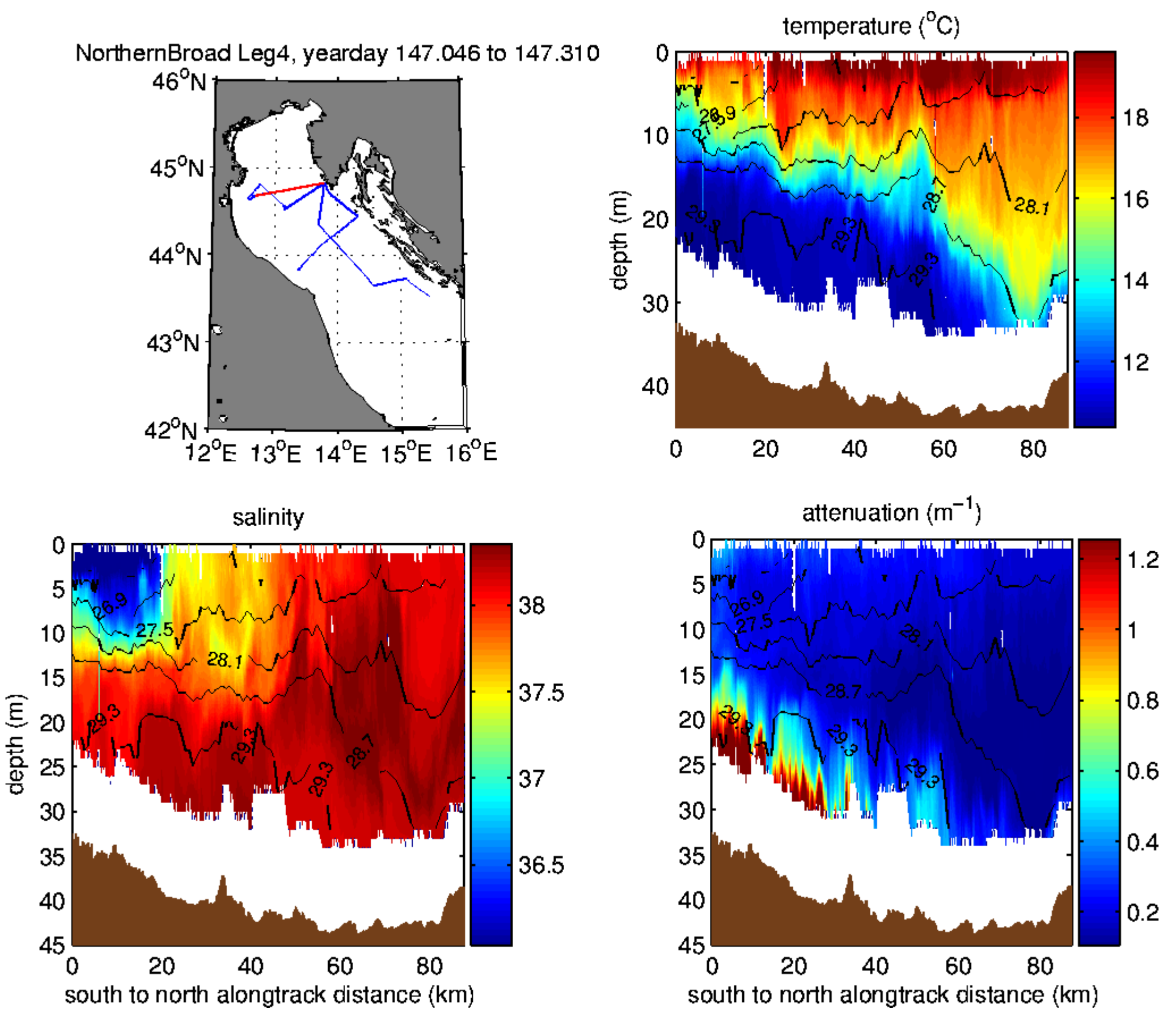


Figure 2.90: Temperature, salinity, and attenuation for NorthernBroad survey, Leg4 section. Overlaid contours are σ_θ.

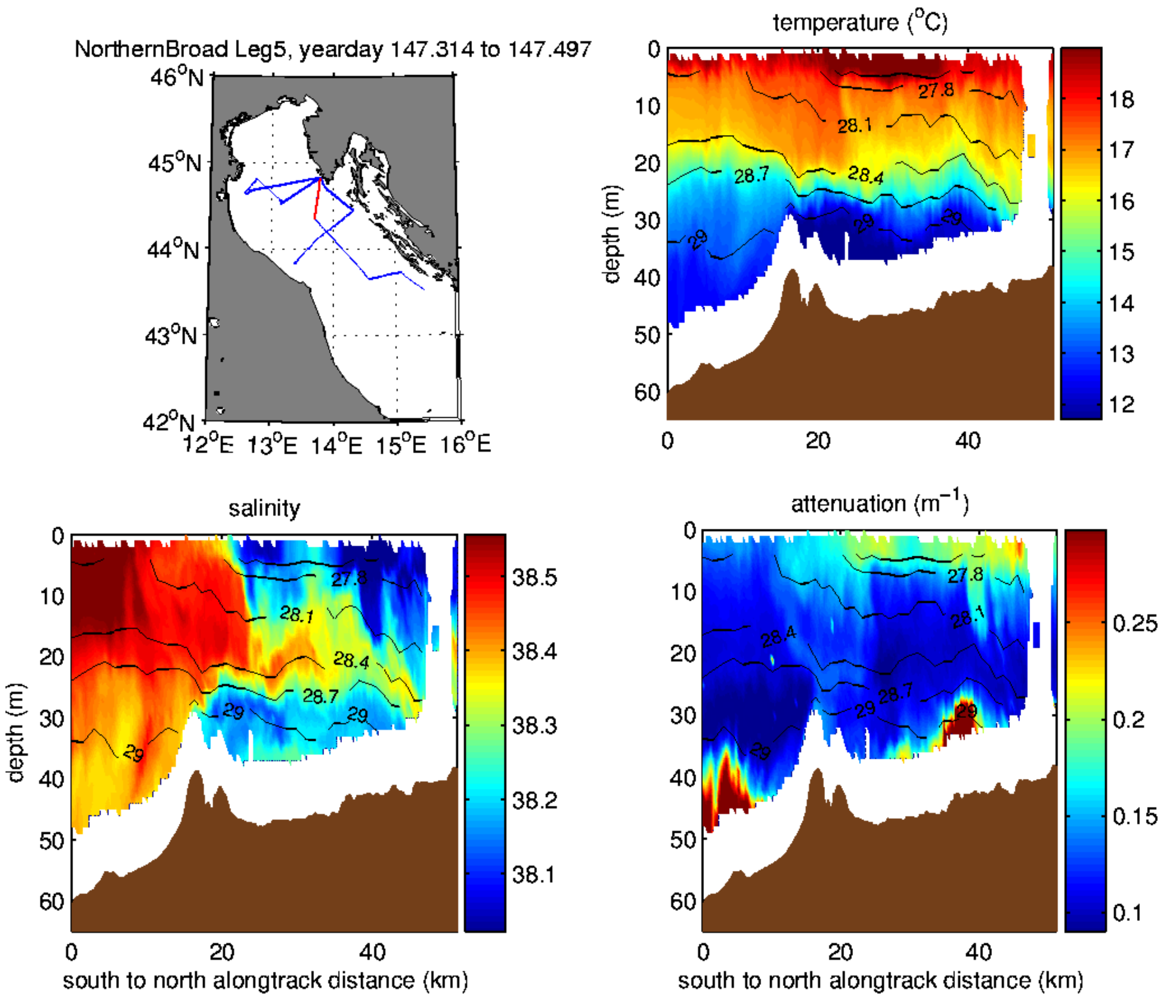


Figure 2.91: Temperature, salinity, and attenuation for NorthernBroad survey, Leg5 section. Overlaid contours are σ_θ.

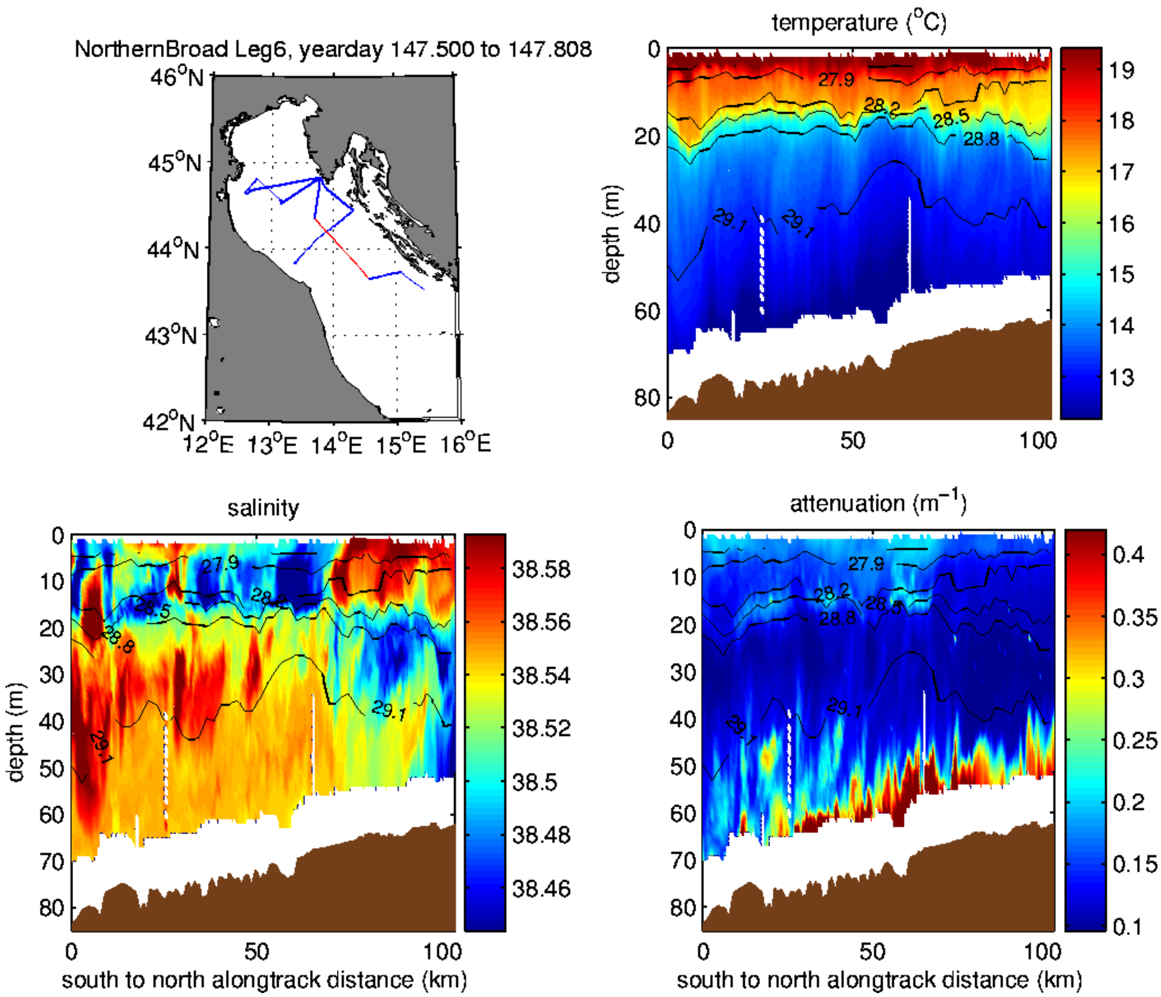


Figure 2.92: Temperature, salinity, and attenuation for NorthernBroad survey, Leg6 section. Overlaid contours are σ_θ.

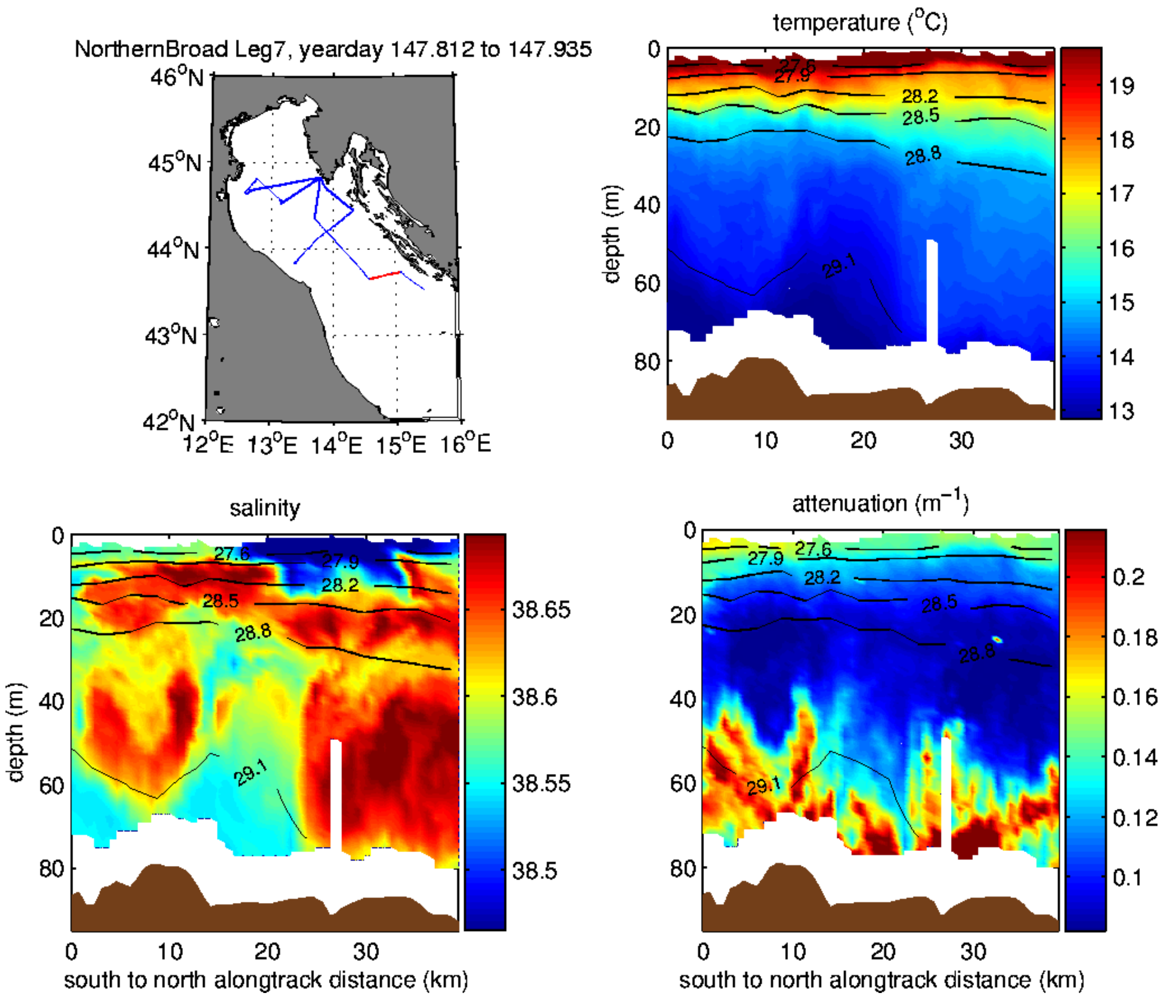


Figure 2.93: Temperature, salinity, and attenuation for NorthernBroad survey, Leg7 section. Overlaid contours are σ_θ.

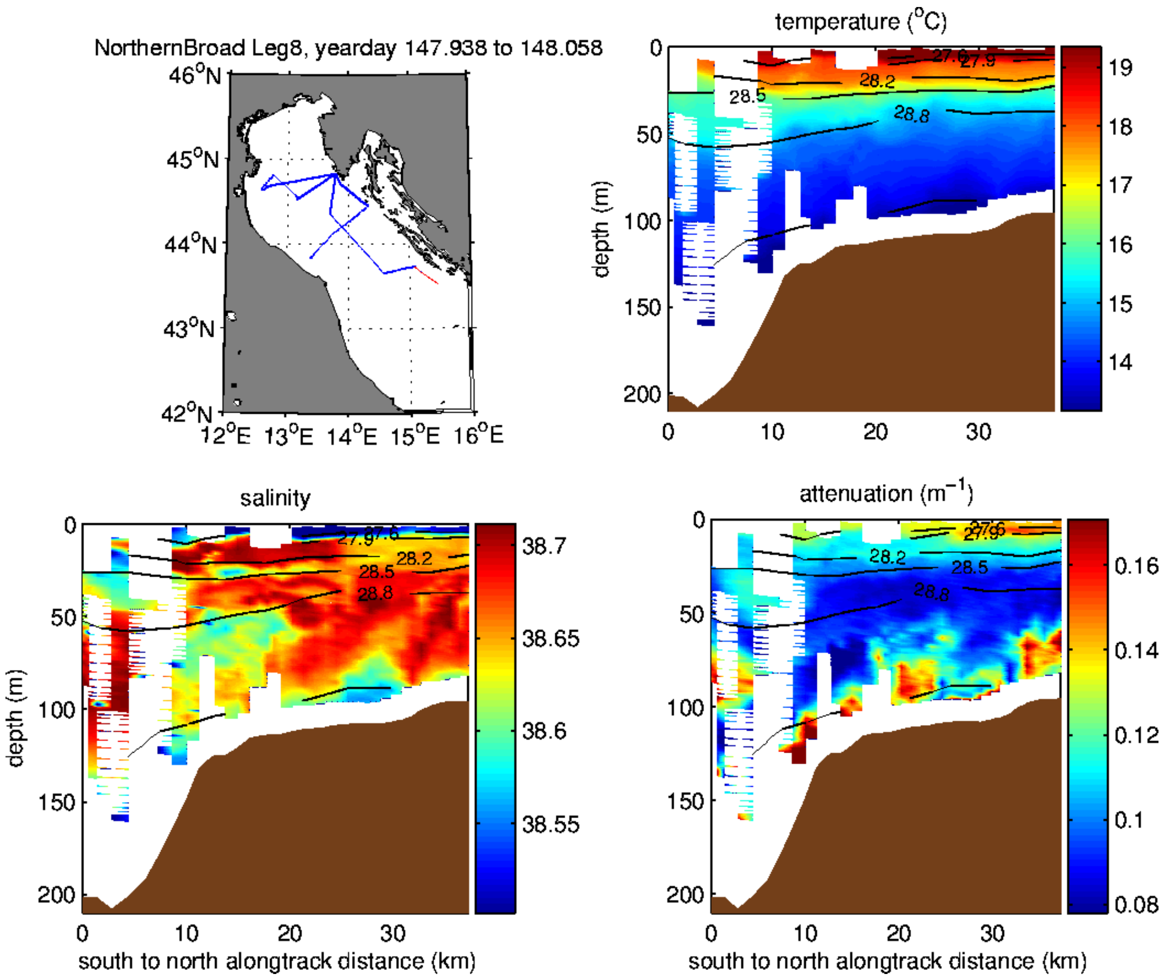


Figure 2.94: Temperature, salinity, and attenuation for NorthernBroad survey, Leg8 section. Overlaid contours are σ_θ.

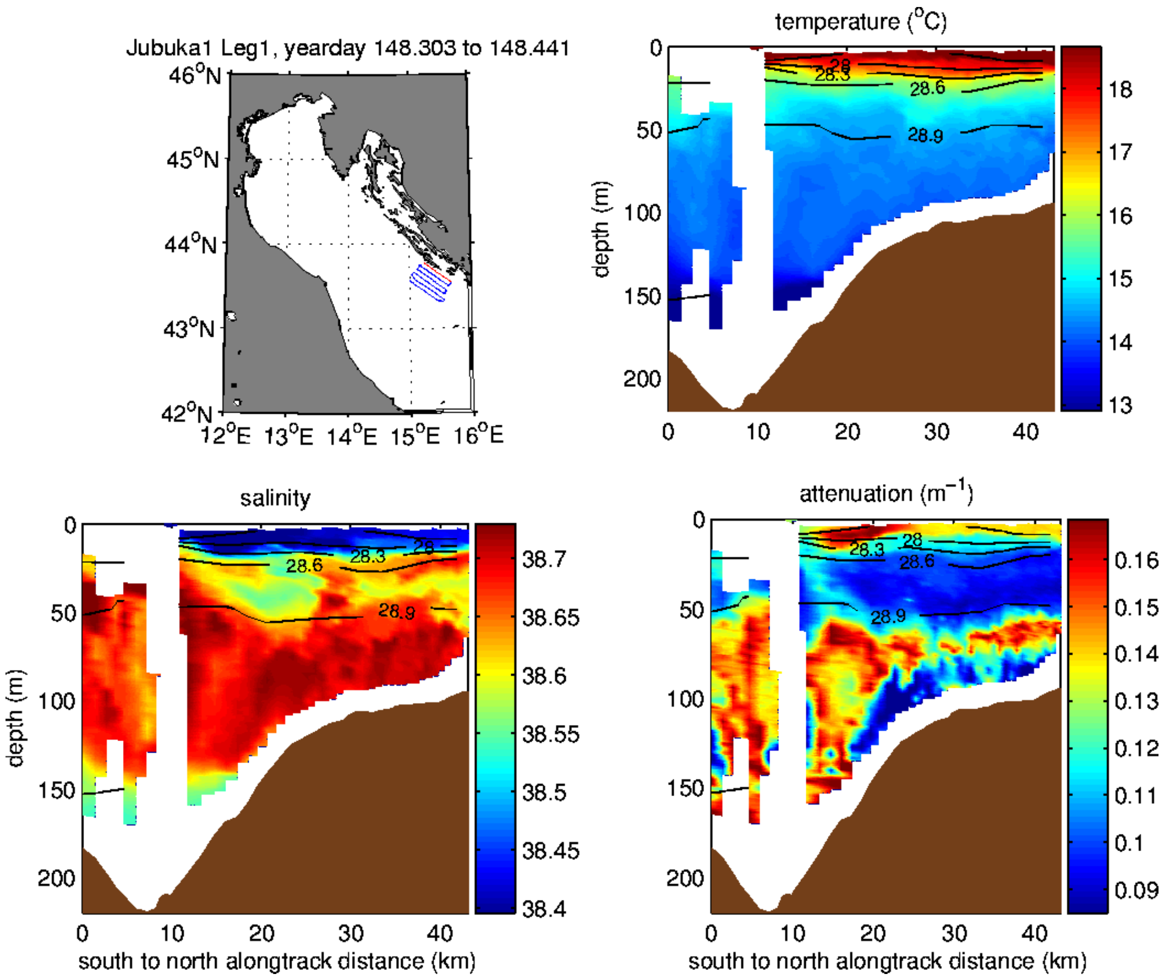


Figure 2.95: Temperature, salinity, and attenuation for Jubuka1 survey, Leg1 section. Overlaid contours are σ_θ.

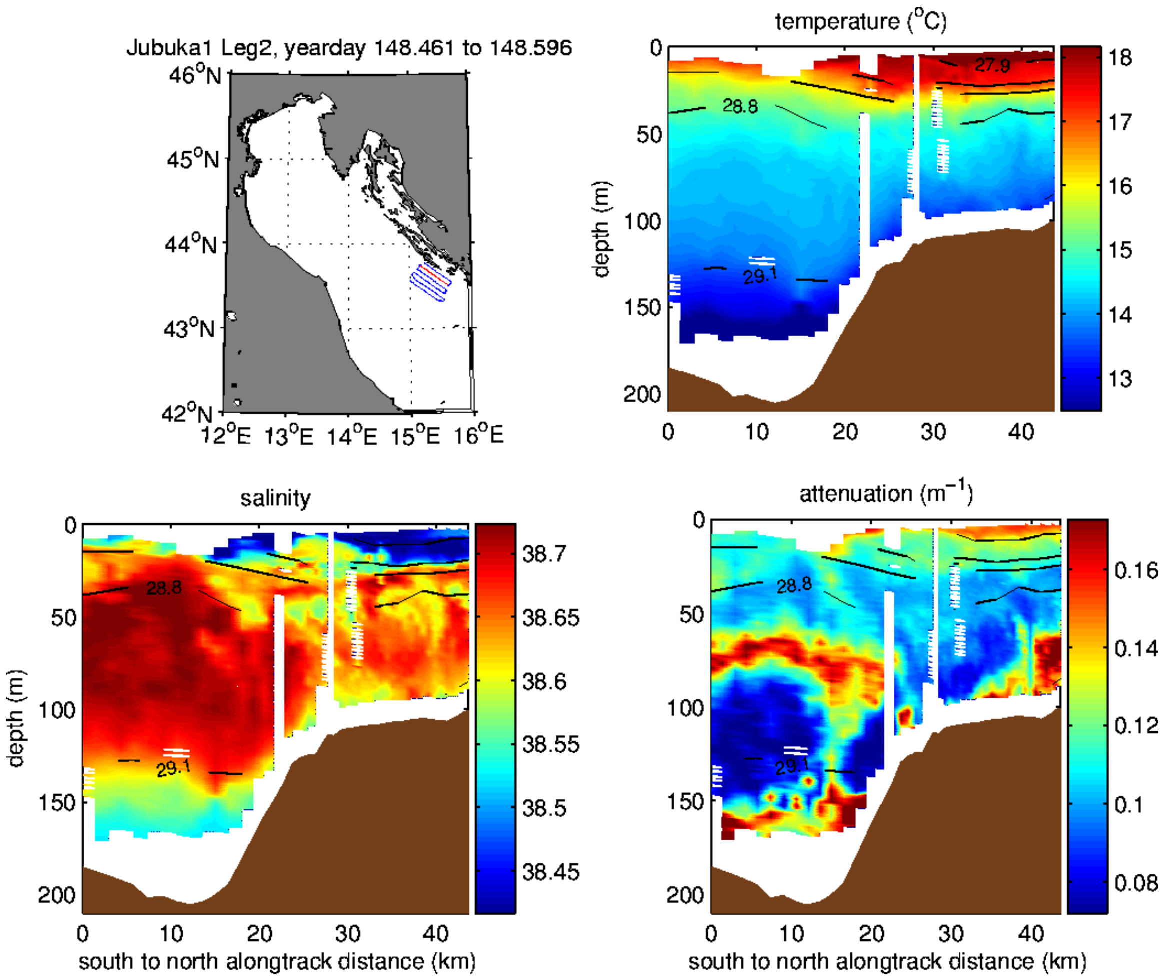


Figure 2.96: Temperature, salinity, and attenuation for Jubuka1 survey, Leg2 section. Overlaid contours are σ_θ.

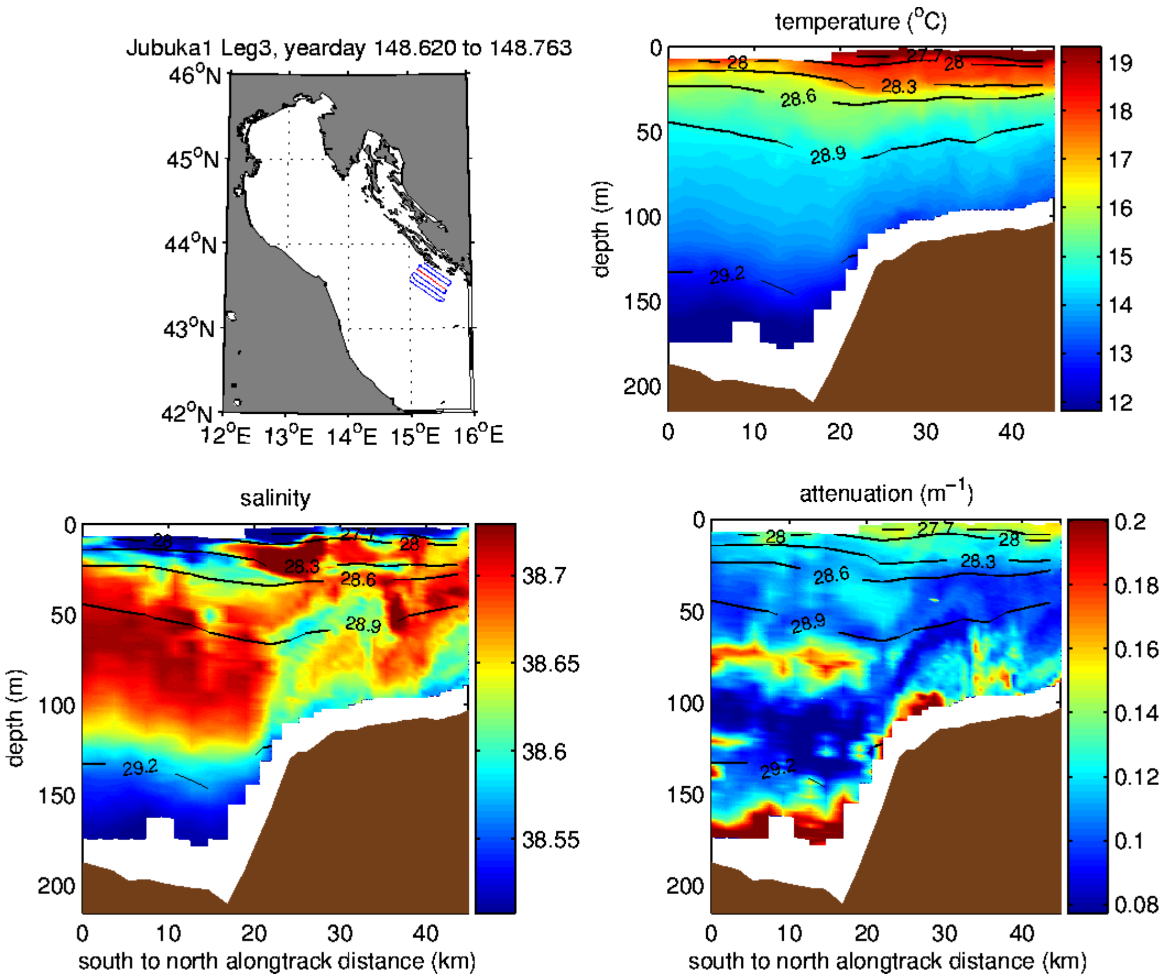


Figure 2.97: Temperature, salinity, and attenuation for Jubuka1 survey, Leg3 section. Overlaid contours are σ_θ.

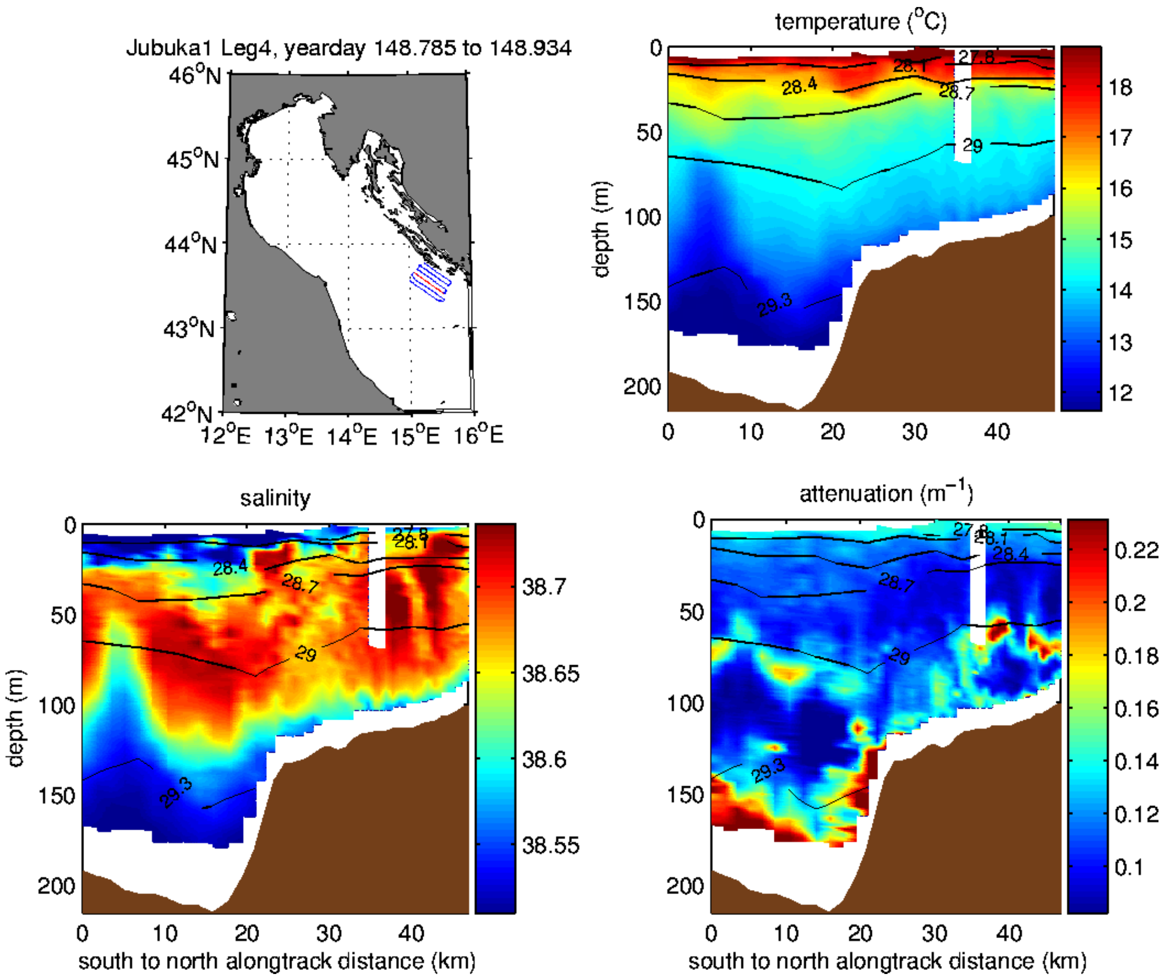


Figure 2.98: Temperature, salinity, and attenuation for Jubuka1 survey, Leg4 section. Overlaid contours are σ_θ.

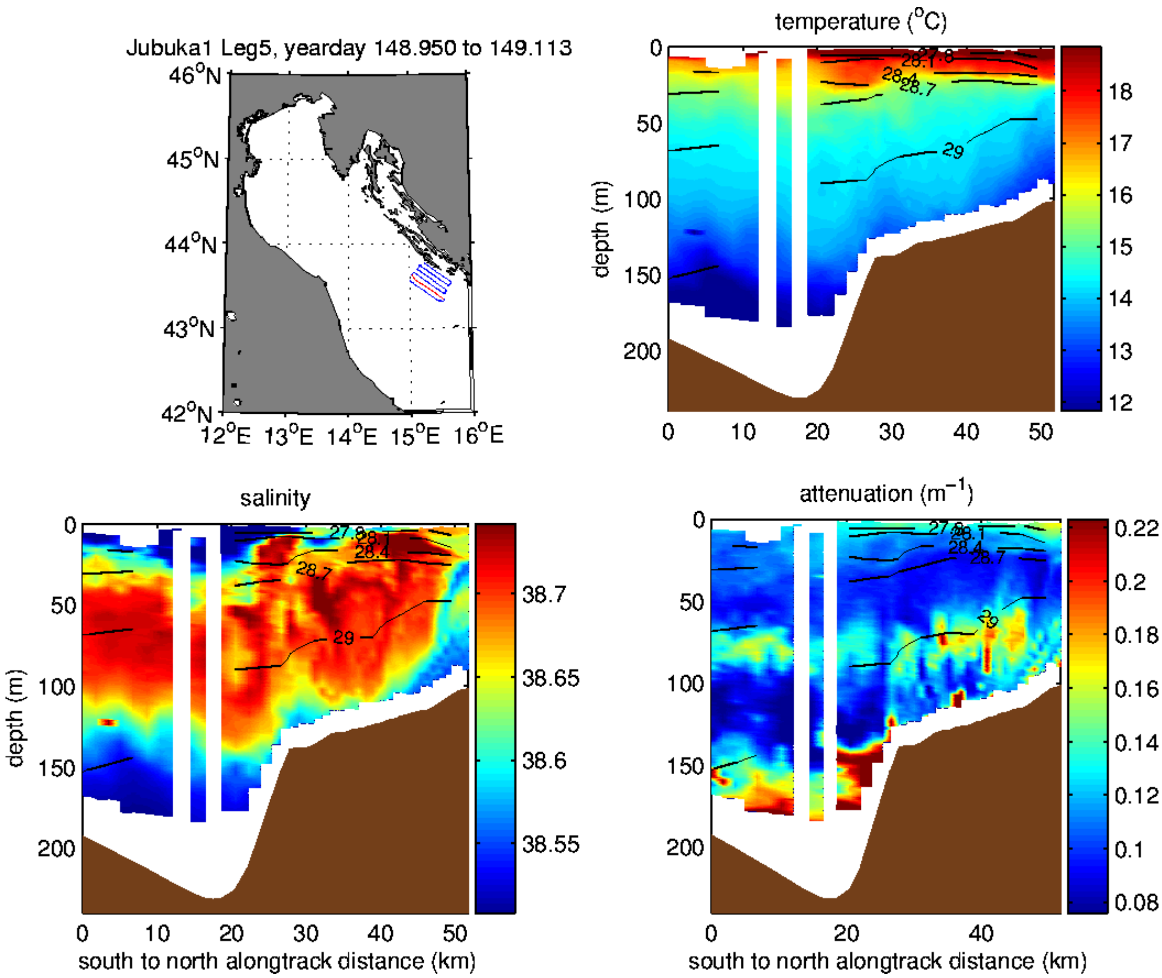


Figure 2.99: Temperature, salinity, and attenuation for Jubuka1 survey, Leg5 section. Overlaid contours are σ_θ.

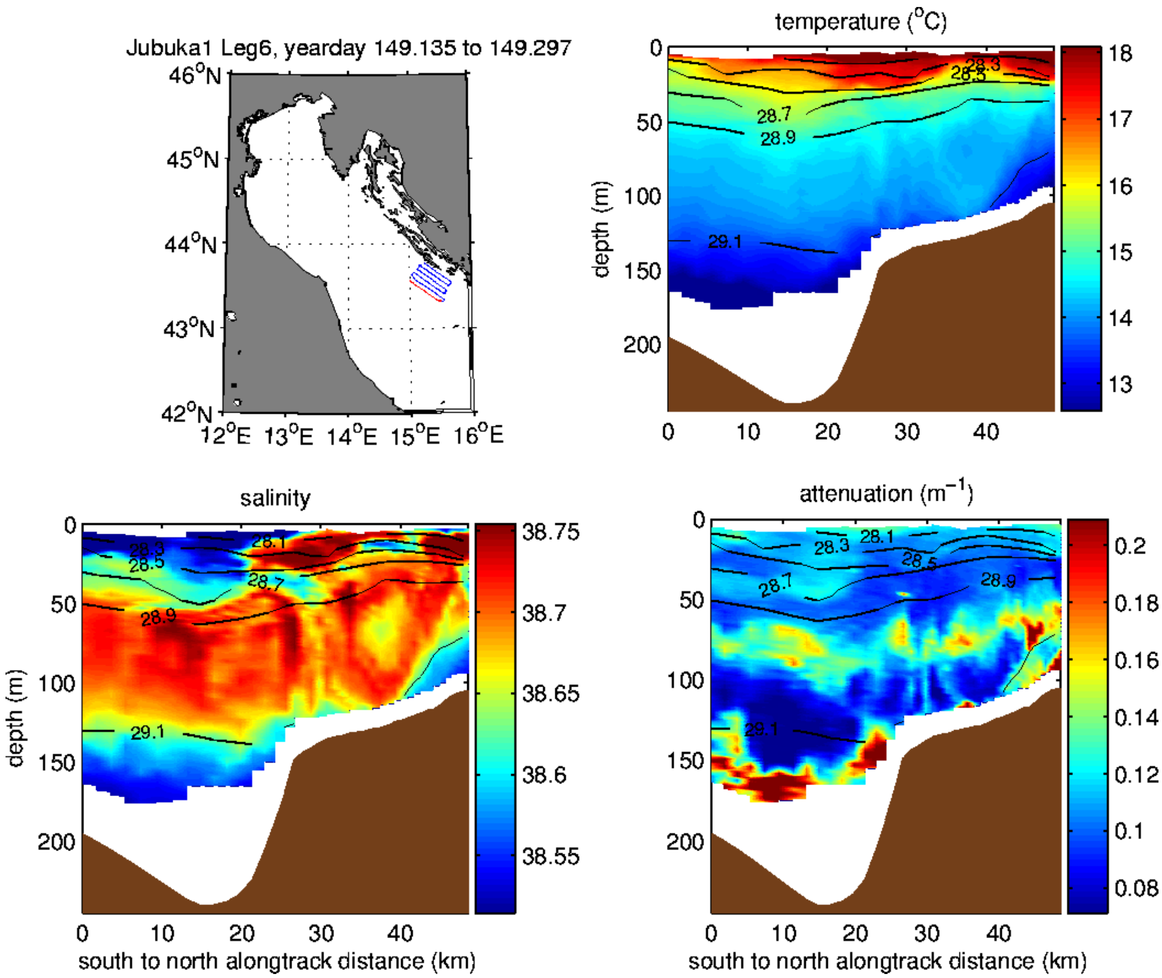


Figure 2.100: Temperature, salinity, and attenuation for Jubuka1 survey, Leg6 section. Overlaid contours are σ_θ.

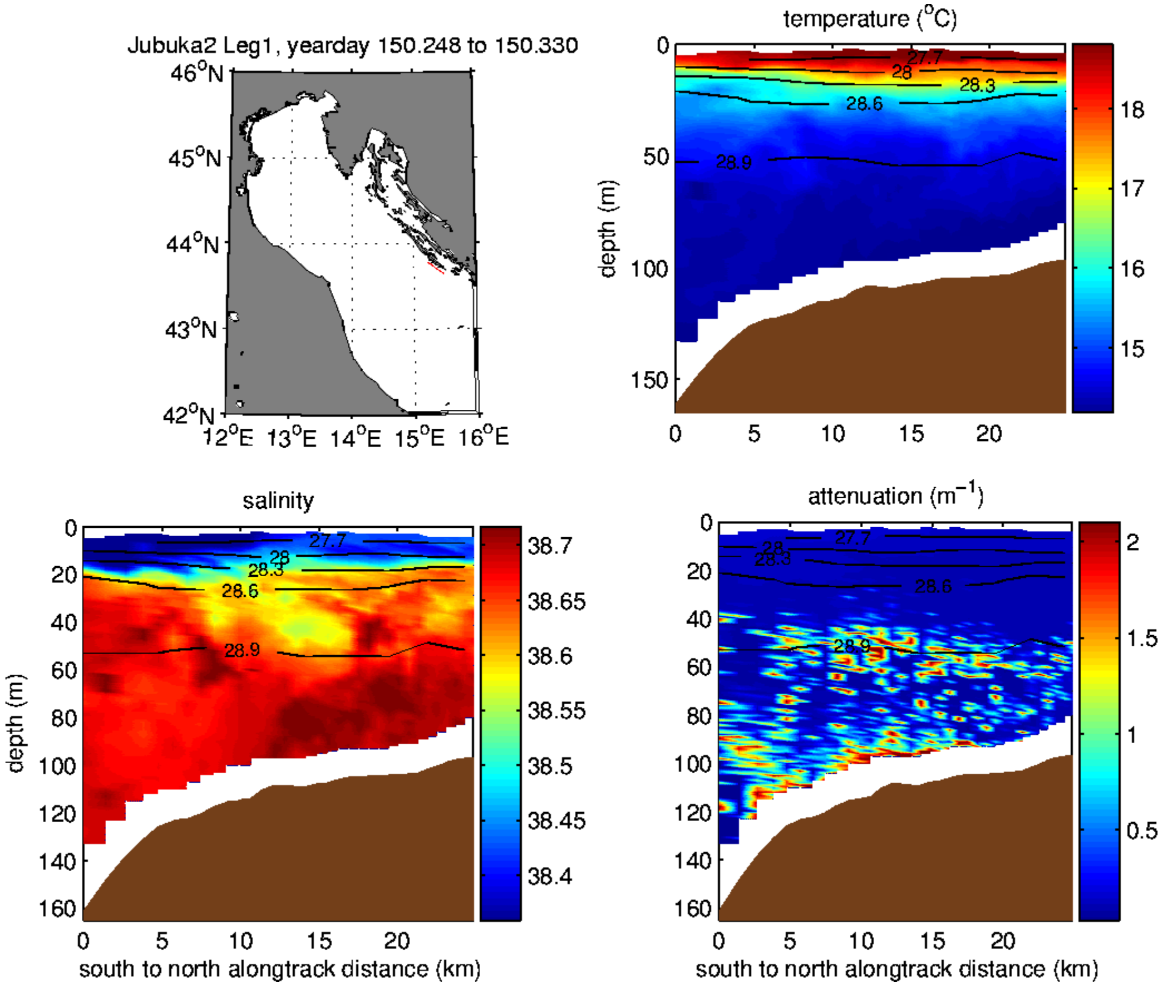


Figure 2.101: Temperature, salinity, and attenuation for Jubuka2 survey, Leg1 section. Overlaid contours are σ_θ.

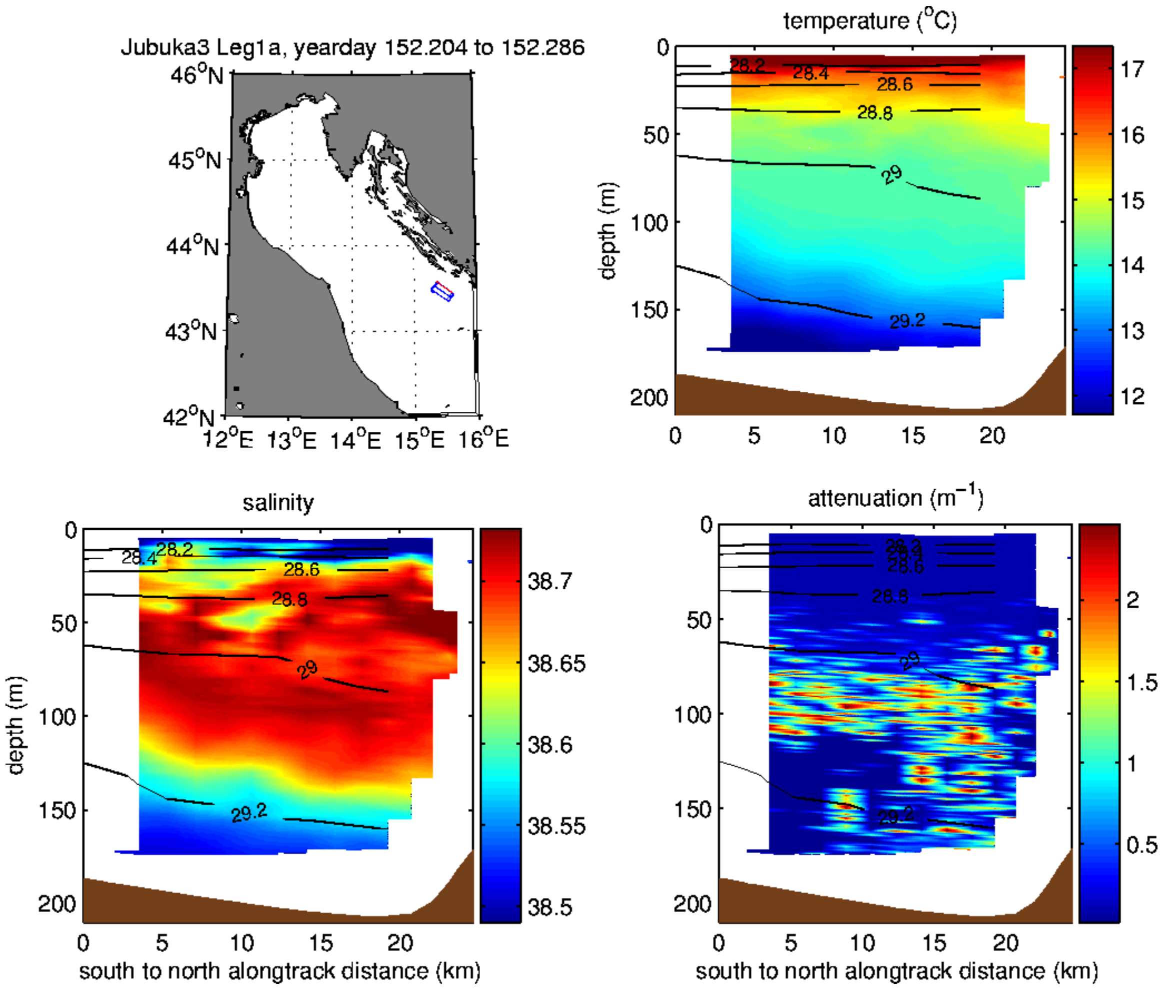


Figure 2.102: Temperature, salinity, and attenuation for Jubuka3 survey, Leg1a section. Overlaid contours are σ_θ.

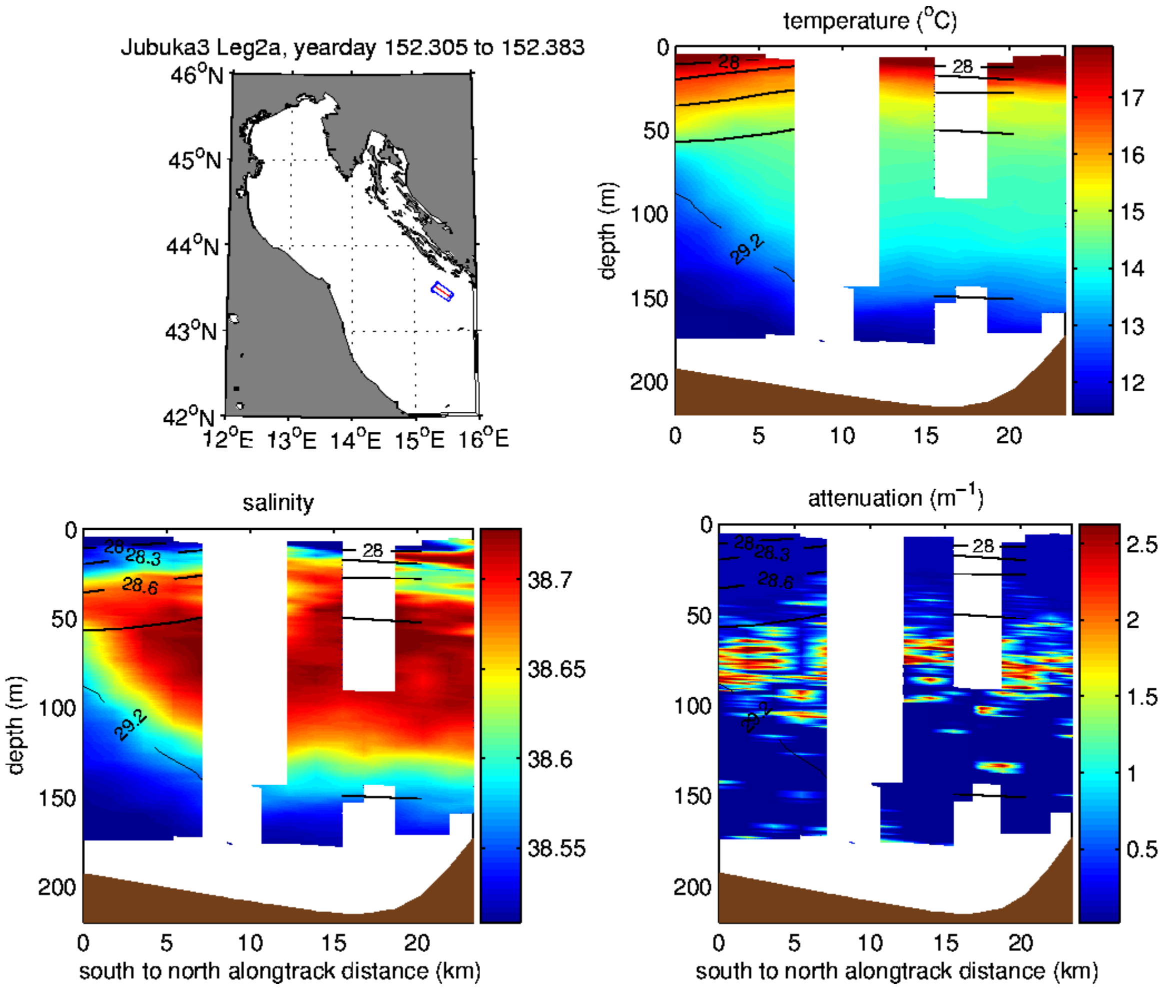


Figure 2.103: Temperature, salinity, and attenuation for Jubuka3 survey, Leg2a section. Overlaid contours are σ_θ.

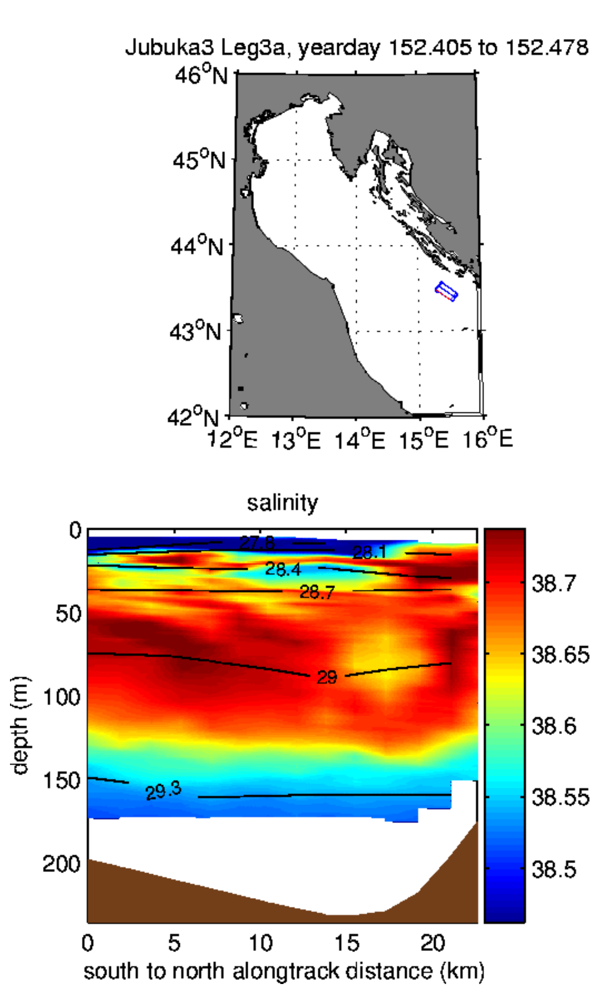


Figure 2.104: Temperature, salinity, and attenuation for Jubuka3 survey, Leg3a section. Overlaid contours are σ_θ.

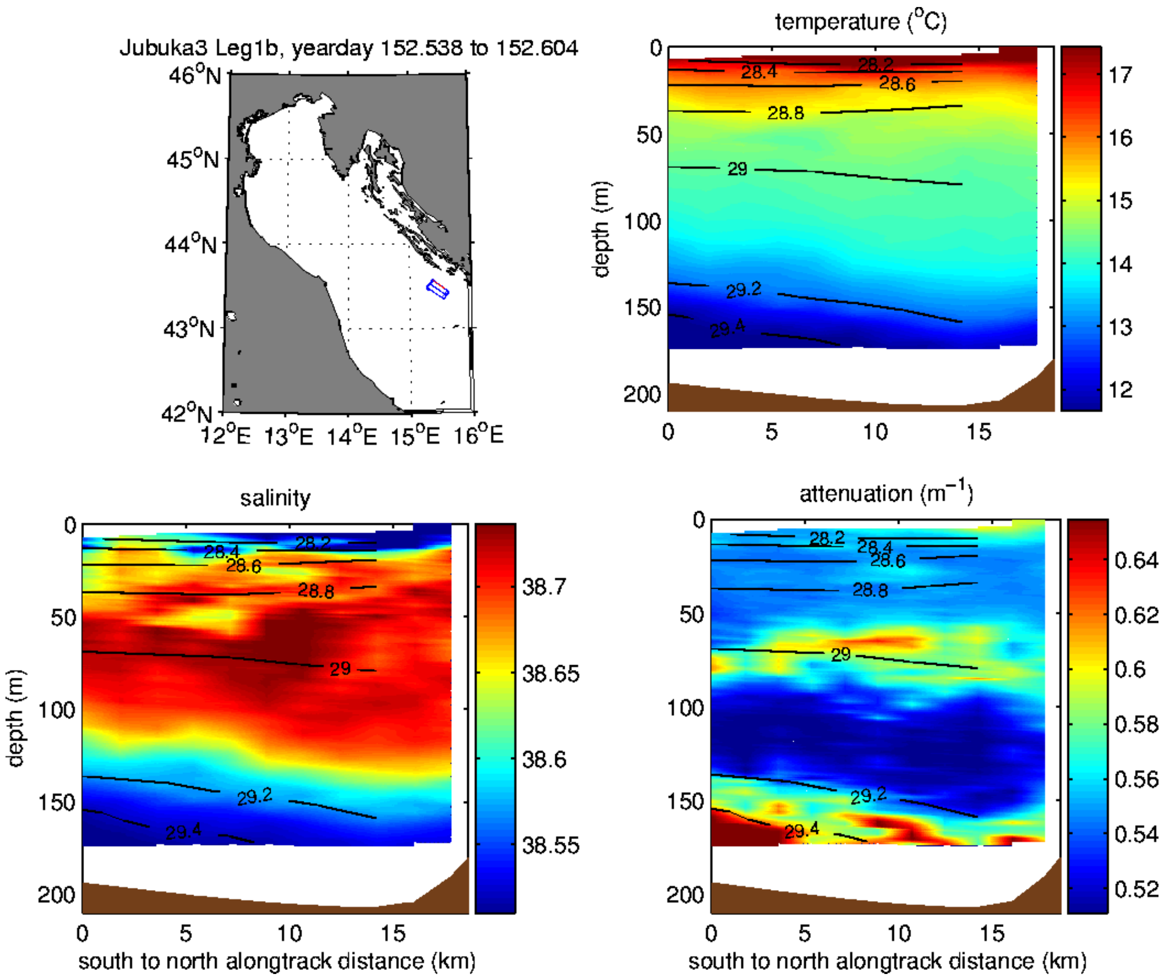


Figure 2.105: Temperature, salinity, and attenuation for Jubuka3 survey, Leg1b section. Overlaid contours are σ_θ.

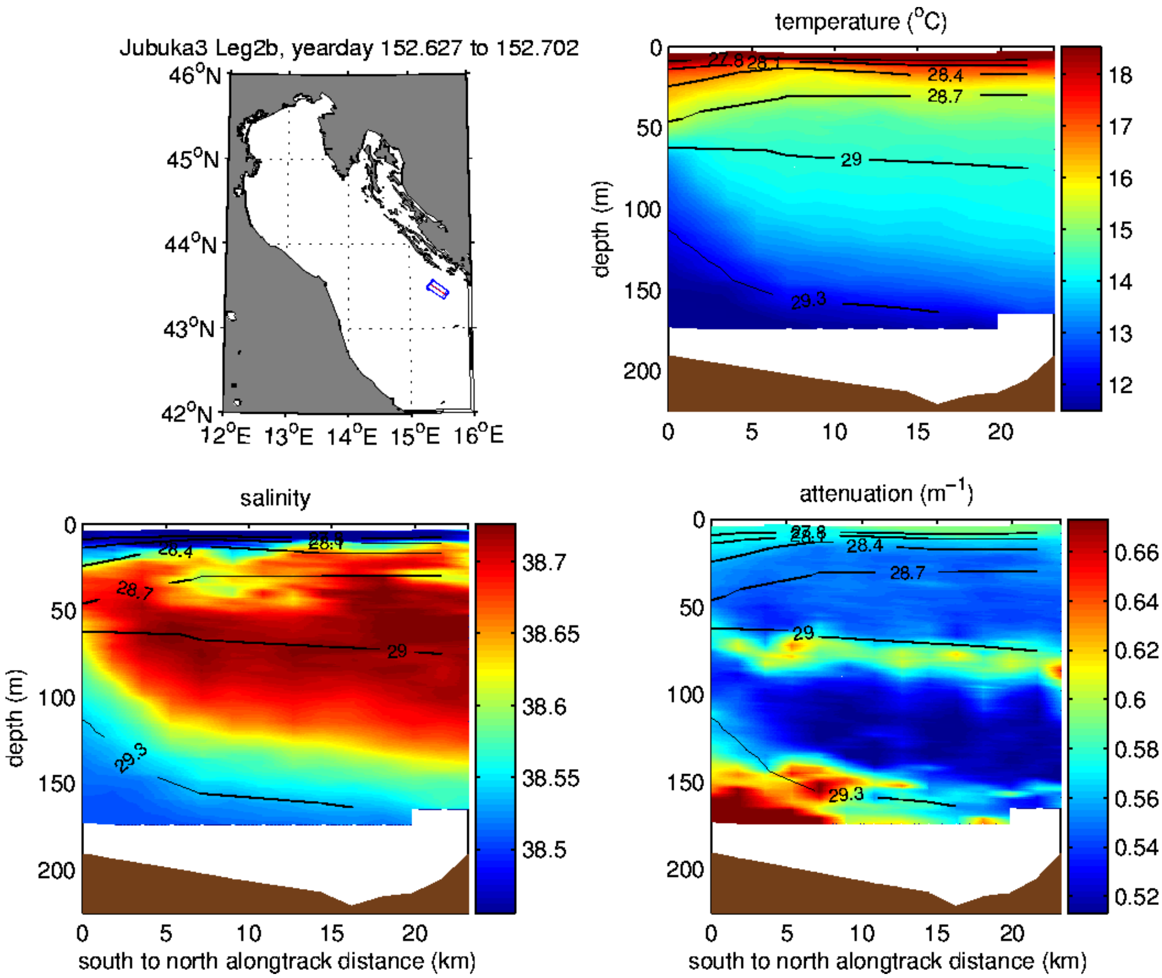


Figure 2.106: Temperature, salinity, and attenuation for Jubuka3 survey, Leg2b section. Overlaid contours are σ_θ.

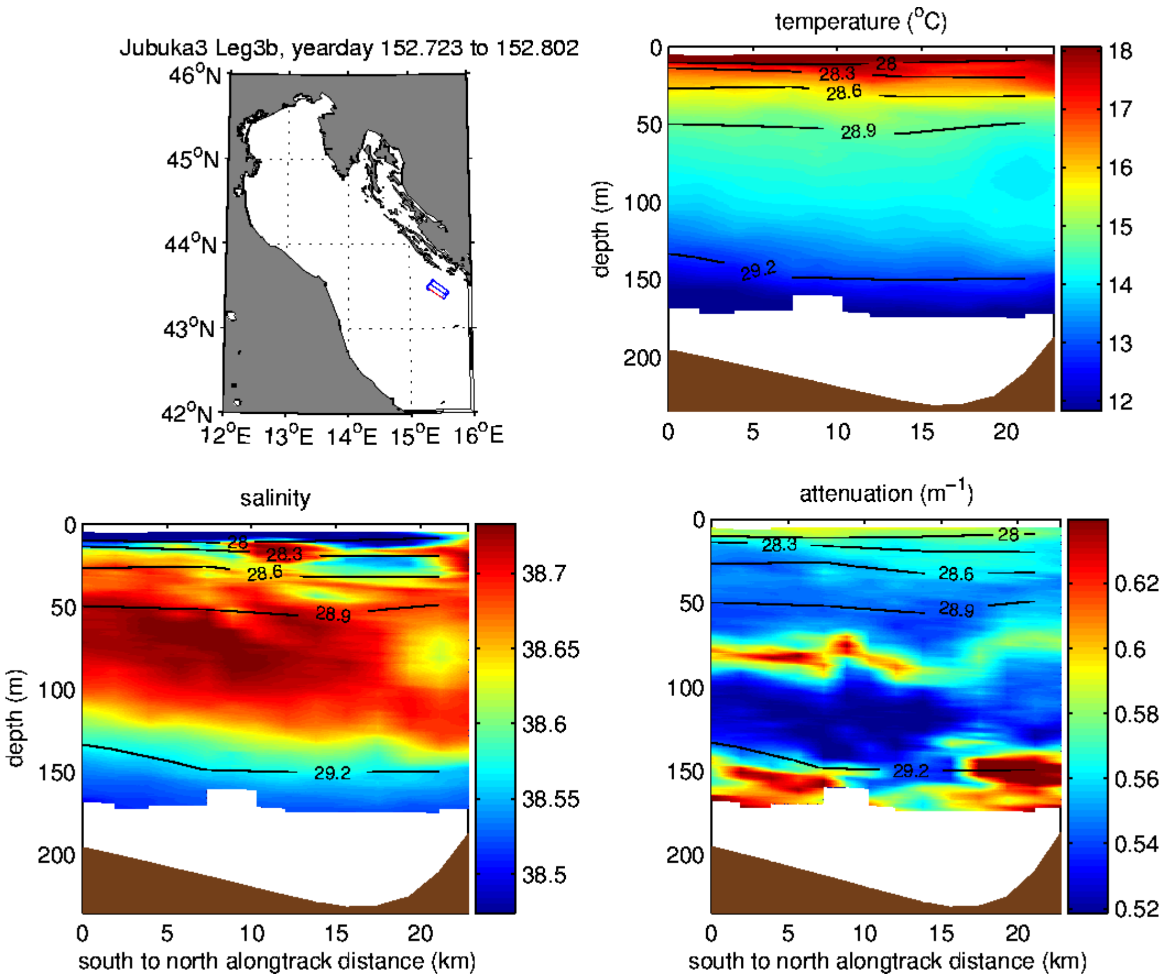


Figure 2.107: Temperature, salinity, and attenuation for Jubuka3 survey, Leg3b section. Overlaid contours are σ_θ.

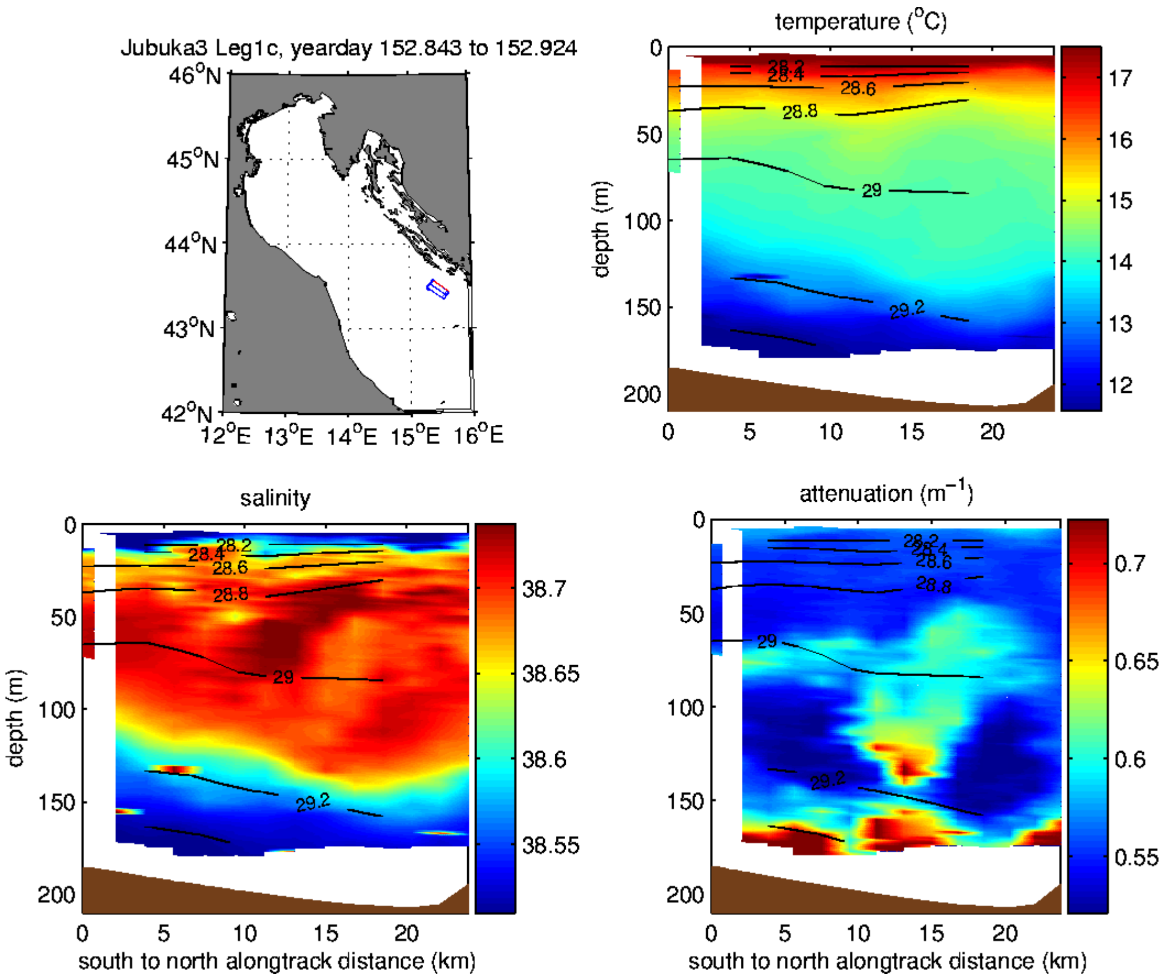


Figure 2.108: Temperature, salinity, and attenuation for Jubuka3 survey, Leg1c section. Overlaid contours are σ_θ.

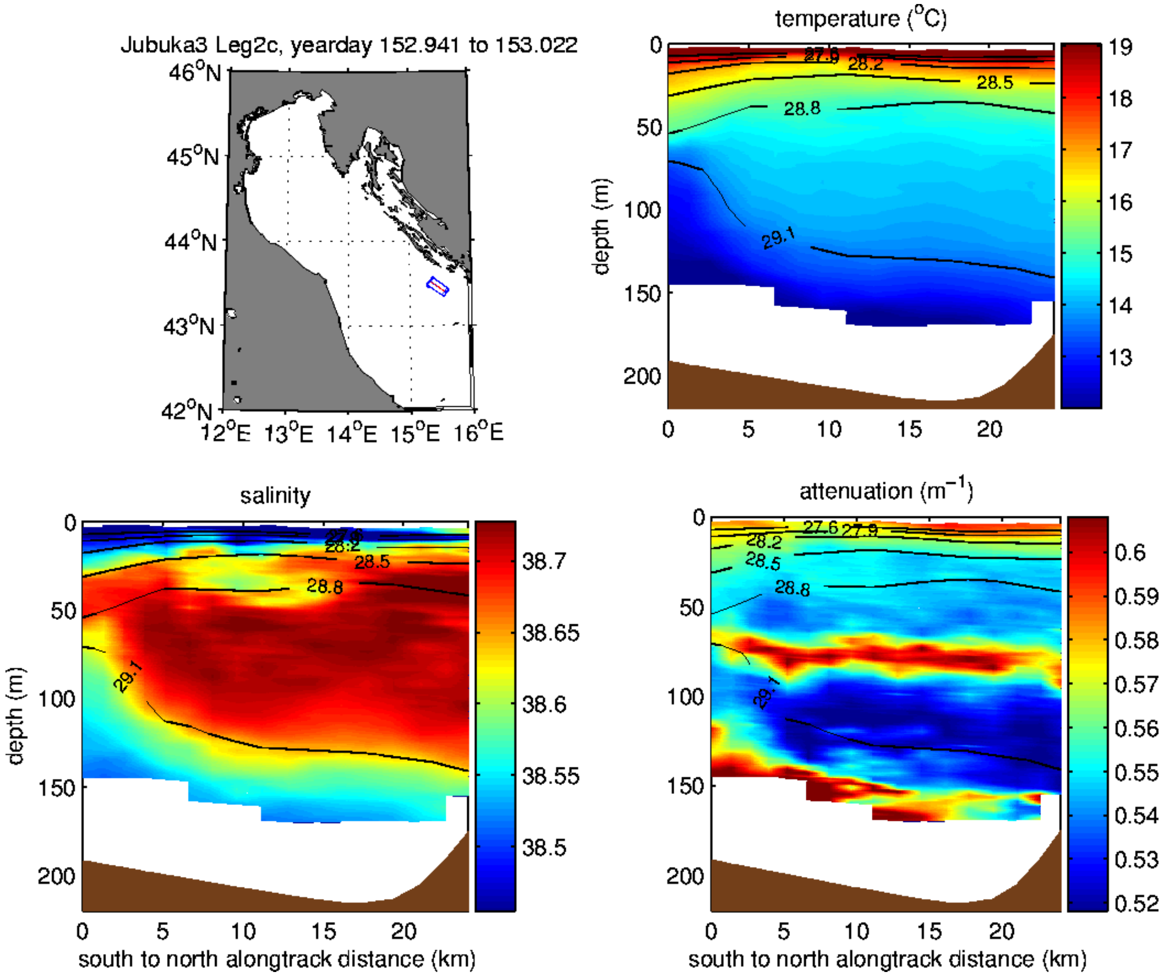


Figure 2.109: Temperature, salinity, and attenuation for Jubuka3 survey, Leg2c section. Overlaid contours are σ_θ.

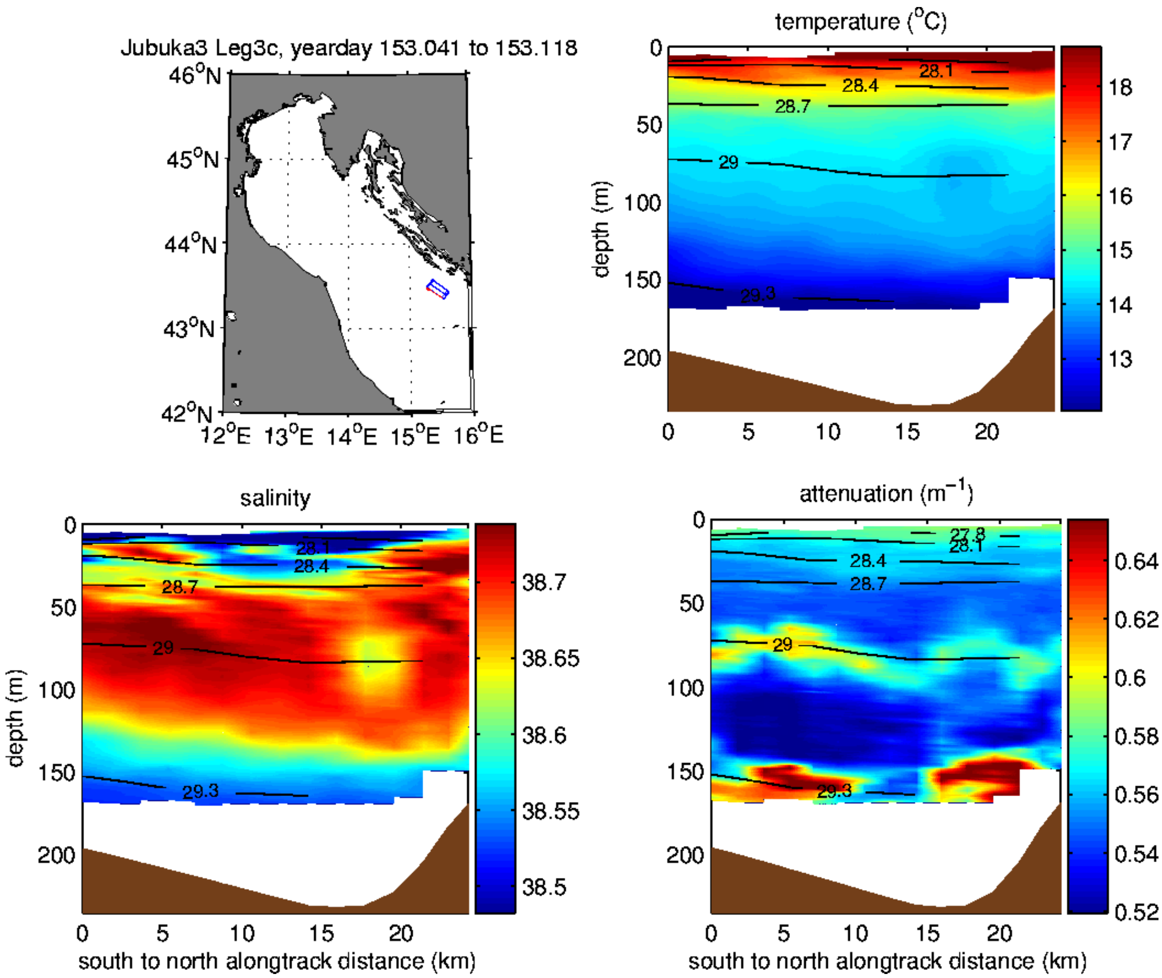


Figure 2.110: Temperature, salinity, and attenuation for Jubuka3 survey, Leg3c section. Overlaid contours are σ_θ.

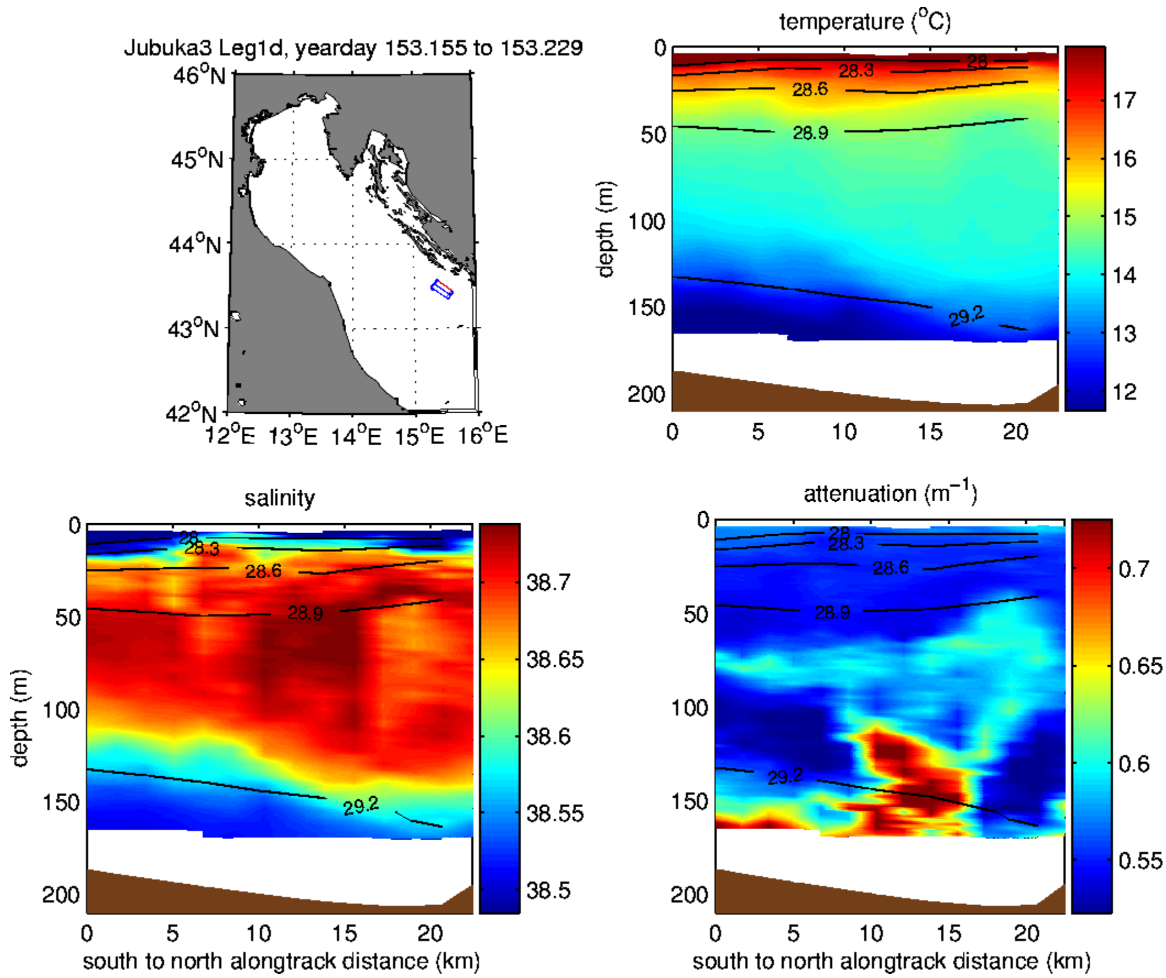


Figure 2.111: Temperature, salinity, and attenuation for Jubuka3 survey, Leg1d section. Overlaid contours are σ_θ.

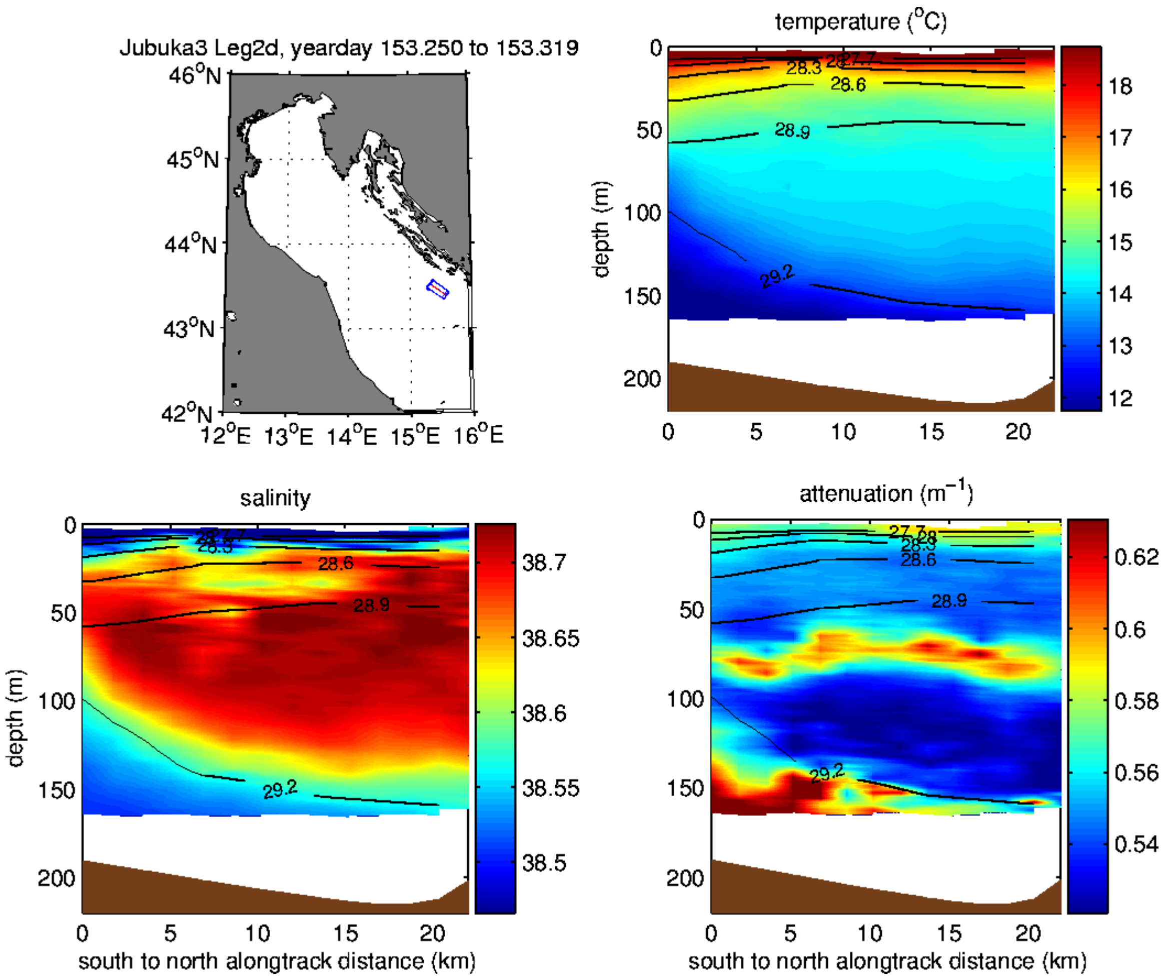


Figure 2.112: Temperature, salinity, and attenuation for Jubuka3 survey, Leg2d section. Overlaid contours are σ_θ.

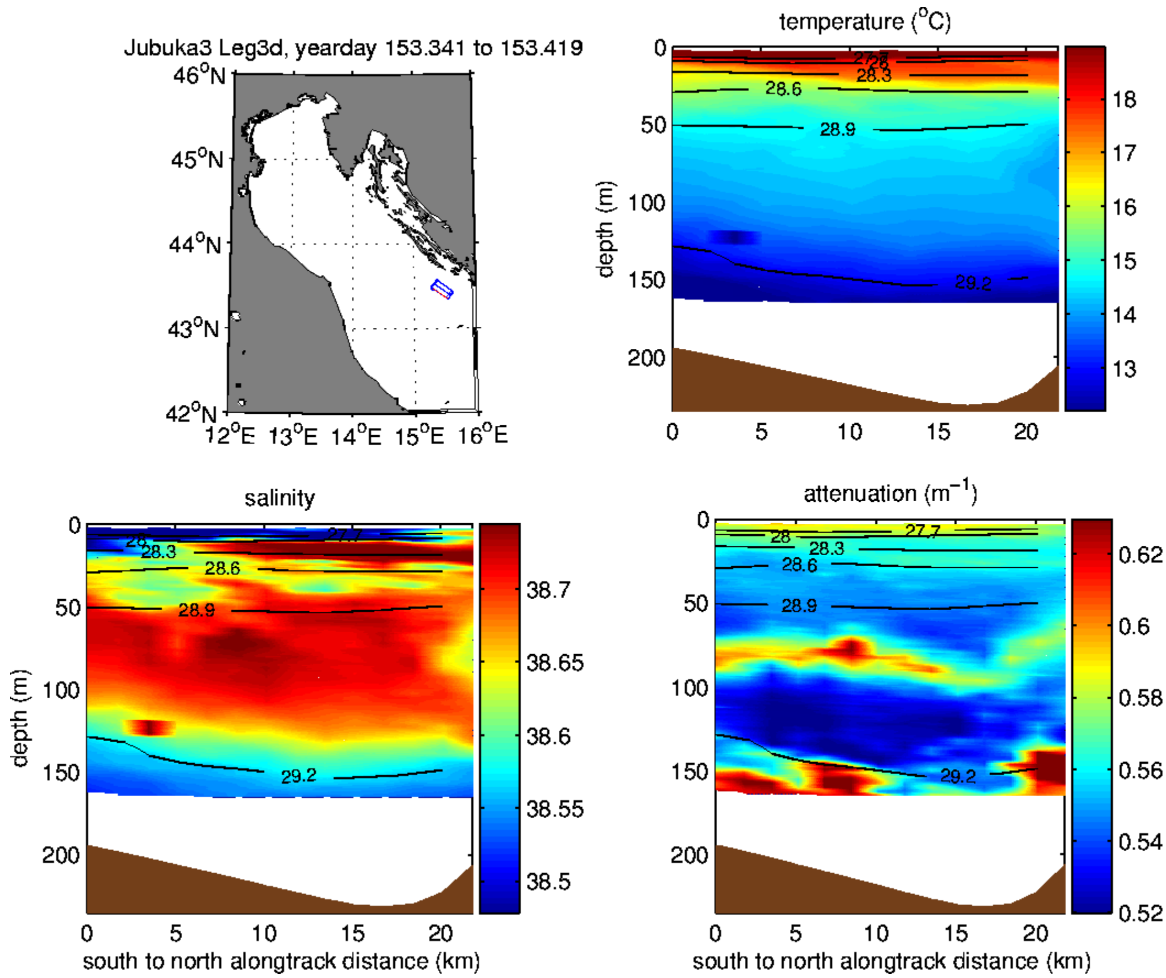


Figure 2.113: Temperature, salinity, and attenuation for Jubuka3 survey, Leg3d section. Overlaid contours are σ_θ.

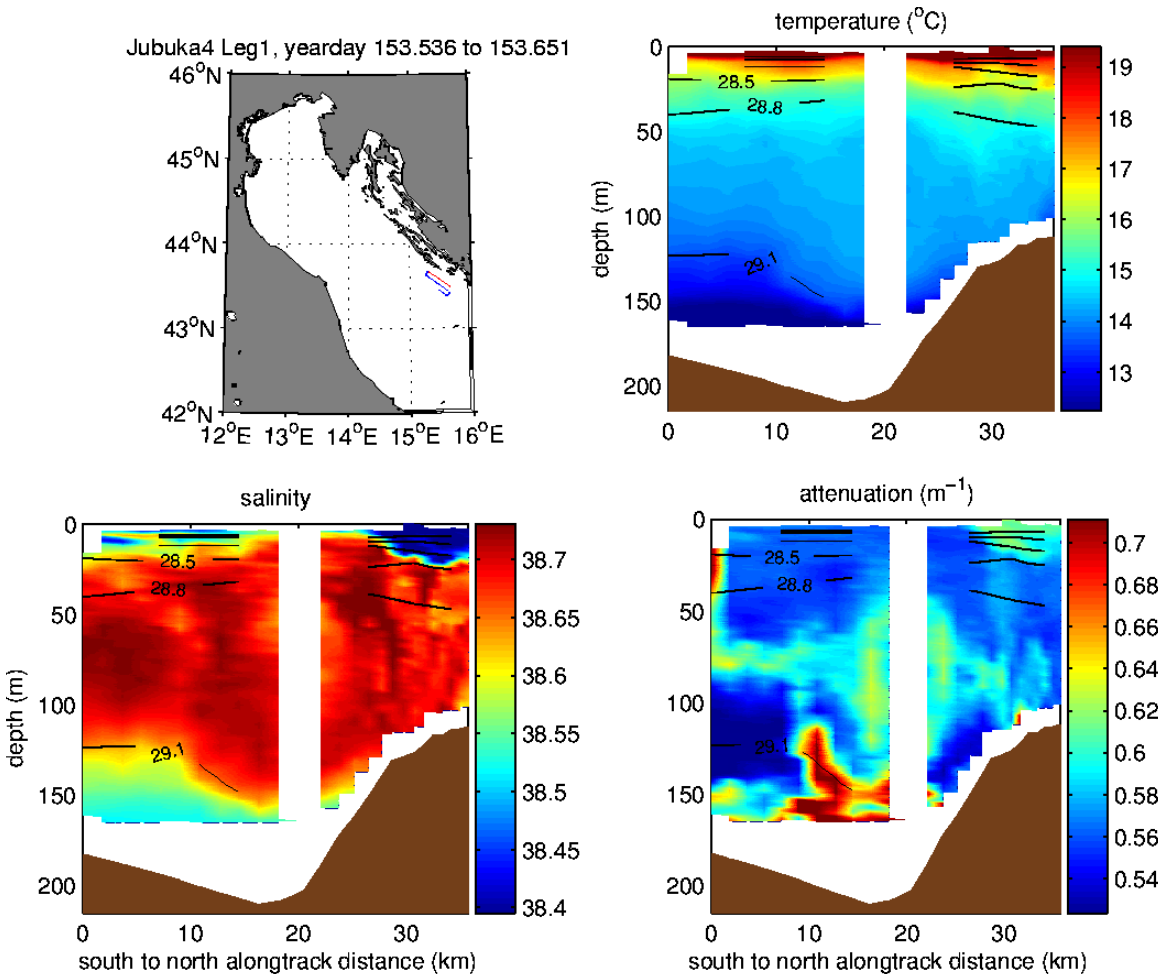


Figure 2.114: Temperature, salinity, and attenuation for Jubuka4 survey, Leg1 section. Overlaid contours are σ_θ.

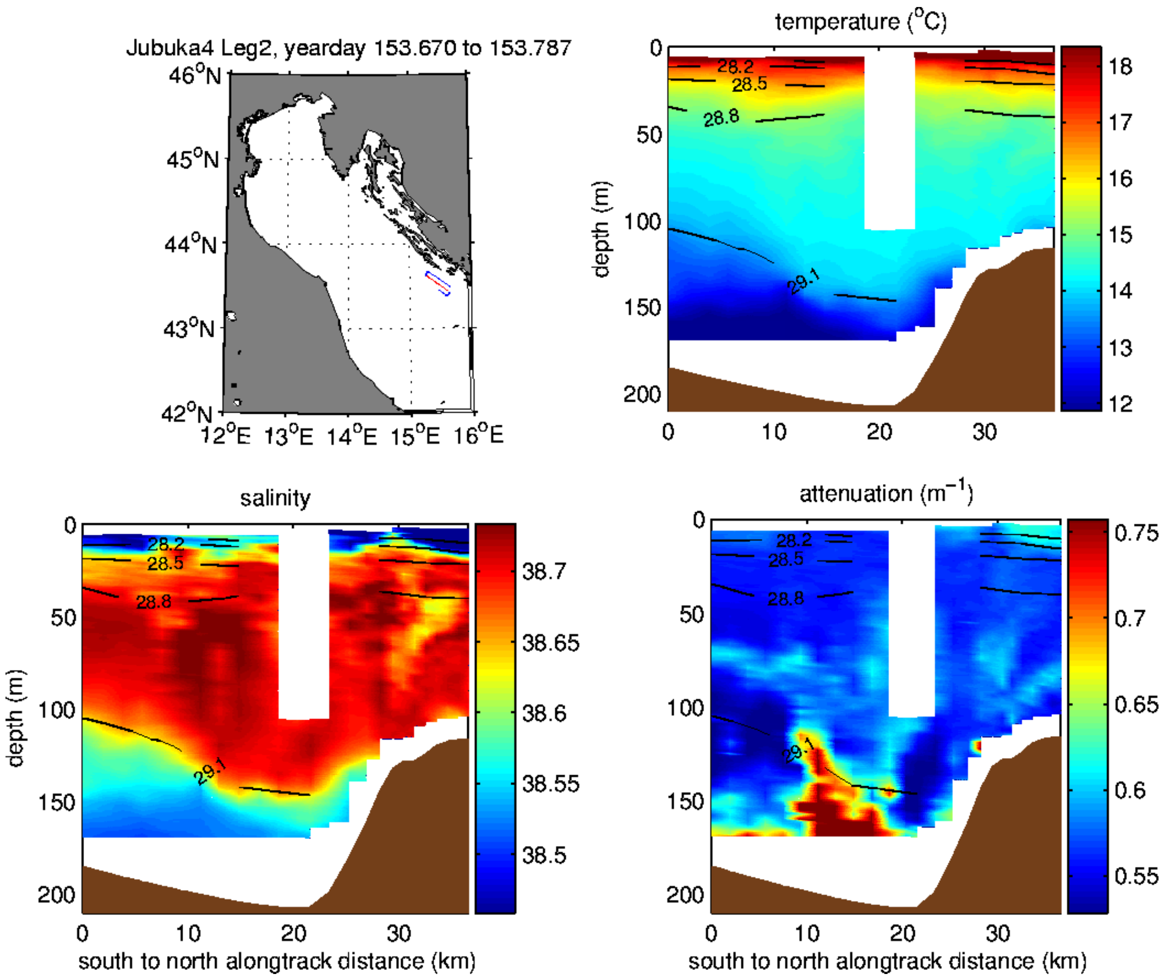


Figure 2.115: Temperature, salinity, and attenuation for Jubuka4 survey, Leg2 section. Overlaid contours are σ_θ.

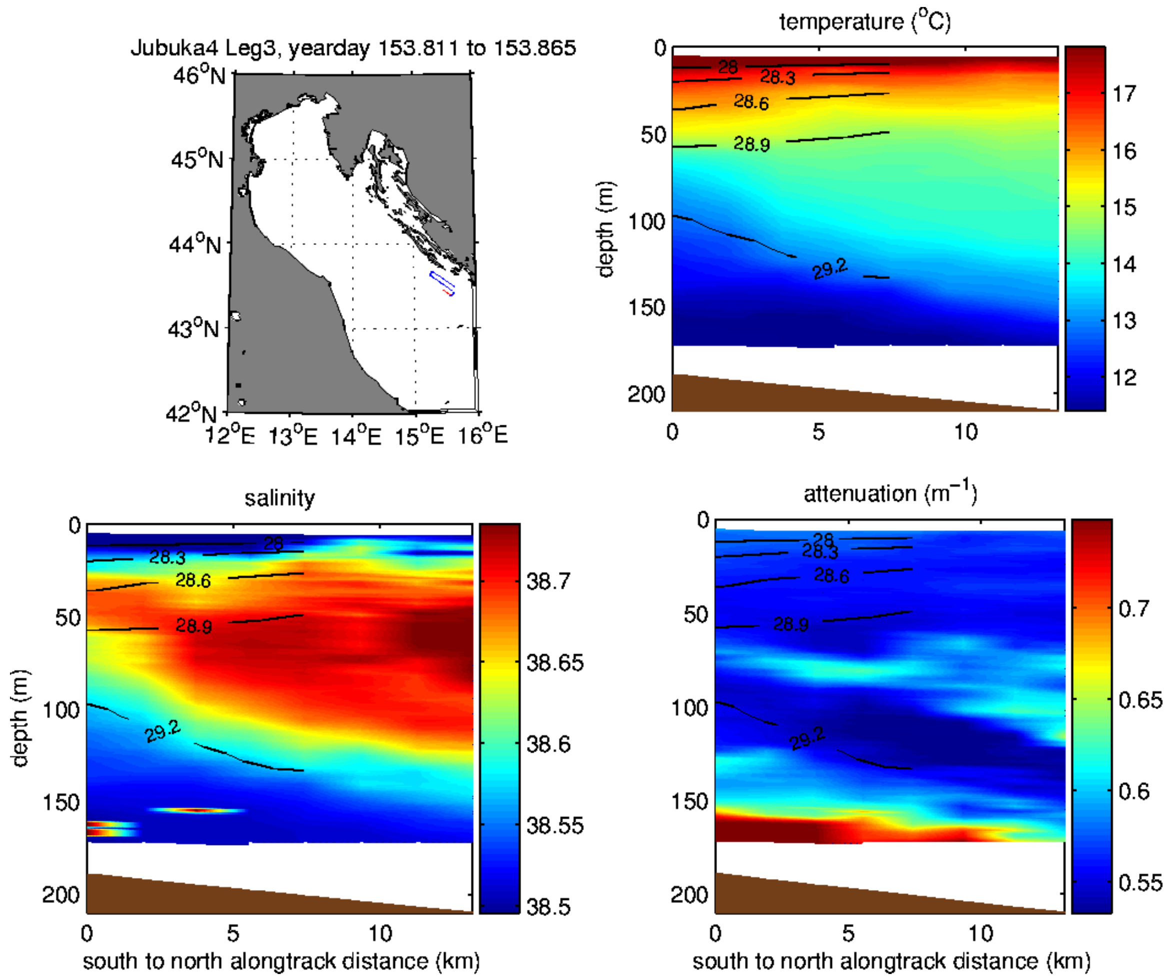


Figure 2.116: Temperature, salinity, and attenuation for Jubuka4 survey, Leg3 section. Overlaid contours are σ_θ.

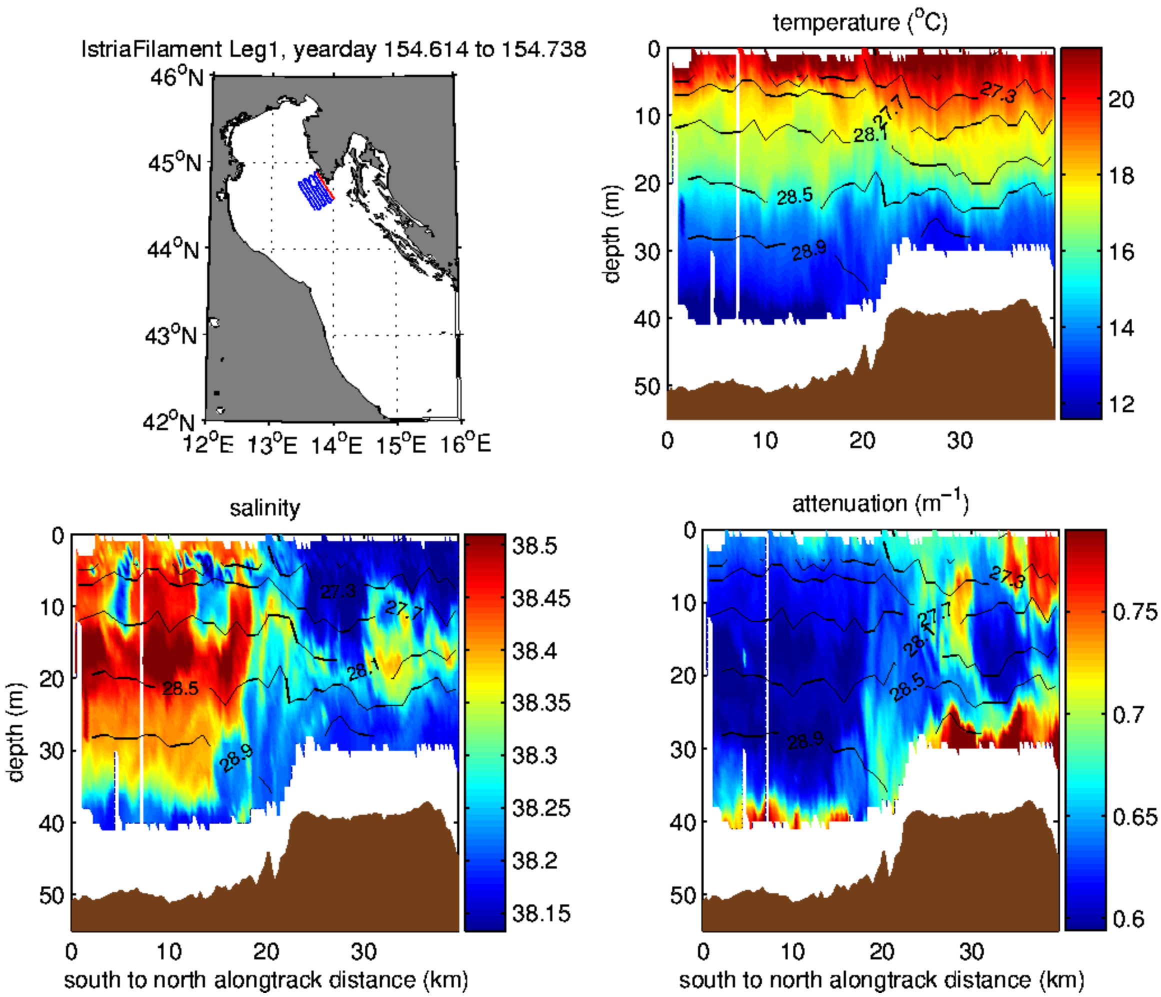


Figure 2.117: Temperature, salinity, and attenuation for IstriaFilament survey, Leg1 section. Overlaid contours are σ_θ.

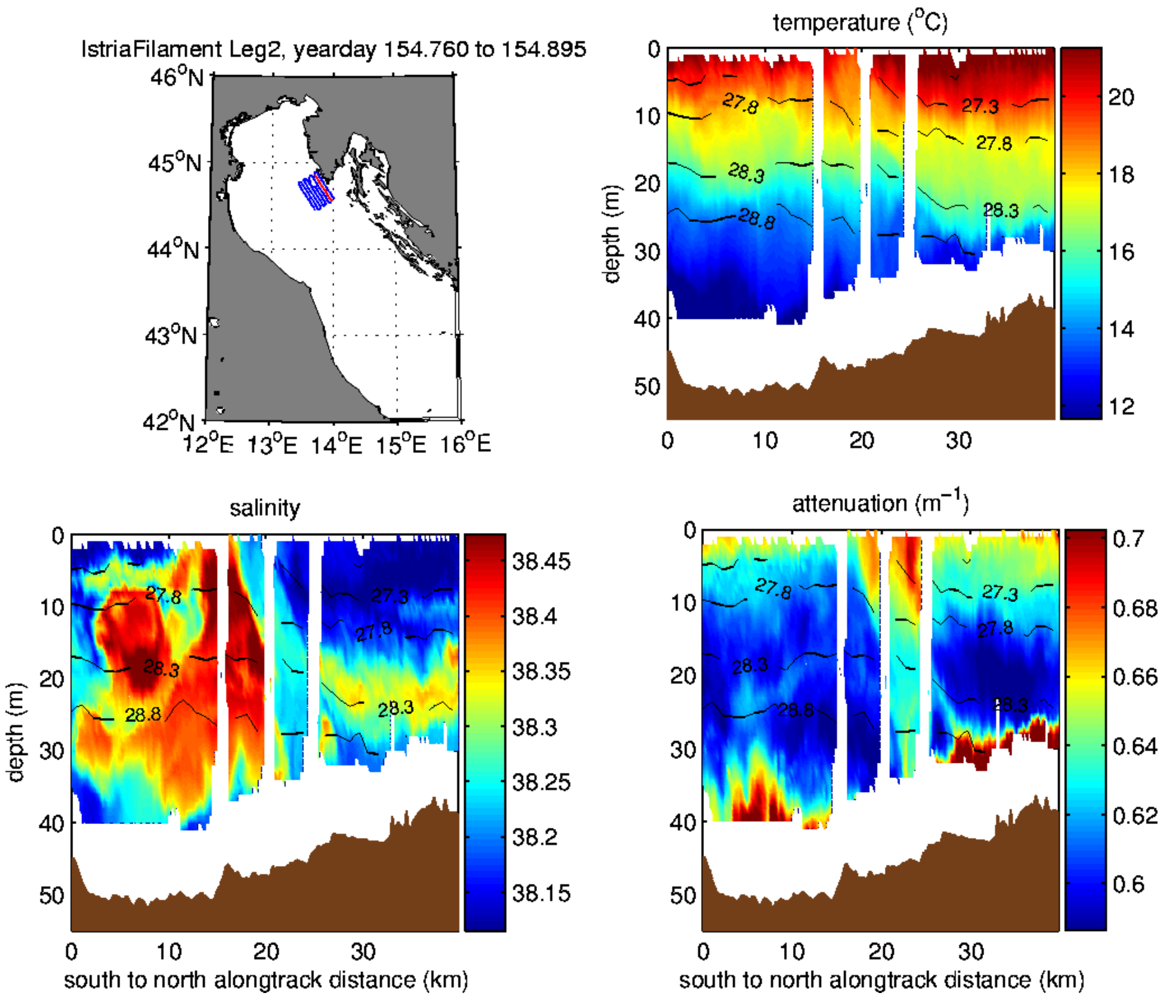


Figure 2.118: Temperature, salinity, and attenuation for IstriaFilament survey, Leg2 section. Overlaid contours are σ_θ.

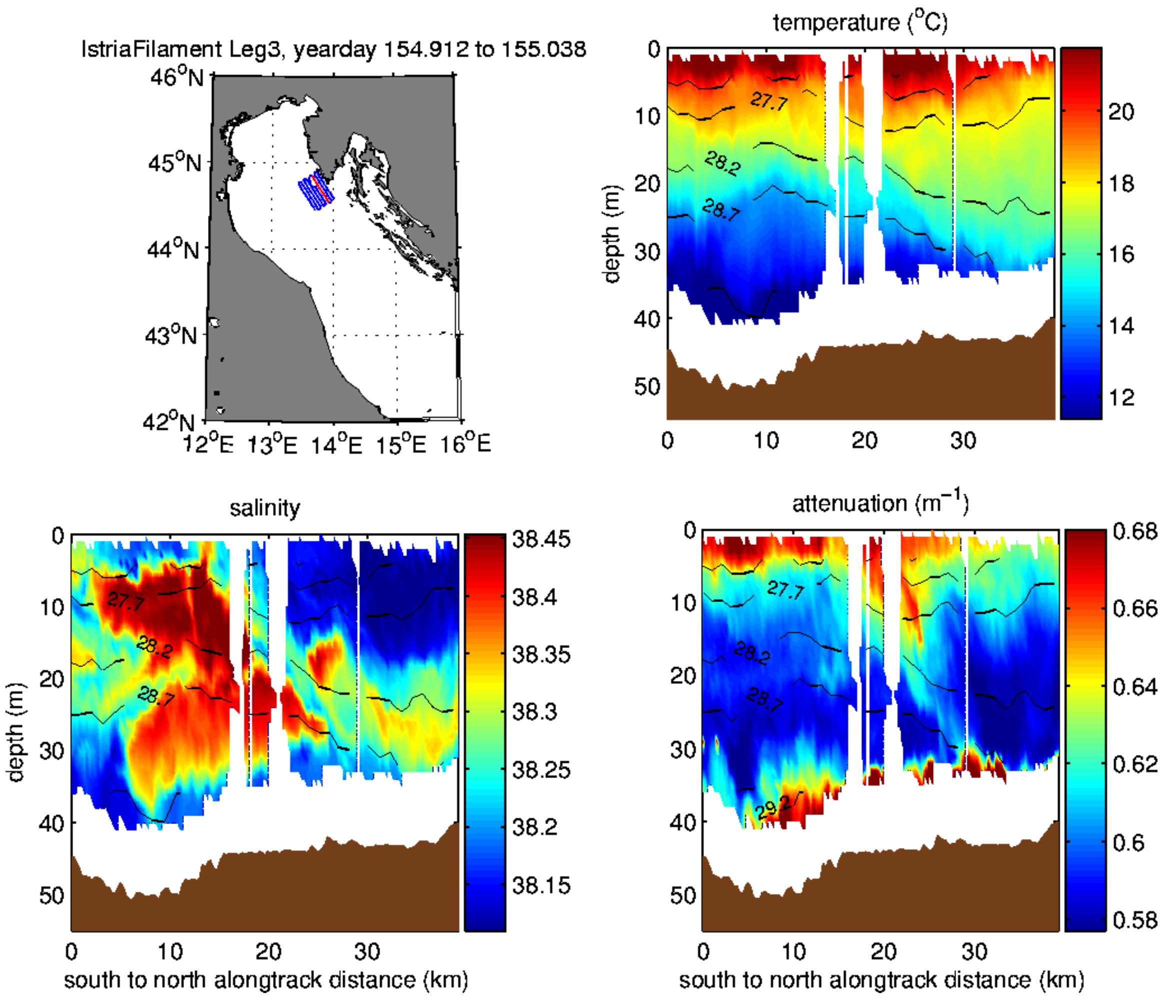


Figure 2.119: Temperature, salinity, and attenuation for IstriaFilament survey, Leg3 section. Overlaid contours are σ_θ.

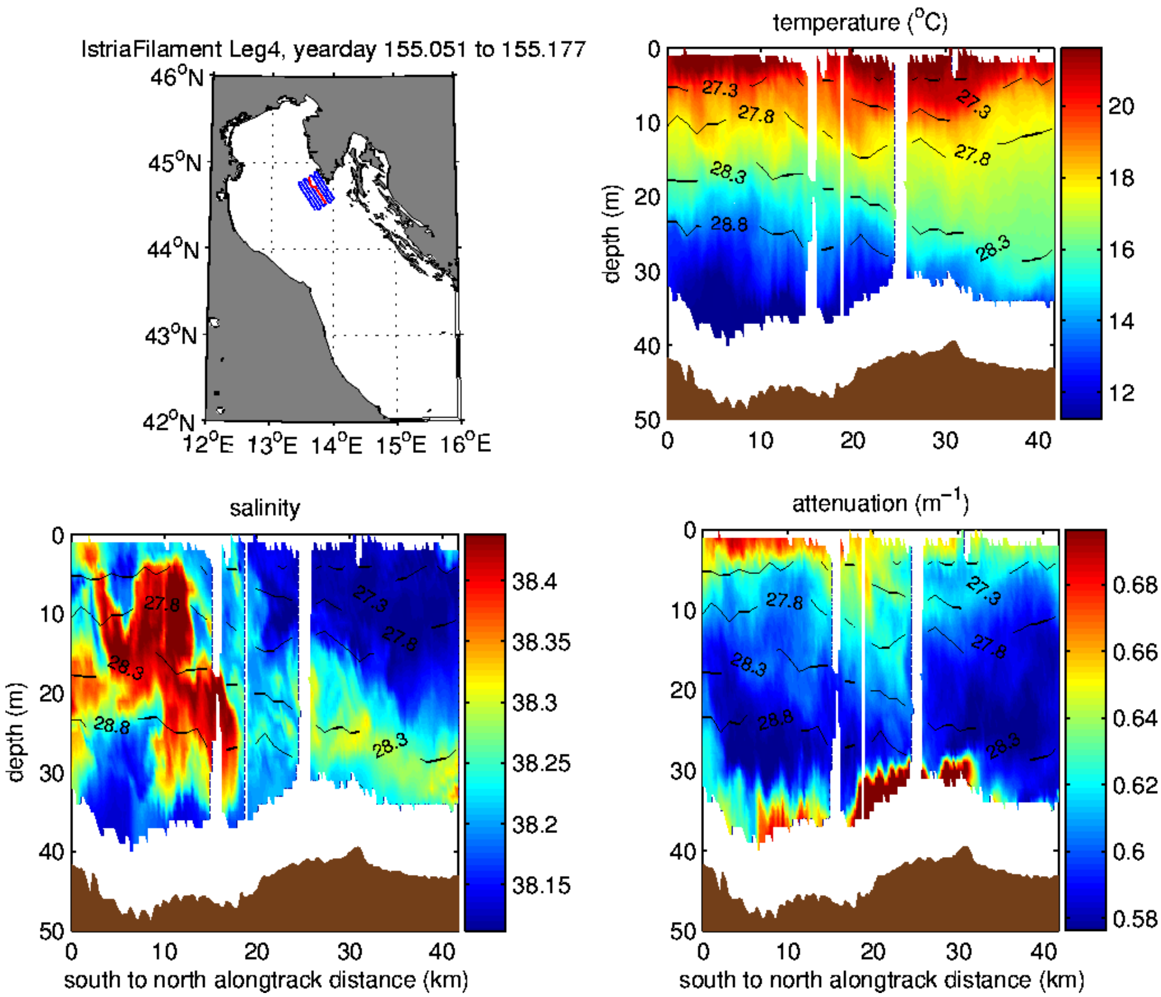


Figure 2.120: Temperature, salinity, and attenuation for IstriaFilament survey, Leg4 section. Overlaid contours are σ_θ.

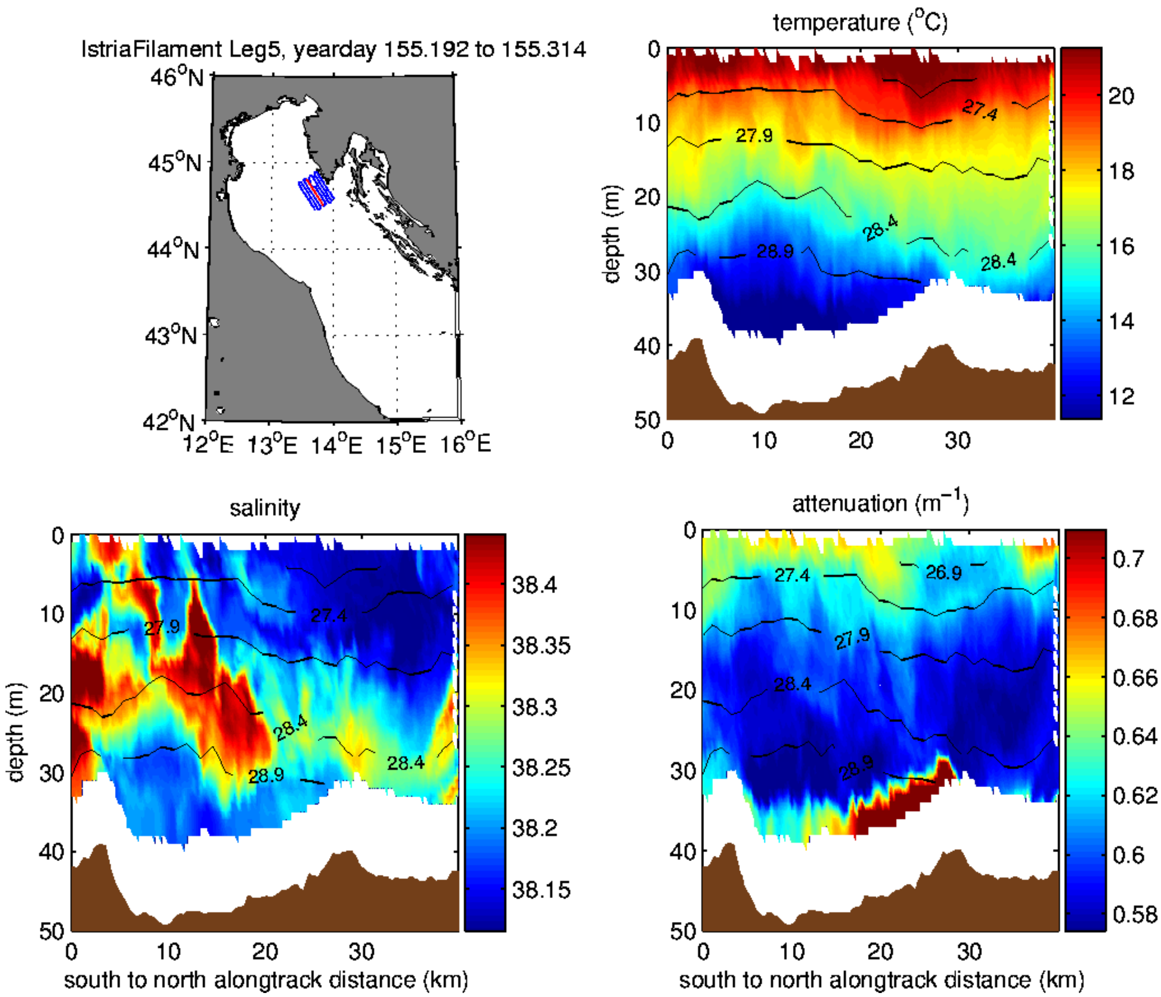


Figure 2.121: Temperature, salinity, and attenuation for IstriaFilament survey, Leg5 section. Overlaid contours are σ_θ.

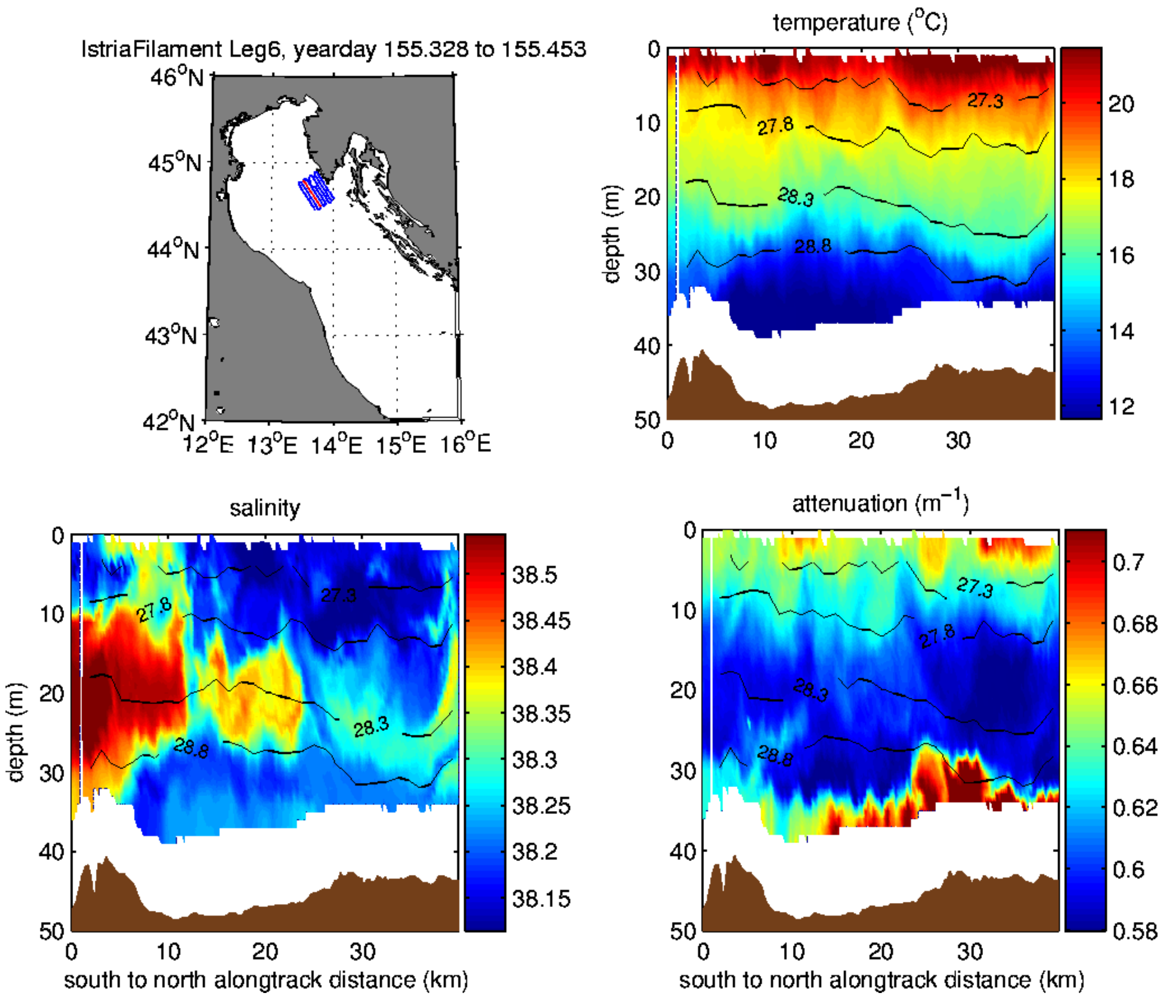


Figure 2.122: Temperature, salinity, and attenuation for IstriaFilament survey, Leg6 section. Overlaid contours are σ_θ.

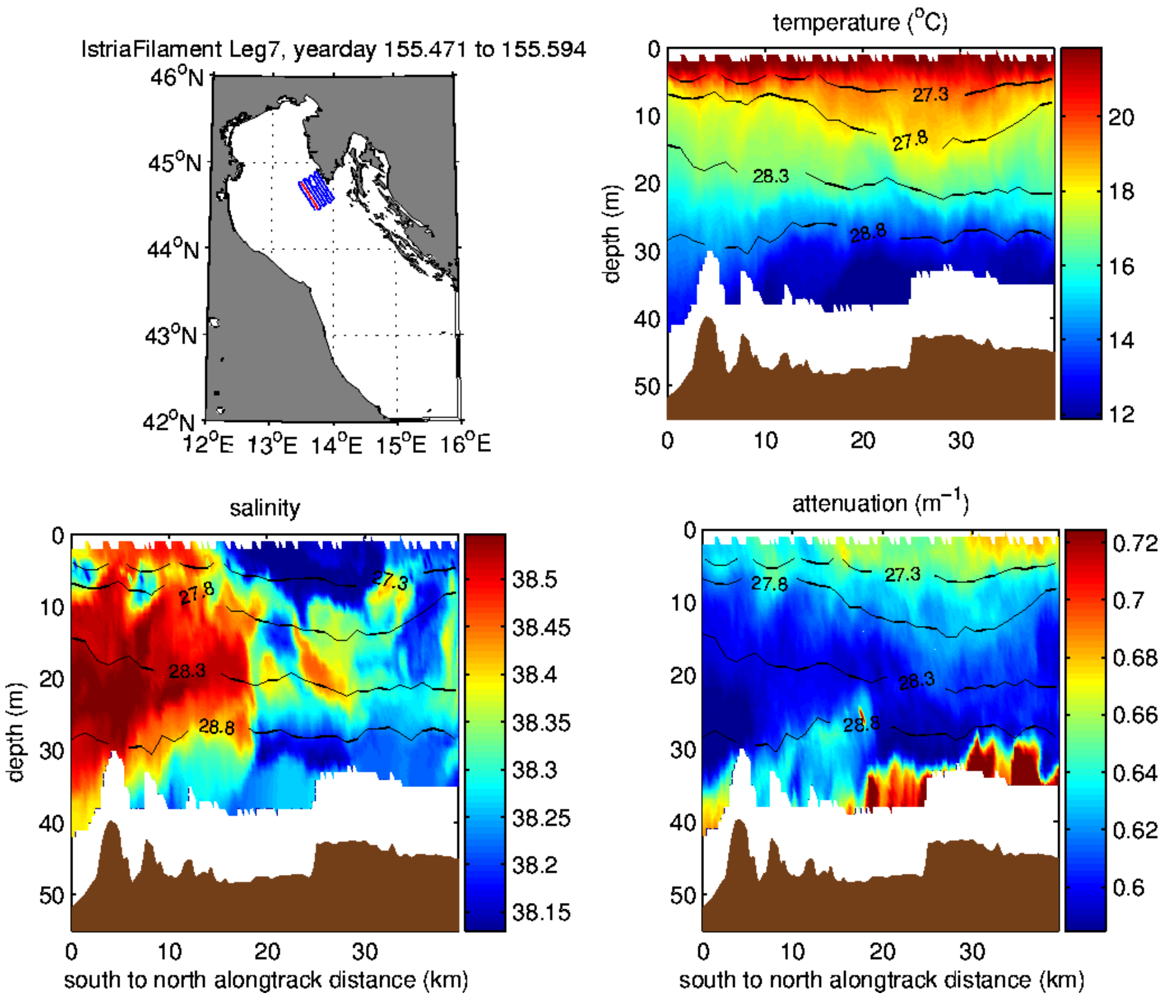


Figure 2.123: Temperature, salinity, and attenuation for IstriaFilament survey, Leg7 section. Overlaid contours are σ_θ.

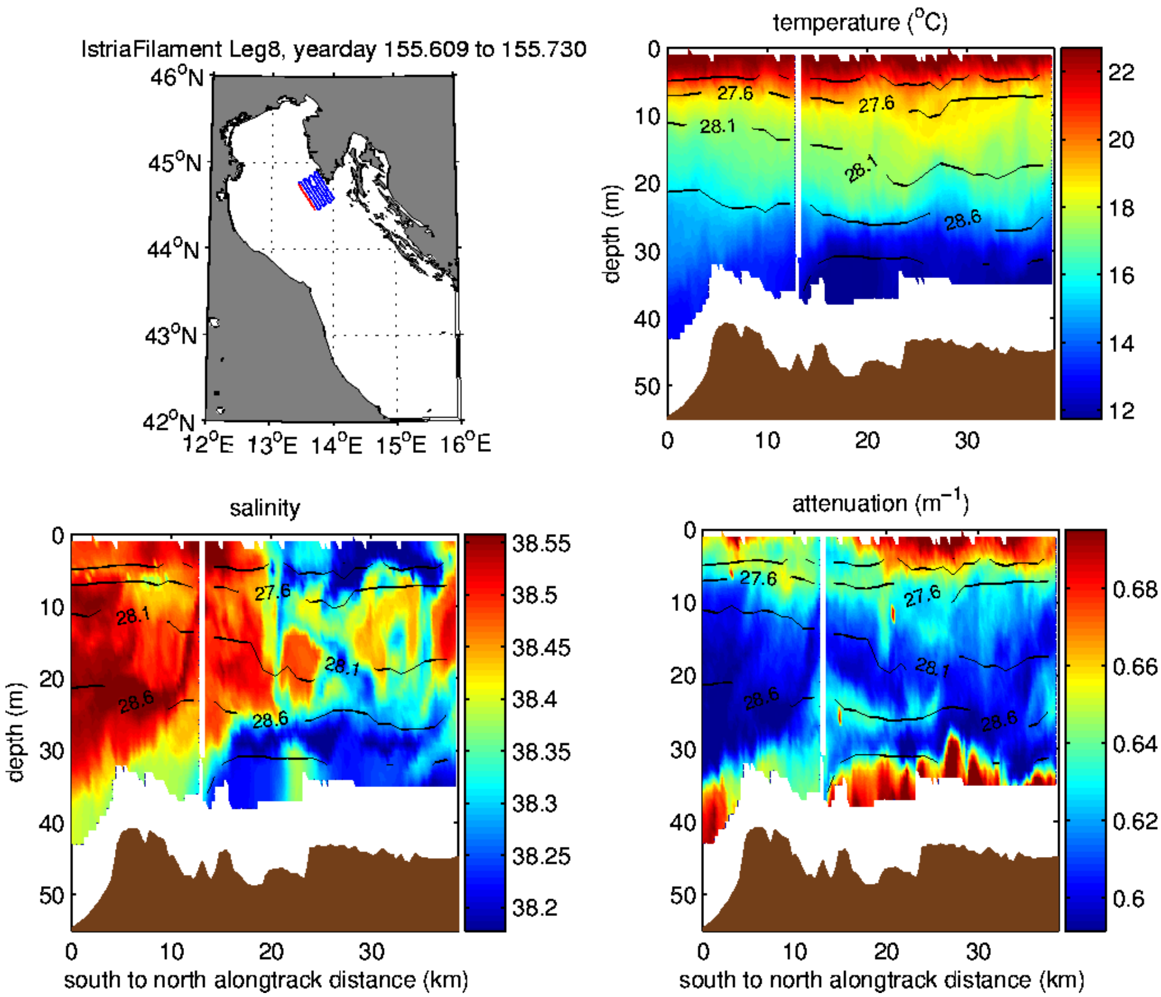


Figure 2.124: Temperature, salinity, and attenuation for IstriaFilament survey, Leg8 section. Overlaid contours are σ_θ.

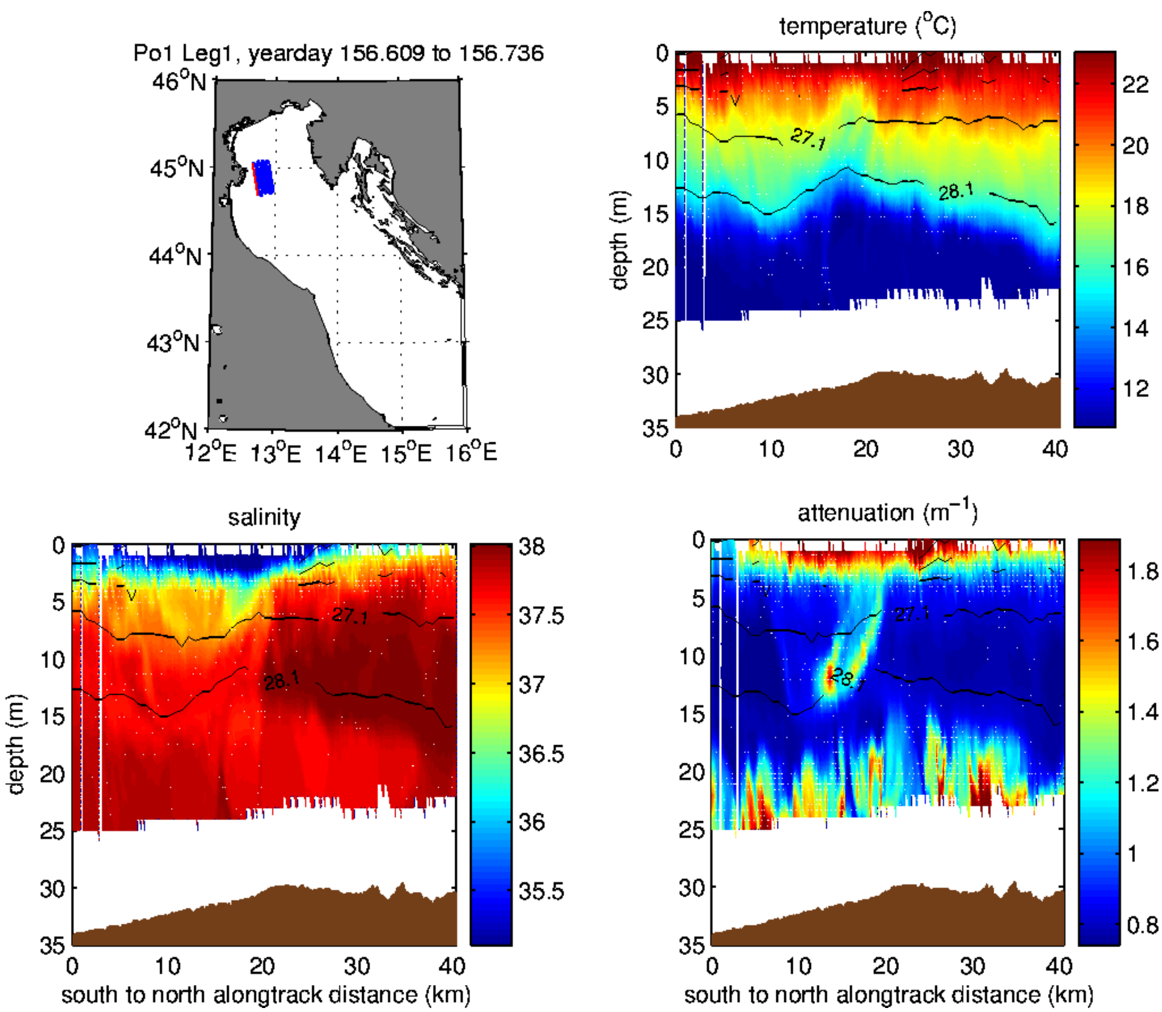


Figure 2.125: Temperature, salinity, and attenuation for Po1 survey, Leg1 section. Overlaid contours are σ_θ.

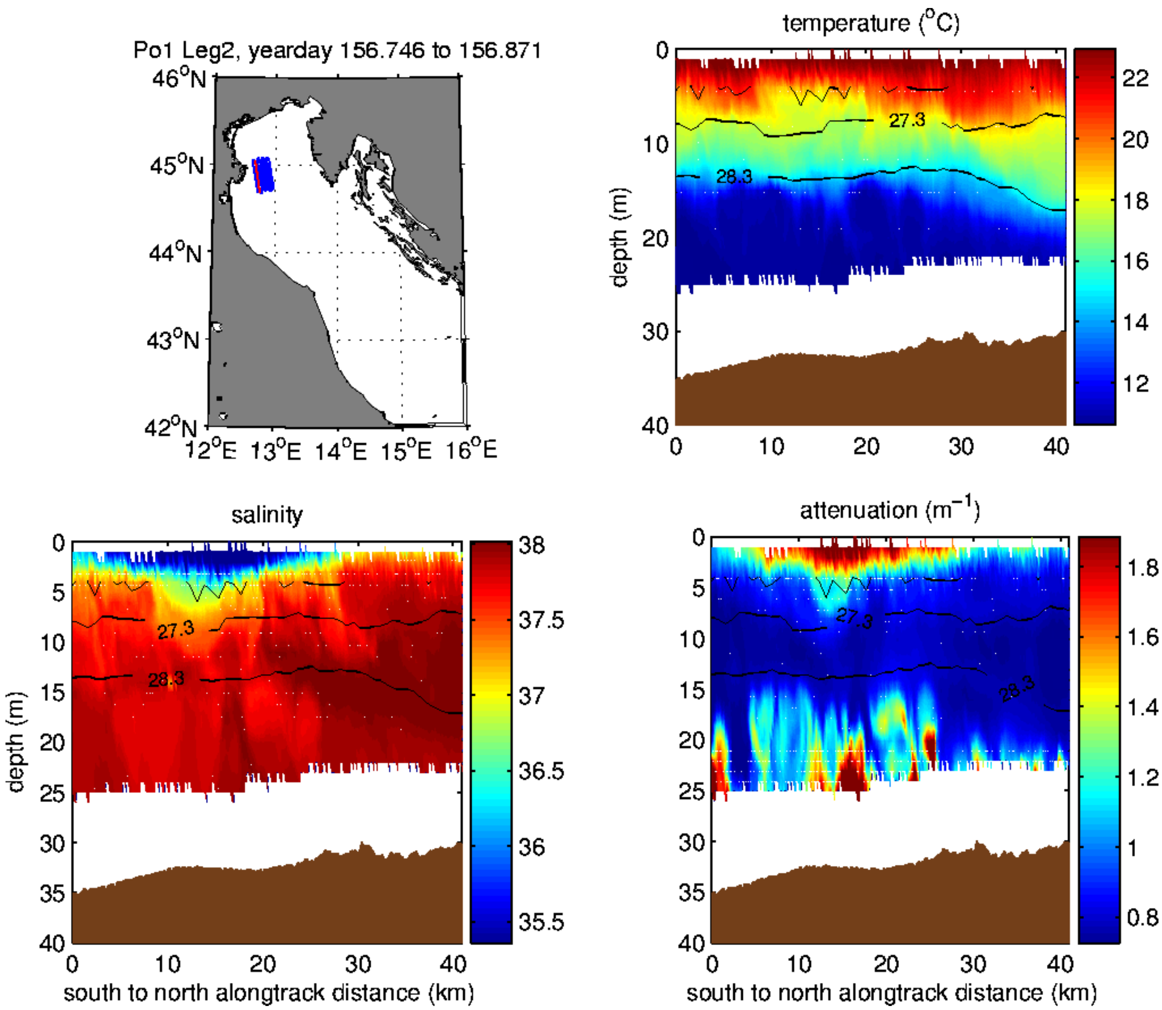


Figure 2.126: Temperature, salinity, and attenuation for Po1 survey, Leg2 section. Overlaid contours are σ_θ.

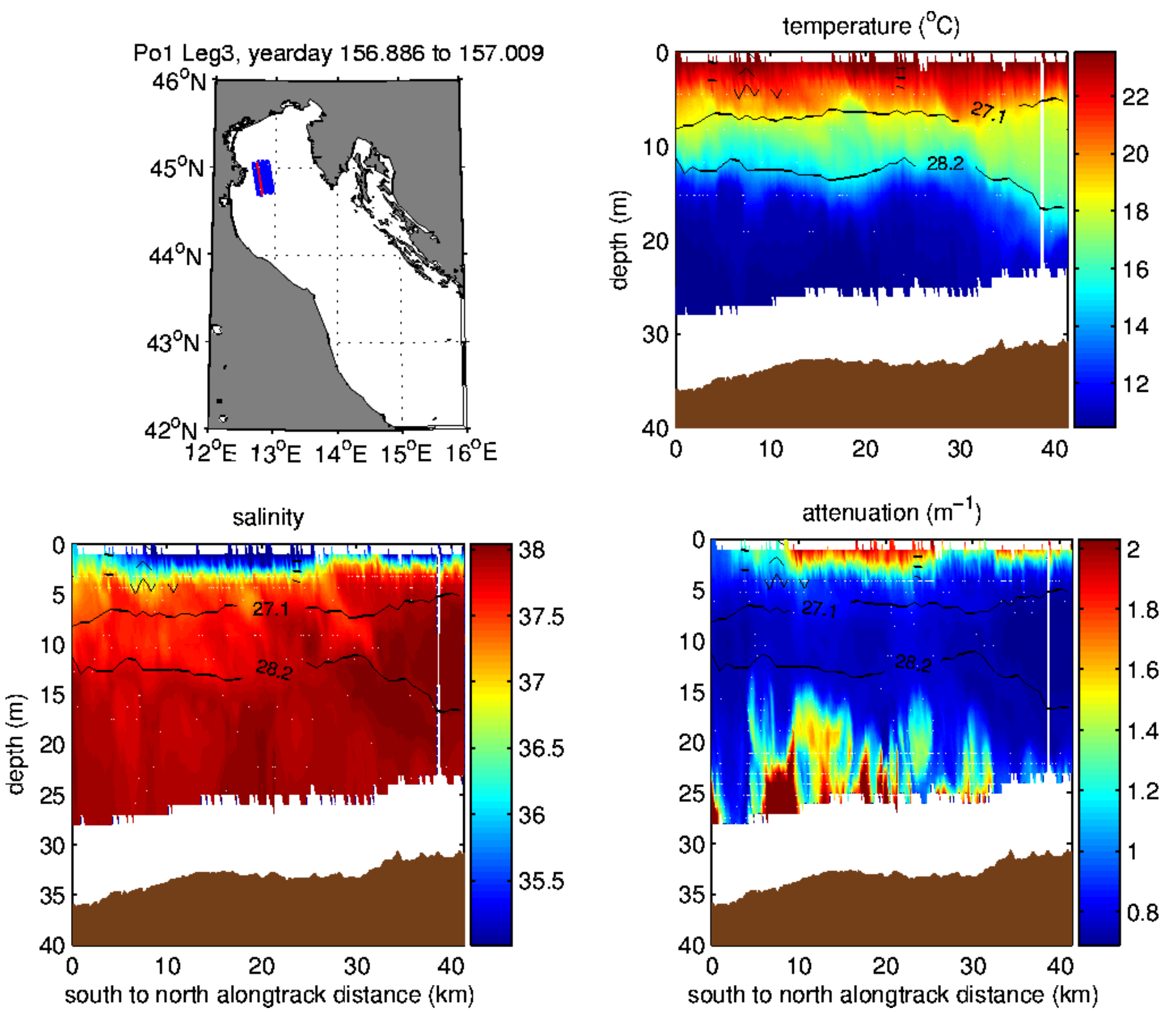


Figure 2.127: Temperature, salinity, and attenuation for Po1 survey, Leg3 section. Overlaid contours are σ_θ.

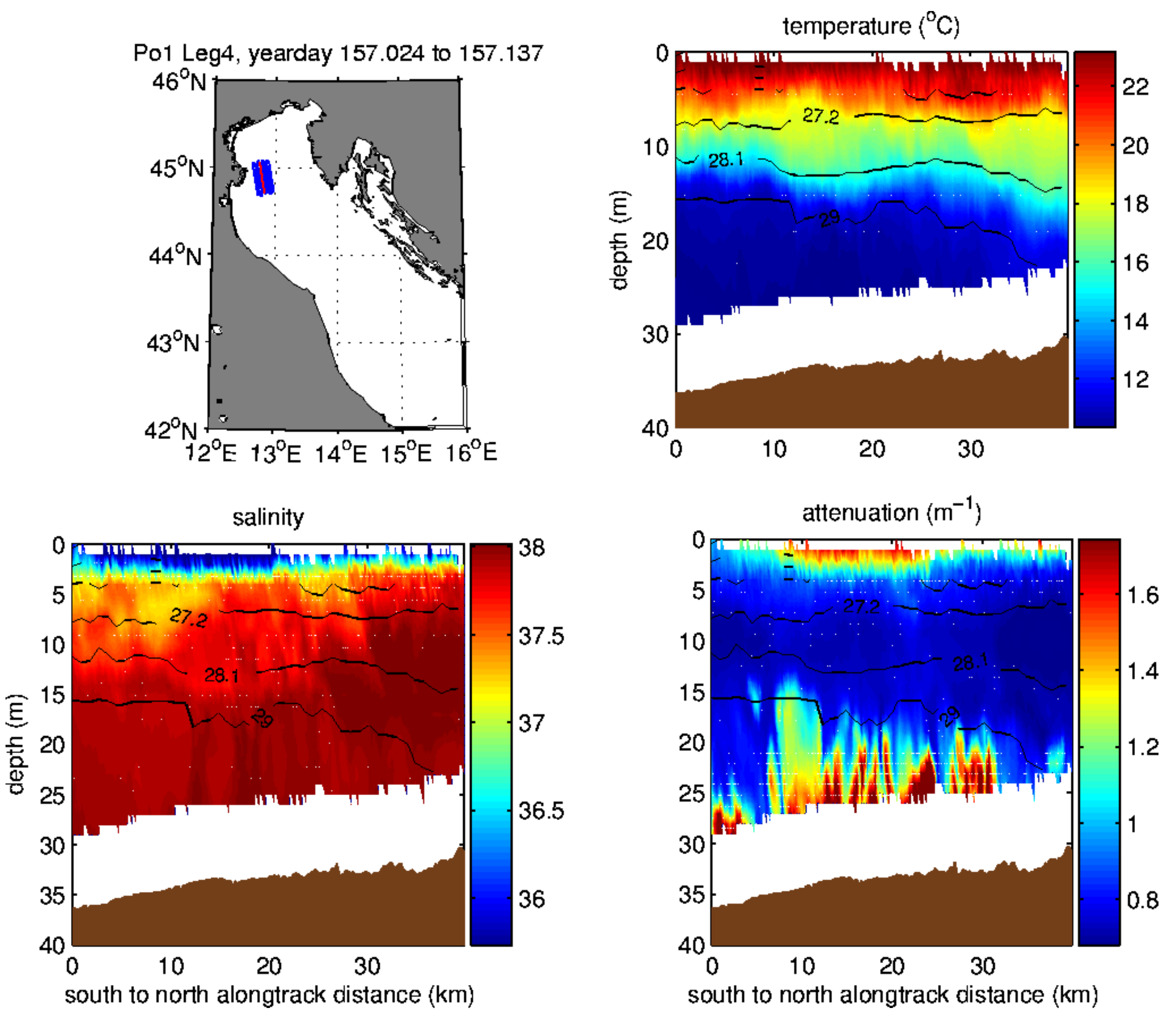


Figure 2.128: Temperature, salinity, and attenuation for Po1 survey, Leg4 section. Overlaid contours are σ_θ.

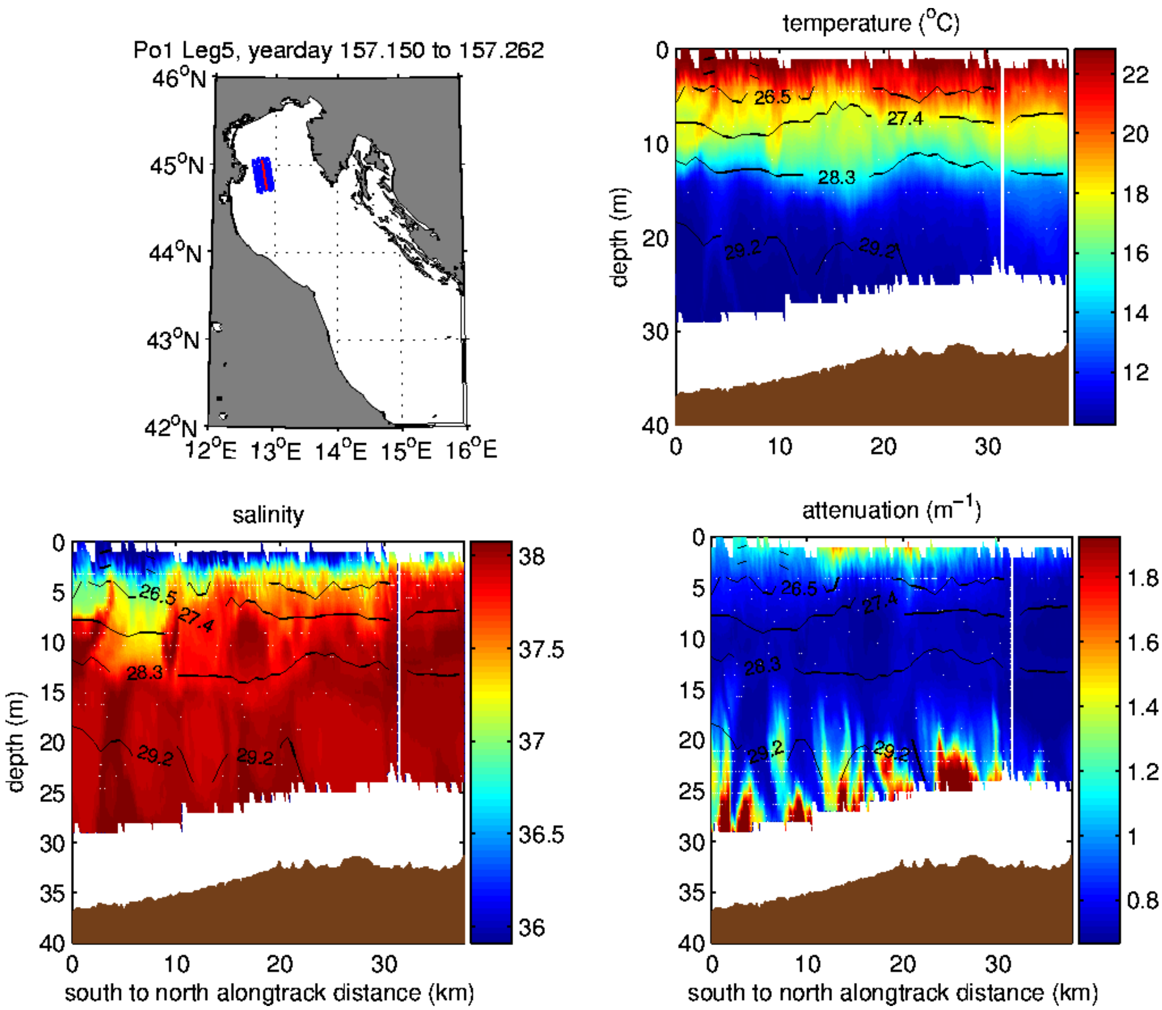


Figure 2.129: Temperature, salinity, and attenuation for Po1 survey, Leg5 section. Overlaid contours are σ_θ.

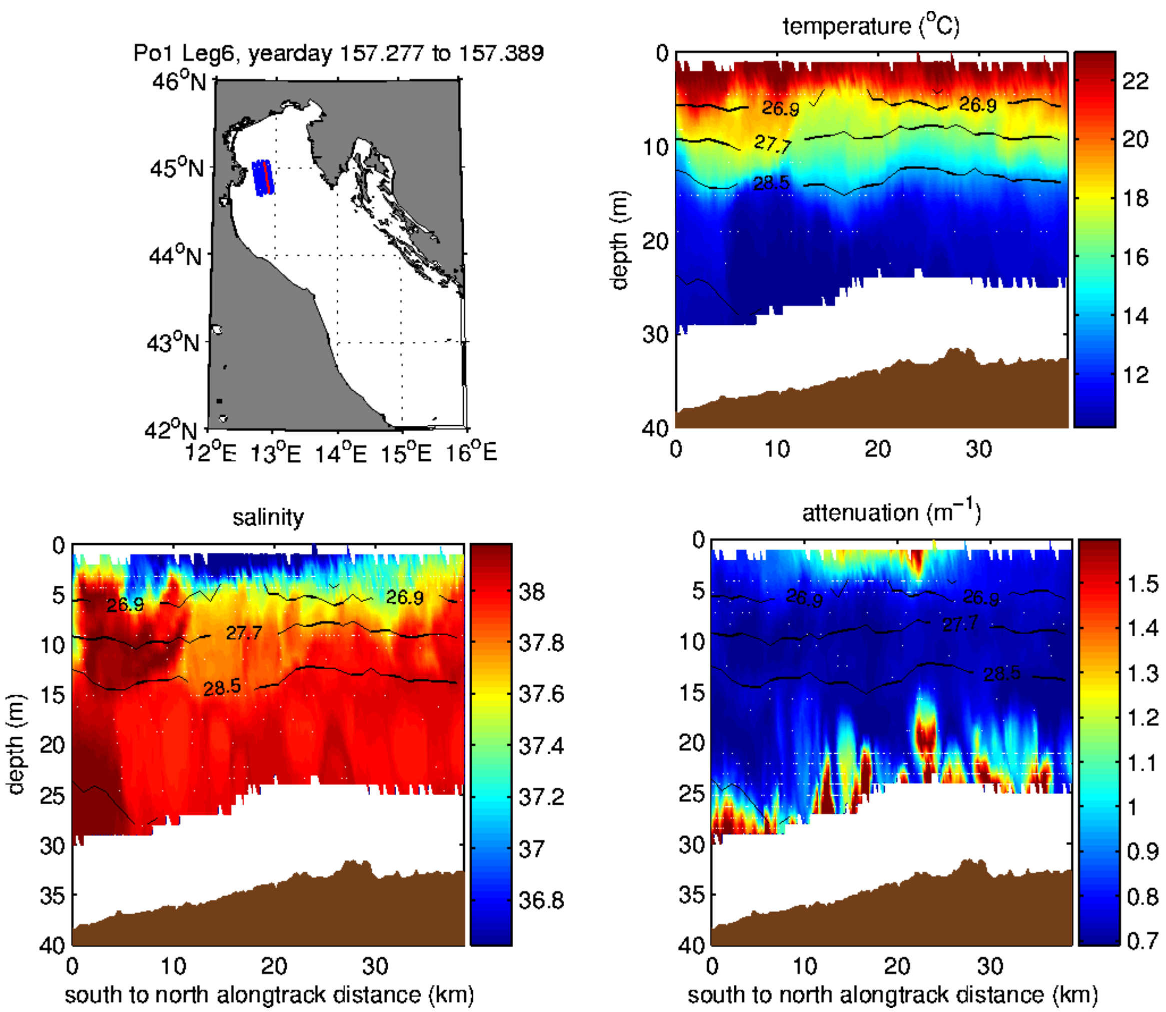


Figure 2.130: Temperature, salinity, and attenuation for Po1 survey, Leg6 section. Overlaid contours are σ_θ.

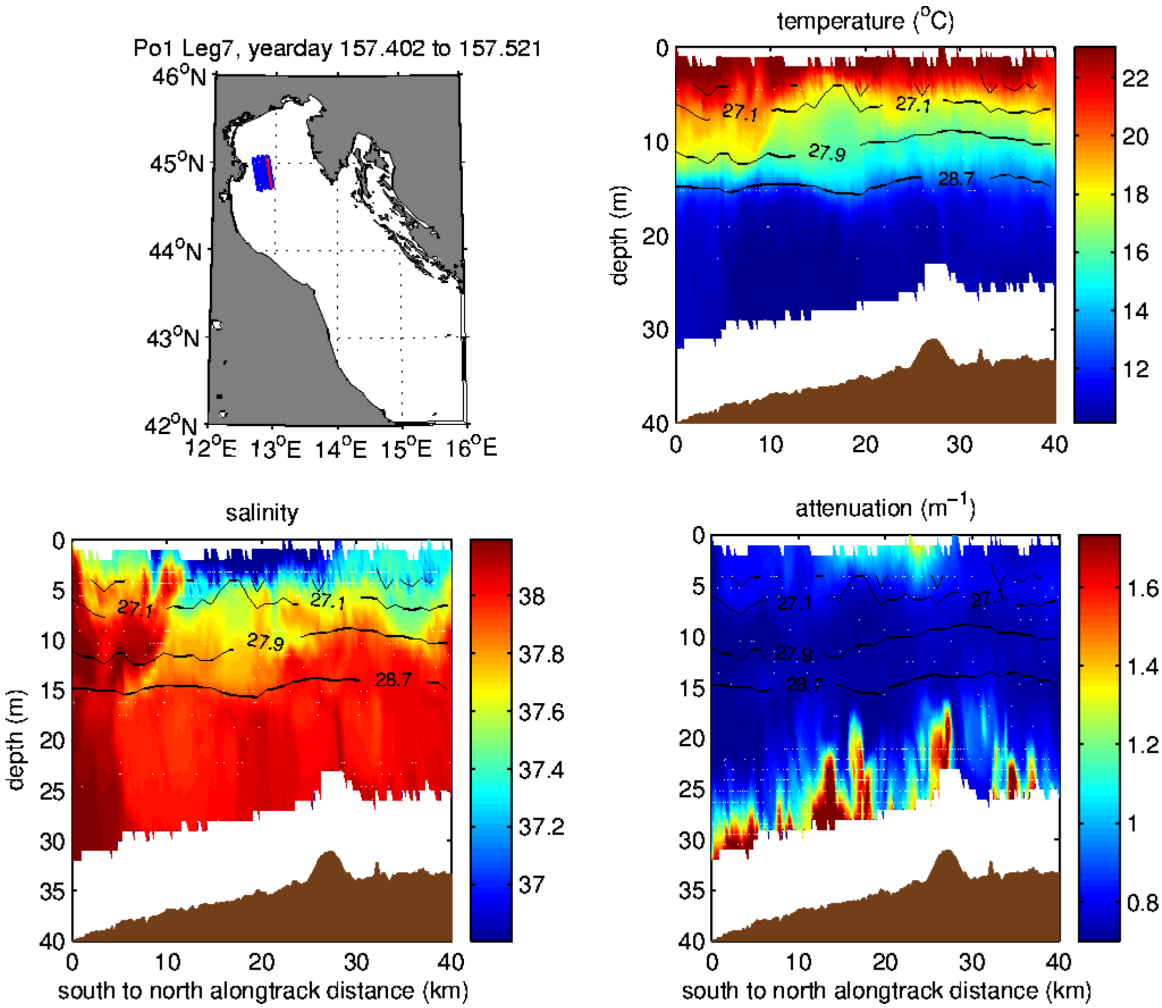


Figure 2.131: Temperature, salinity, and attenuation for Po1 survey, Leg7 section. Overlaid contours are σ_θ.

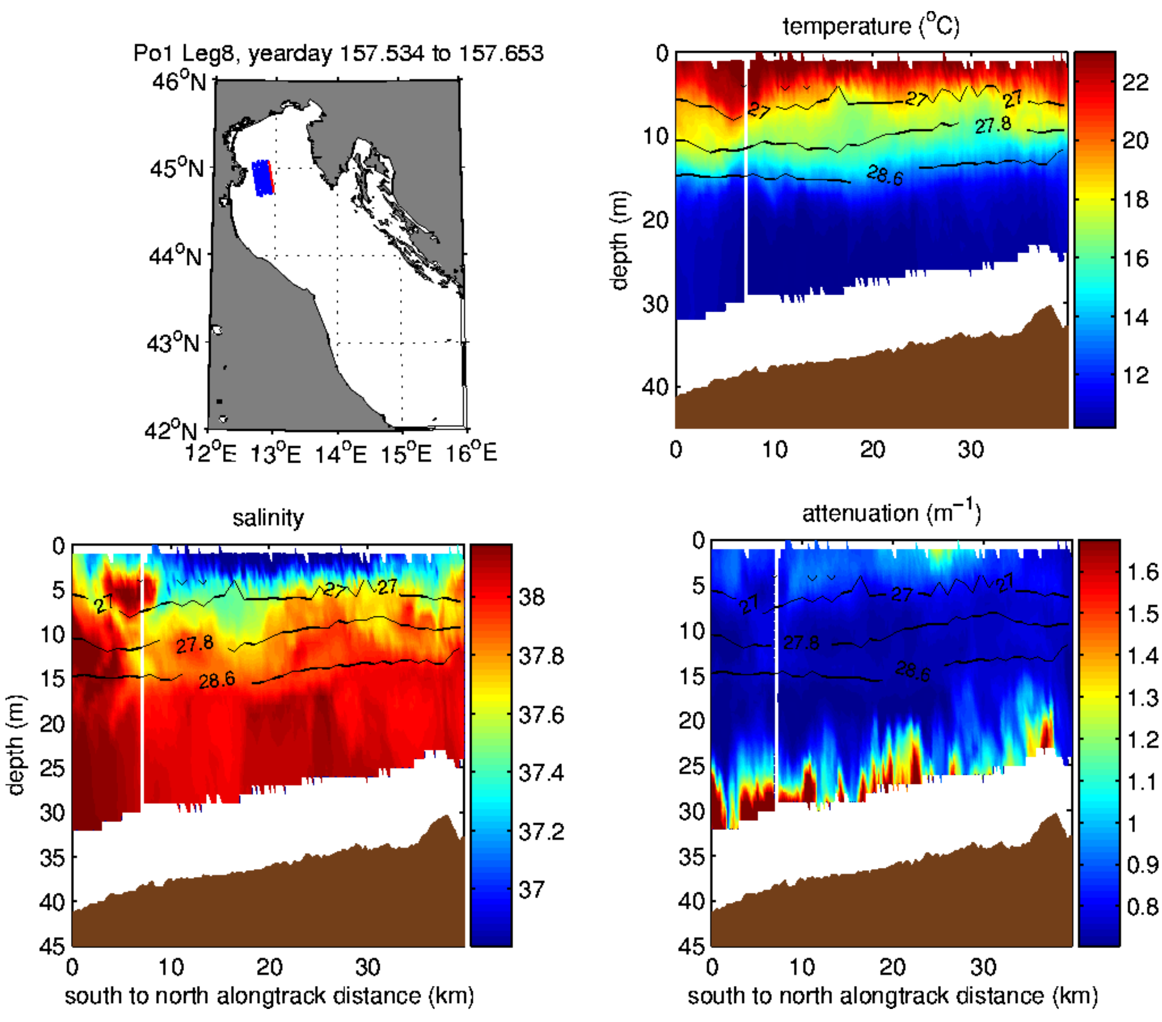


Figure 2.132: Temperature, salinity, and attenuation for Po1 survey, Leg8 section. Overlaid contours are σ_θ.

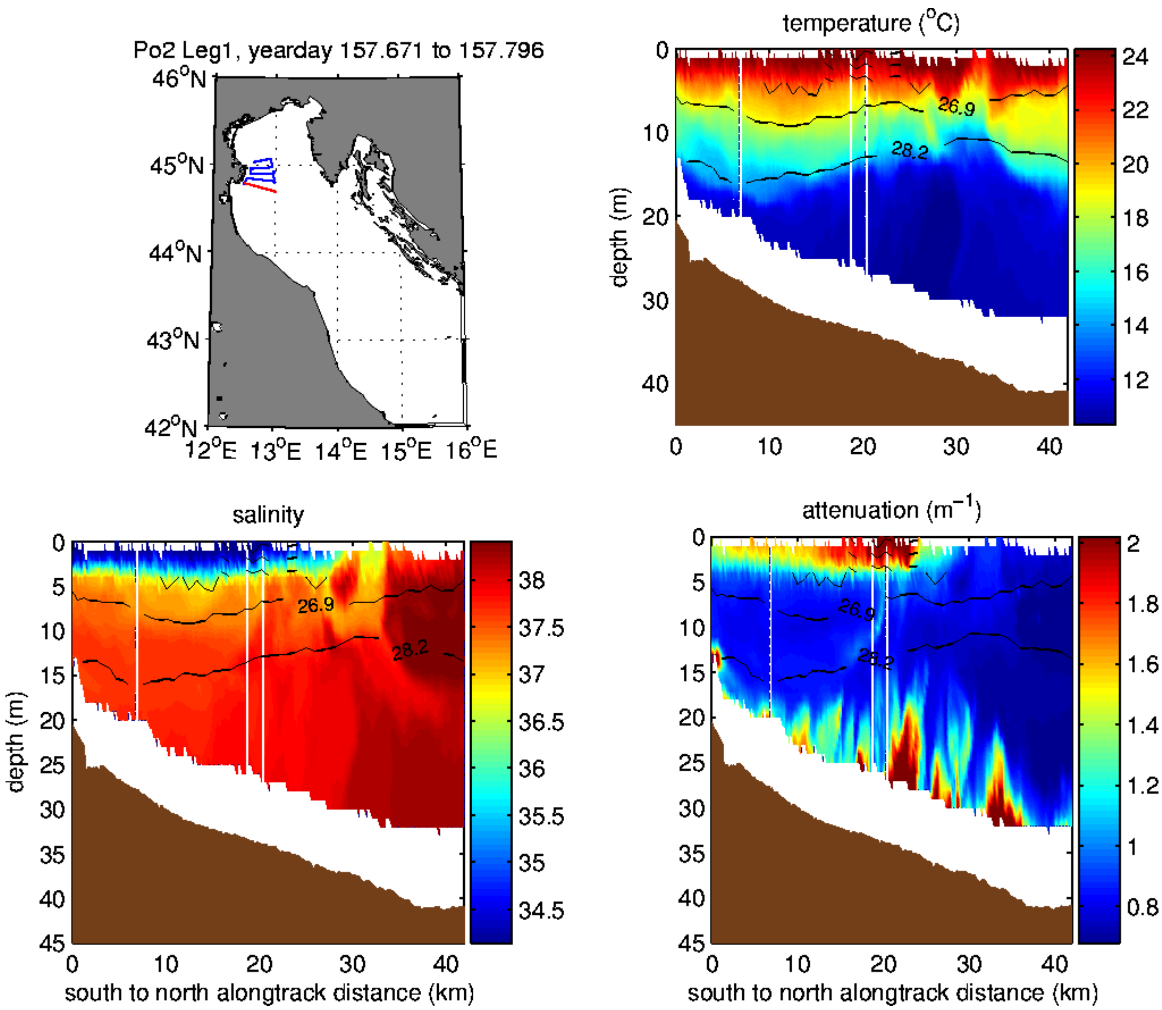


Figure 2.133: Temperature, salinity, and attenuation for Po2 survey, Leg1 section. Overlaid contours are σ_θ.

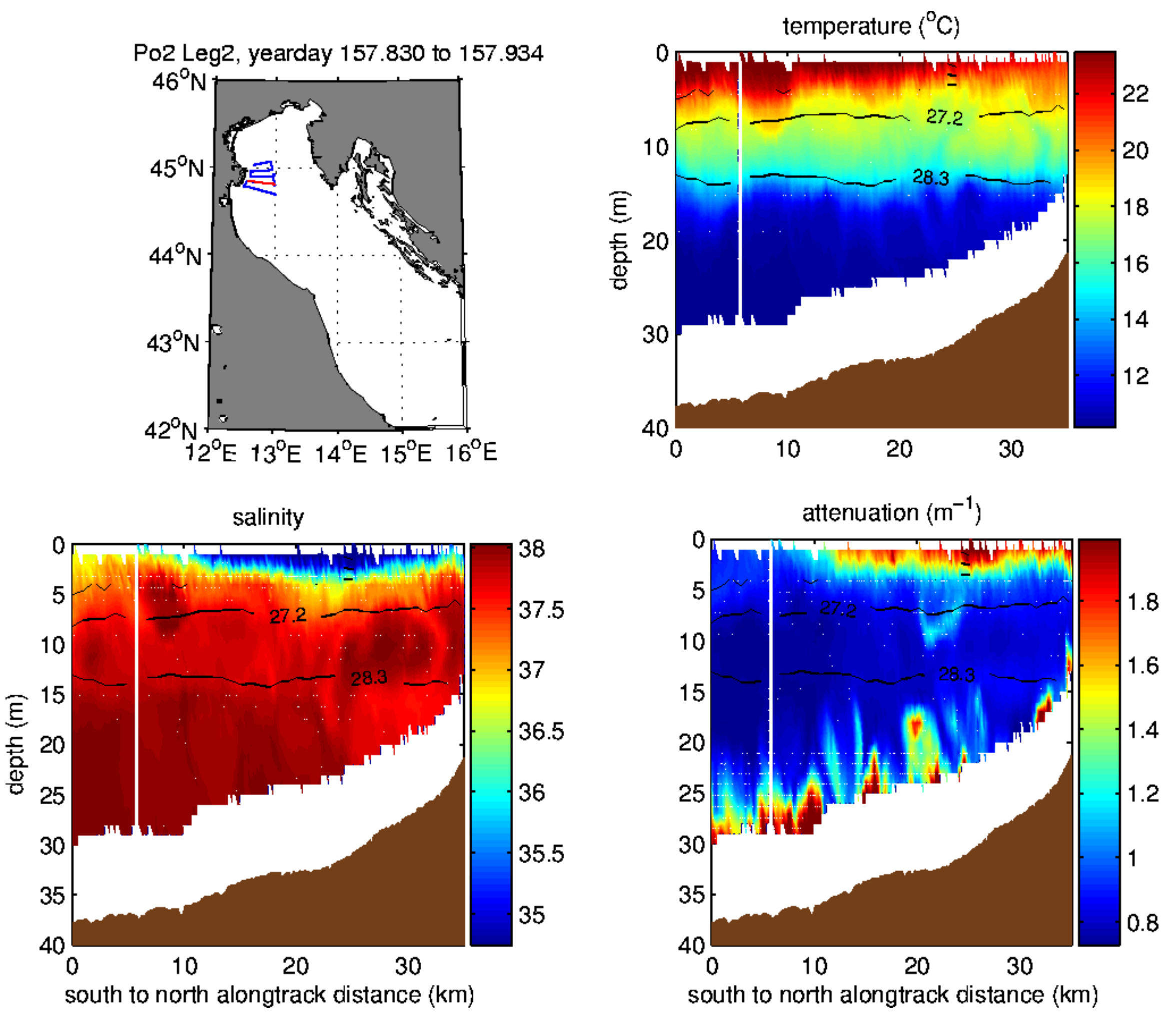


Figure 2.134: Temperature, salinity, and attenuation for Po2 survey, Leg2 section. Overlaid contours are σ_θ.

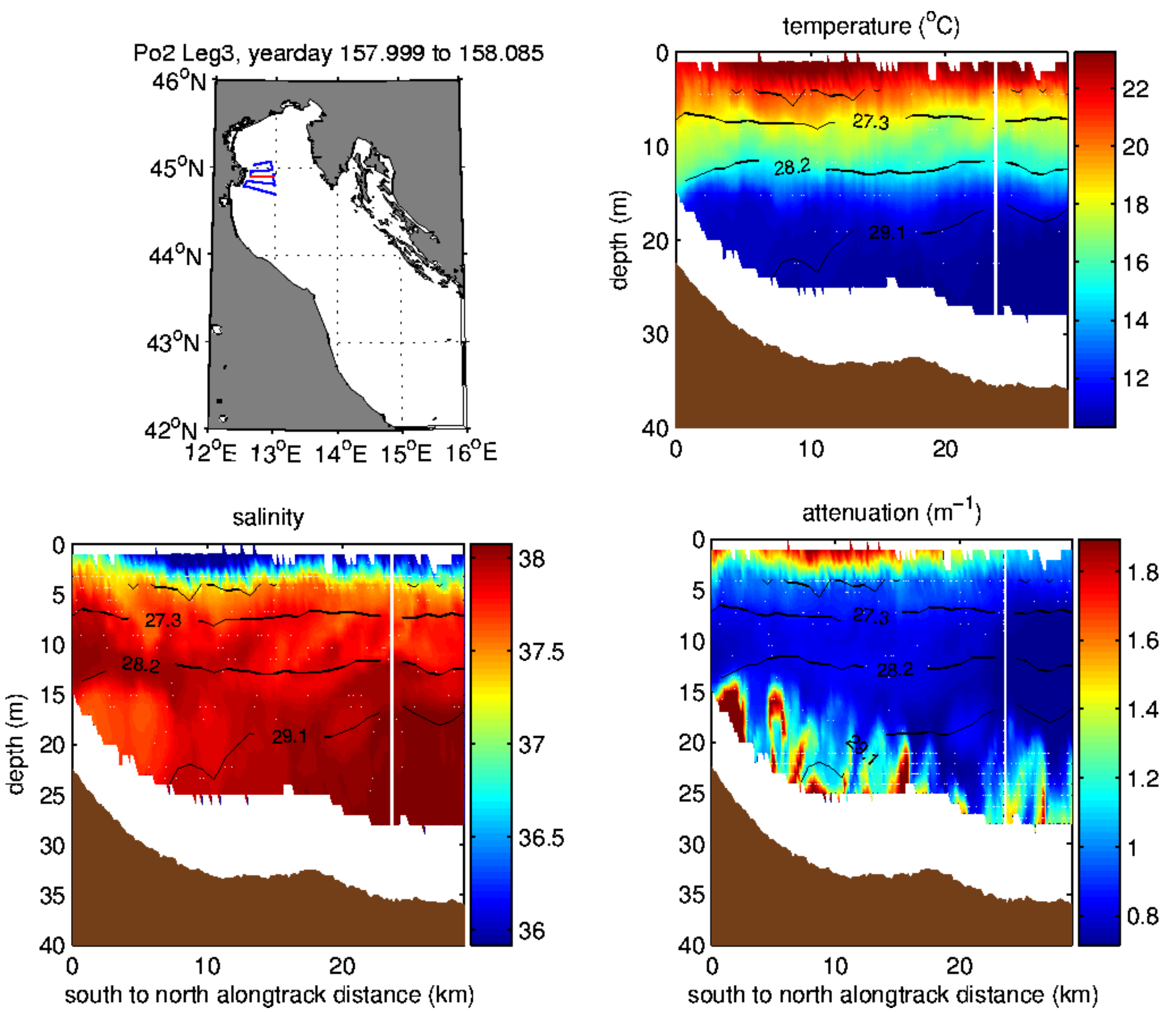


Figure 2.135: Temperature, salinity, and attenuation for Po2 survey, Leg3 section. Overlaid contours are σ_θ.

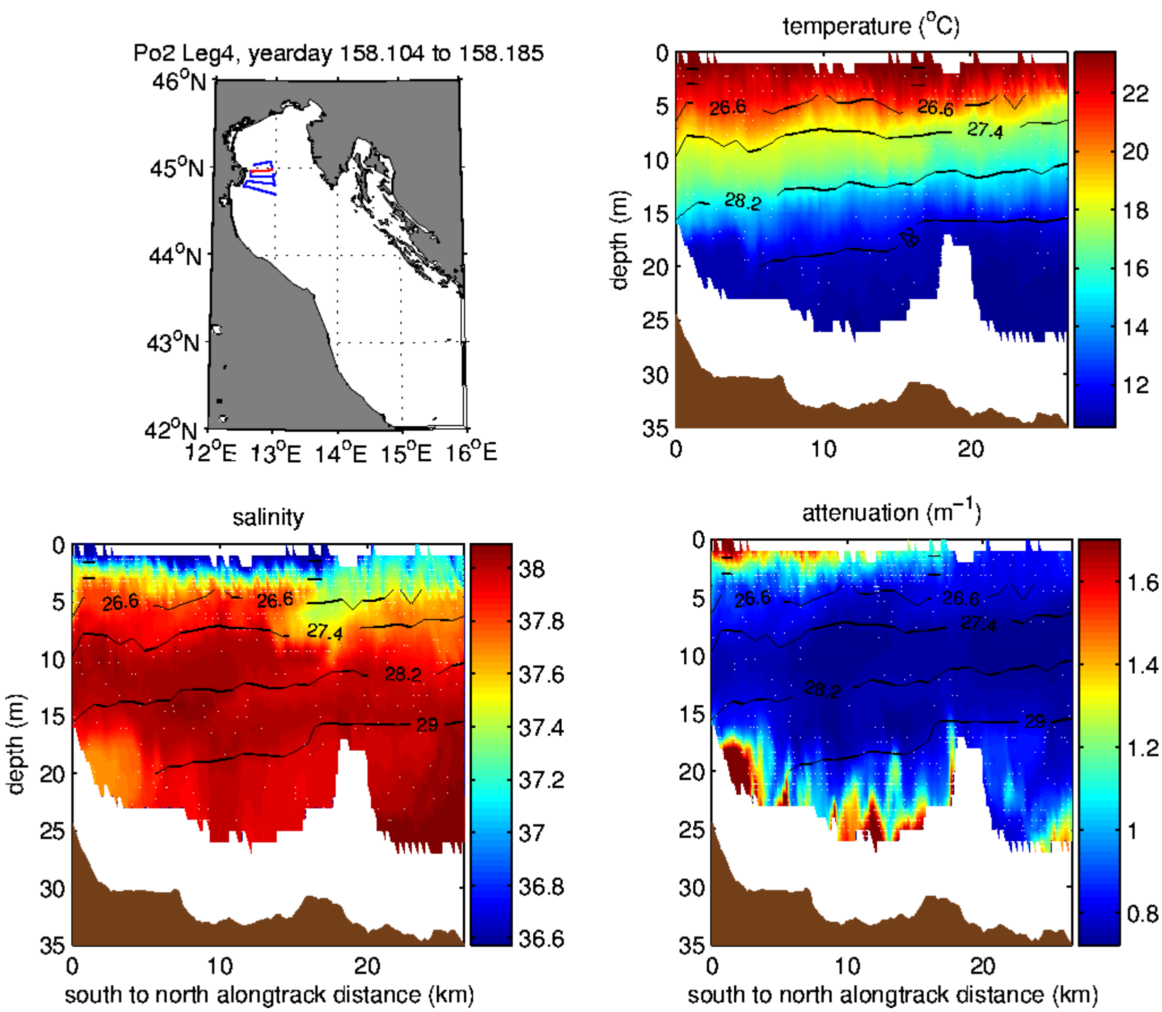


Figure 2.136: Temperature, salinity, and attenuation for Po2 survey, Leg4 section. Overlaid contours are σ_θ.

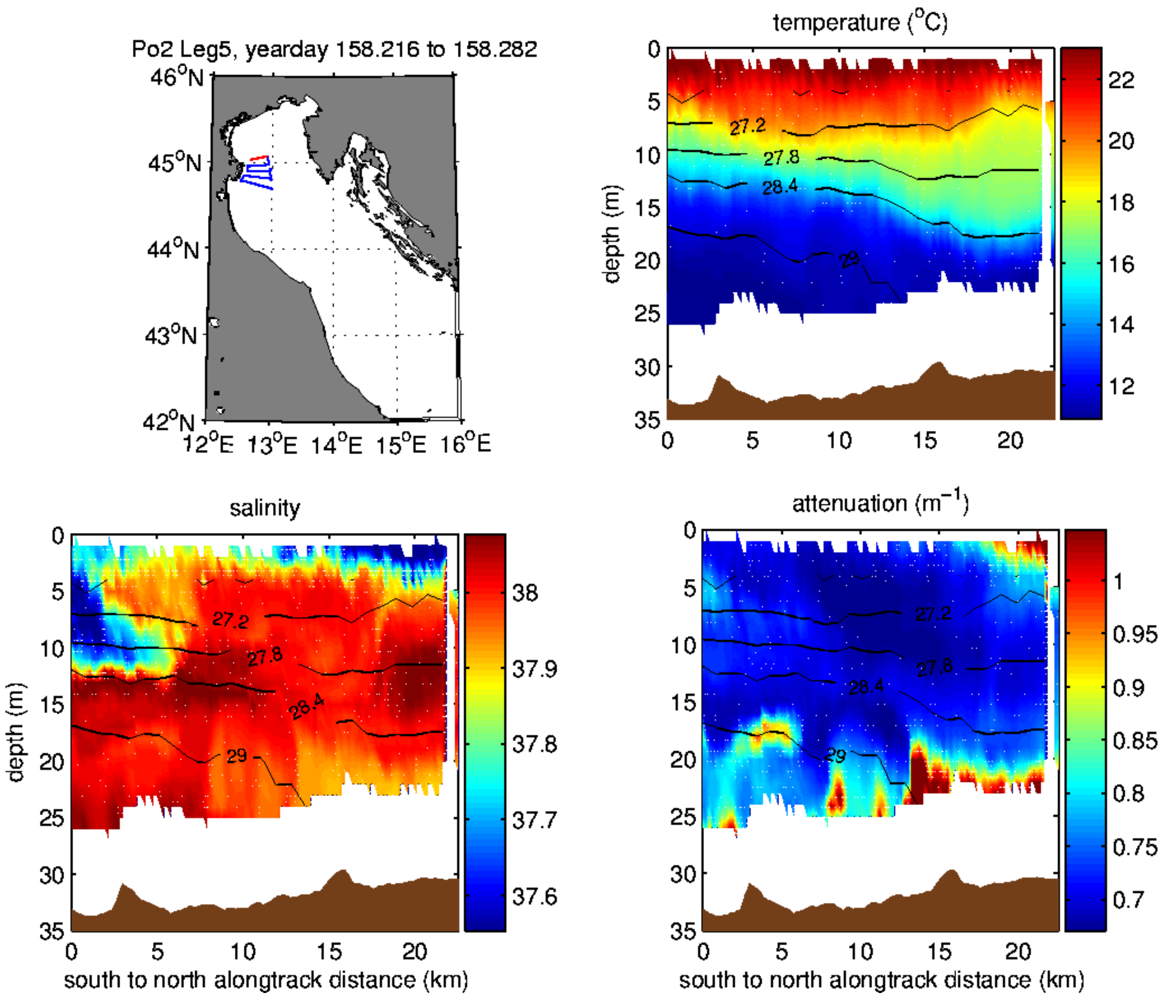


Figure 2.137: Temperature, salinity, and attenuation for Po2 survey, Leg5 section. Overlaid contours are σ_θ.

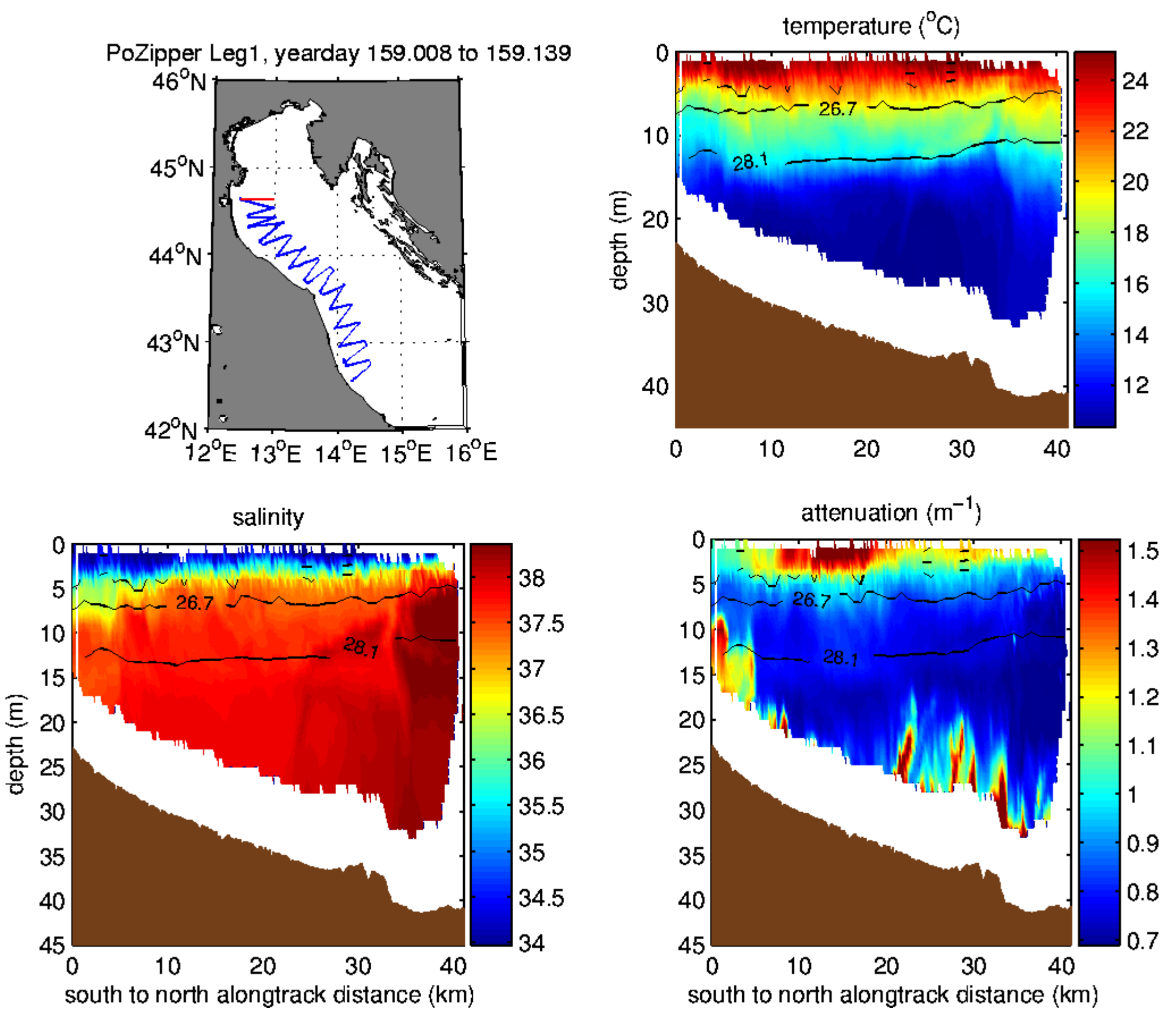


Figure 2.138: Temperature, salinity, and attenuation for PoZipper survey, Leg1 section. Overlaid contours are σ_θ.

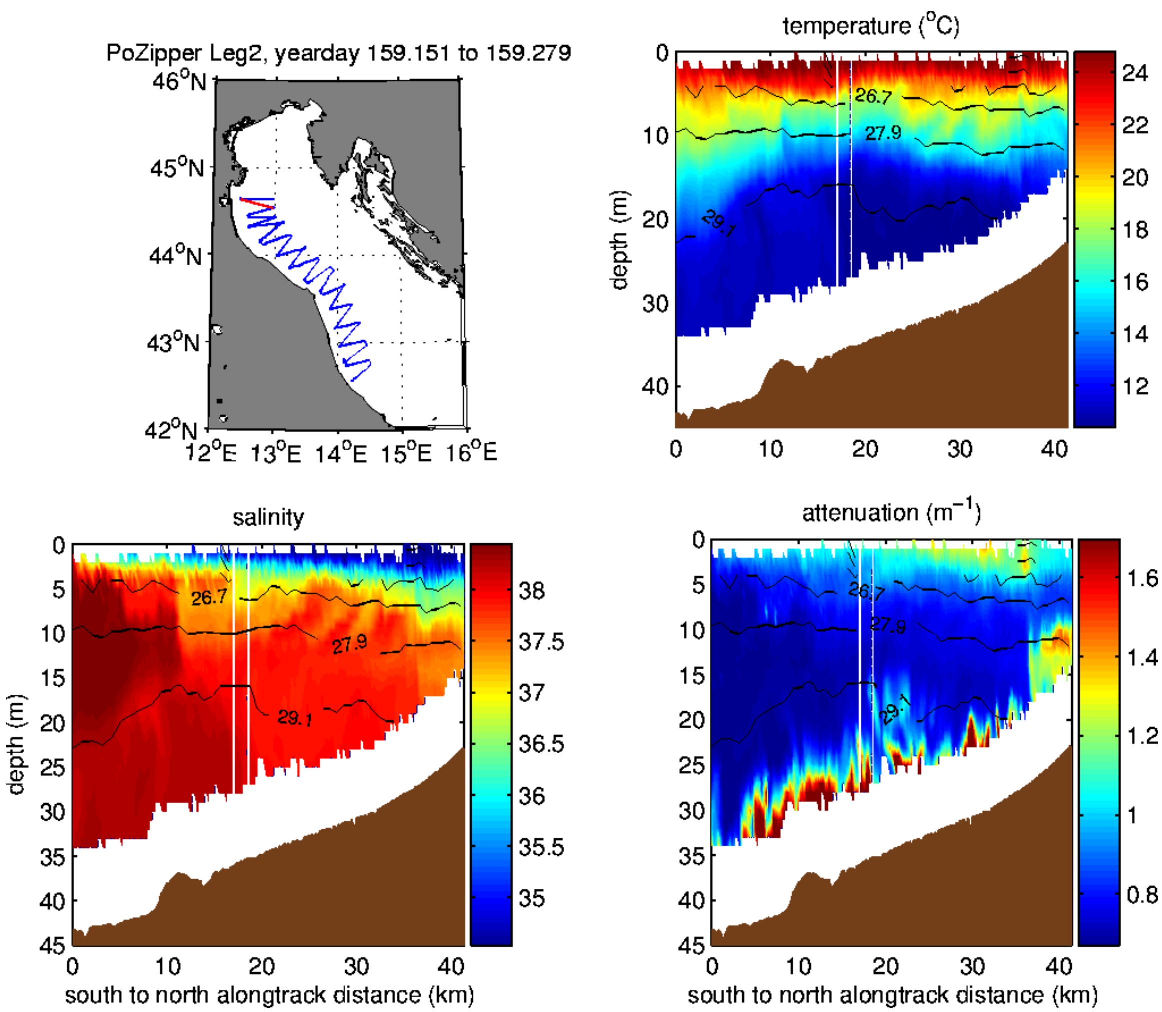


Figure 2.139: Temperature, salinity, and attenuation for PoZipper survey, Leg2 section. Overlaid contours are σ_θ.

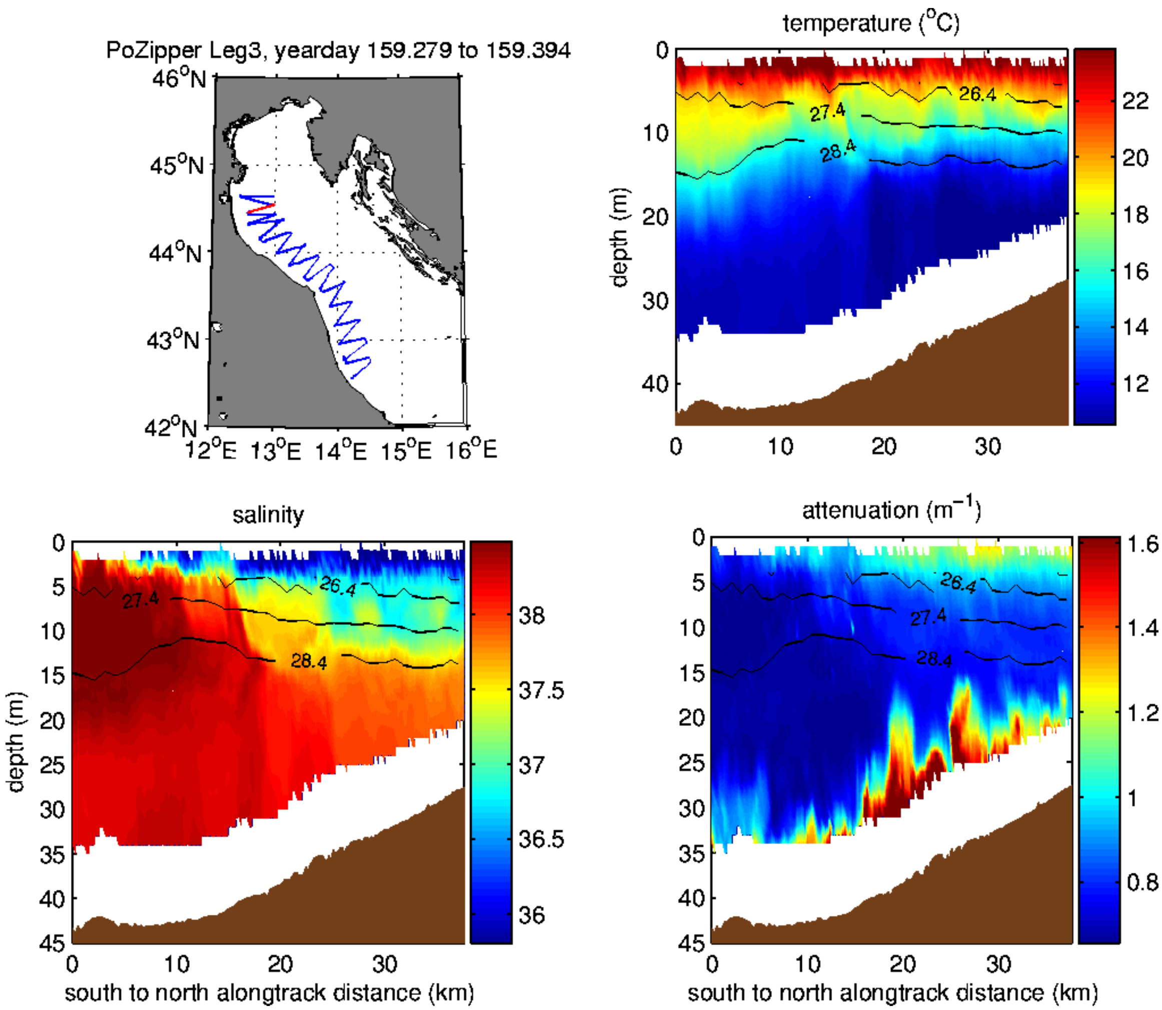


Figure 2.140: Temperature, salinity, and attenuation for PoZipper survey, Leg3 section. Overlaid contours are σ_θ.

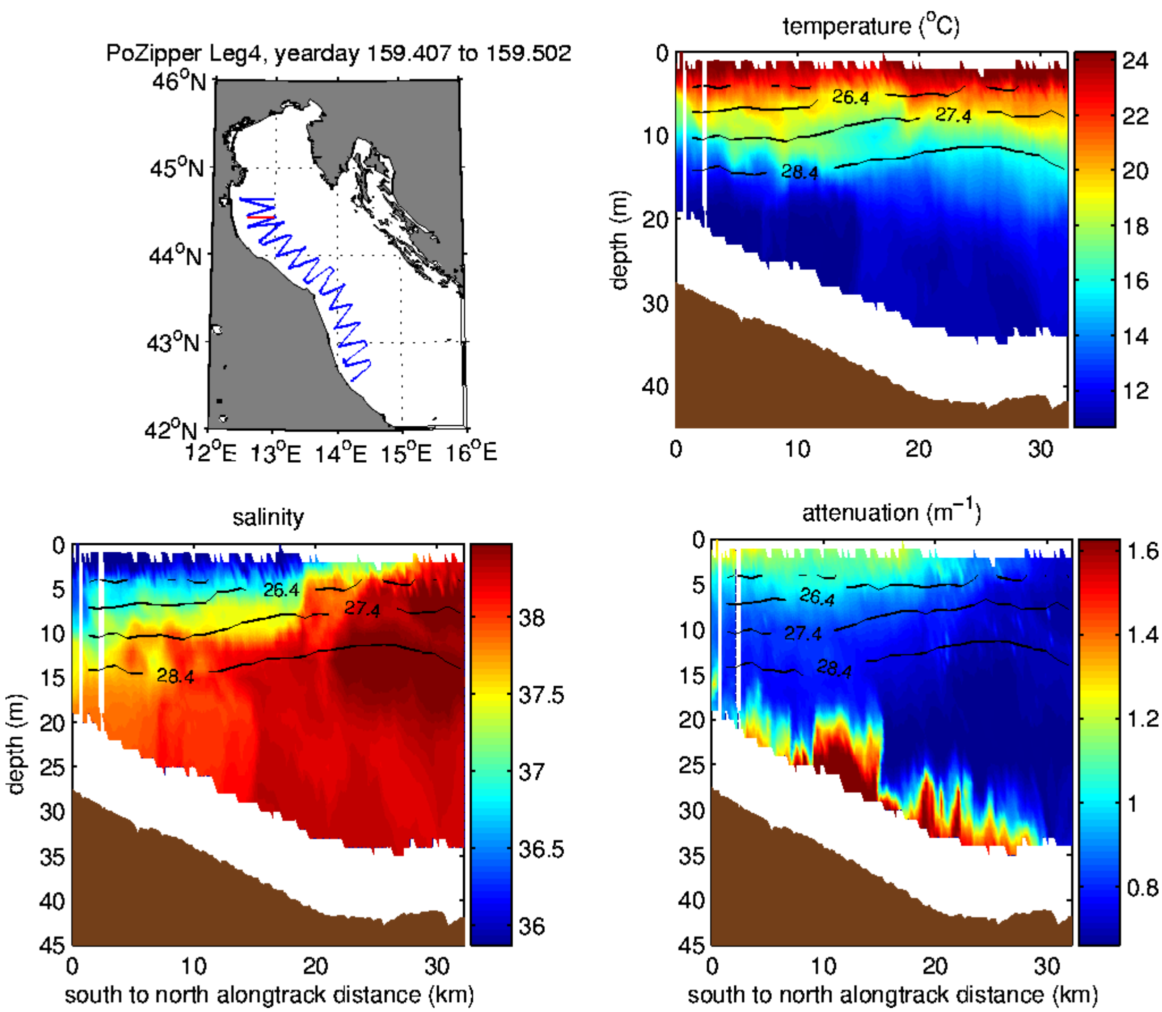


Figure 2.141: Temperature, salinity, and attenuation for PoZipper survey, Leg4 section. Overlaid contours are σ_θ.

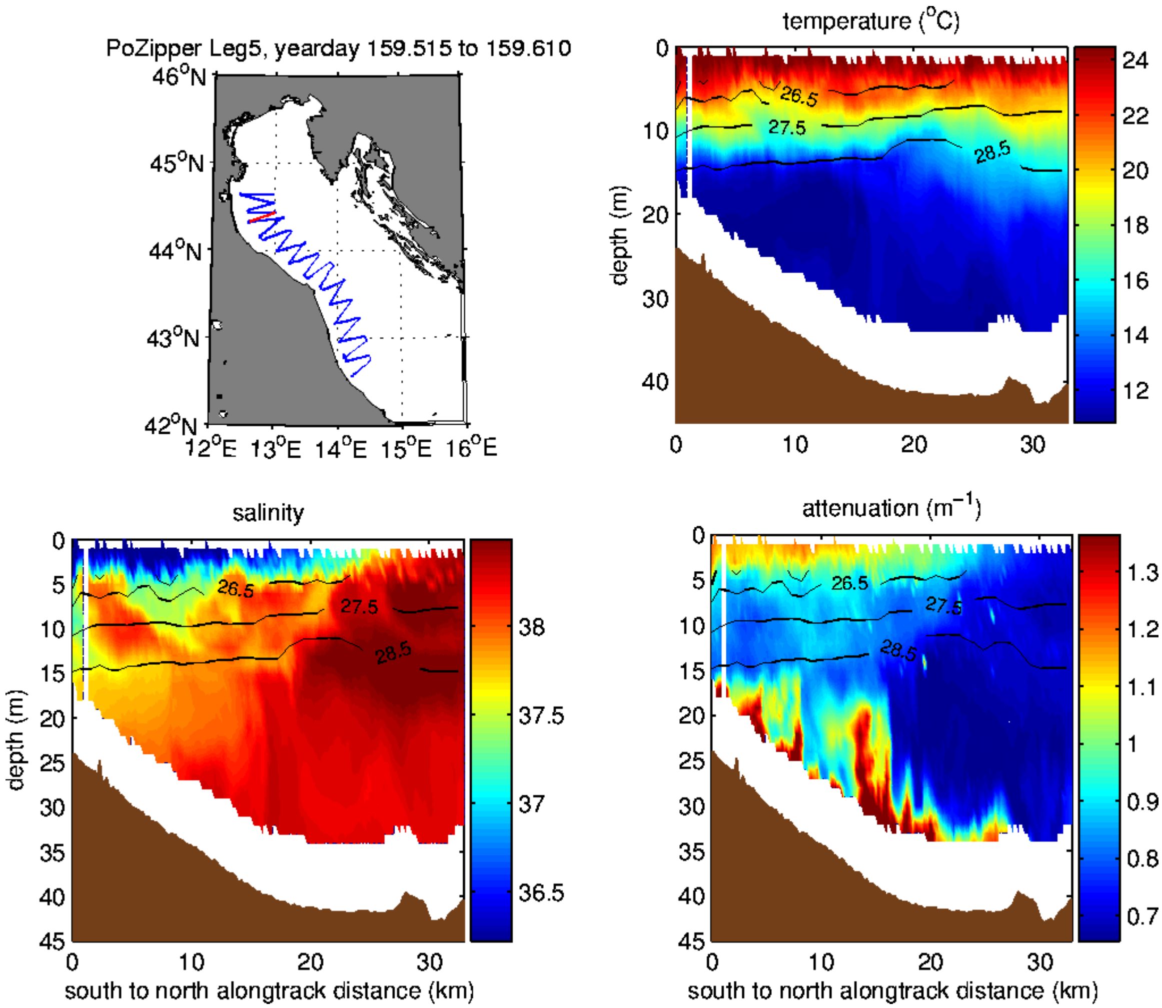


Figure 2.142: Temperature, salinity, and attenuation for PoZipper survey, Leg5 section. Overlaid contours are σ_θ.

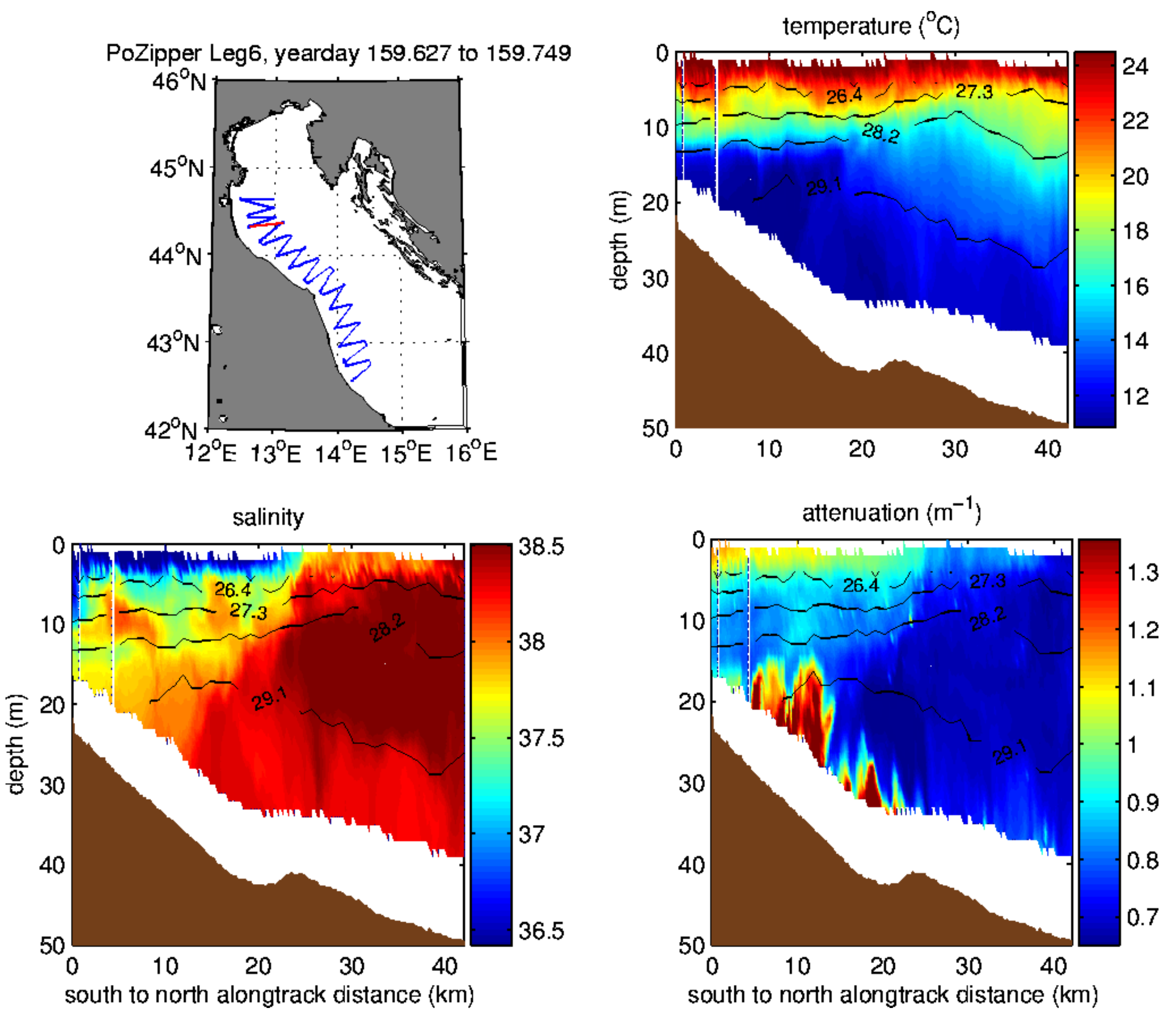


Figure 2.143: Temperature, salinity, and attenuation for PoZipper survey, Leg6 section. Overlaid contours are σ_θ.

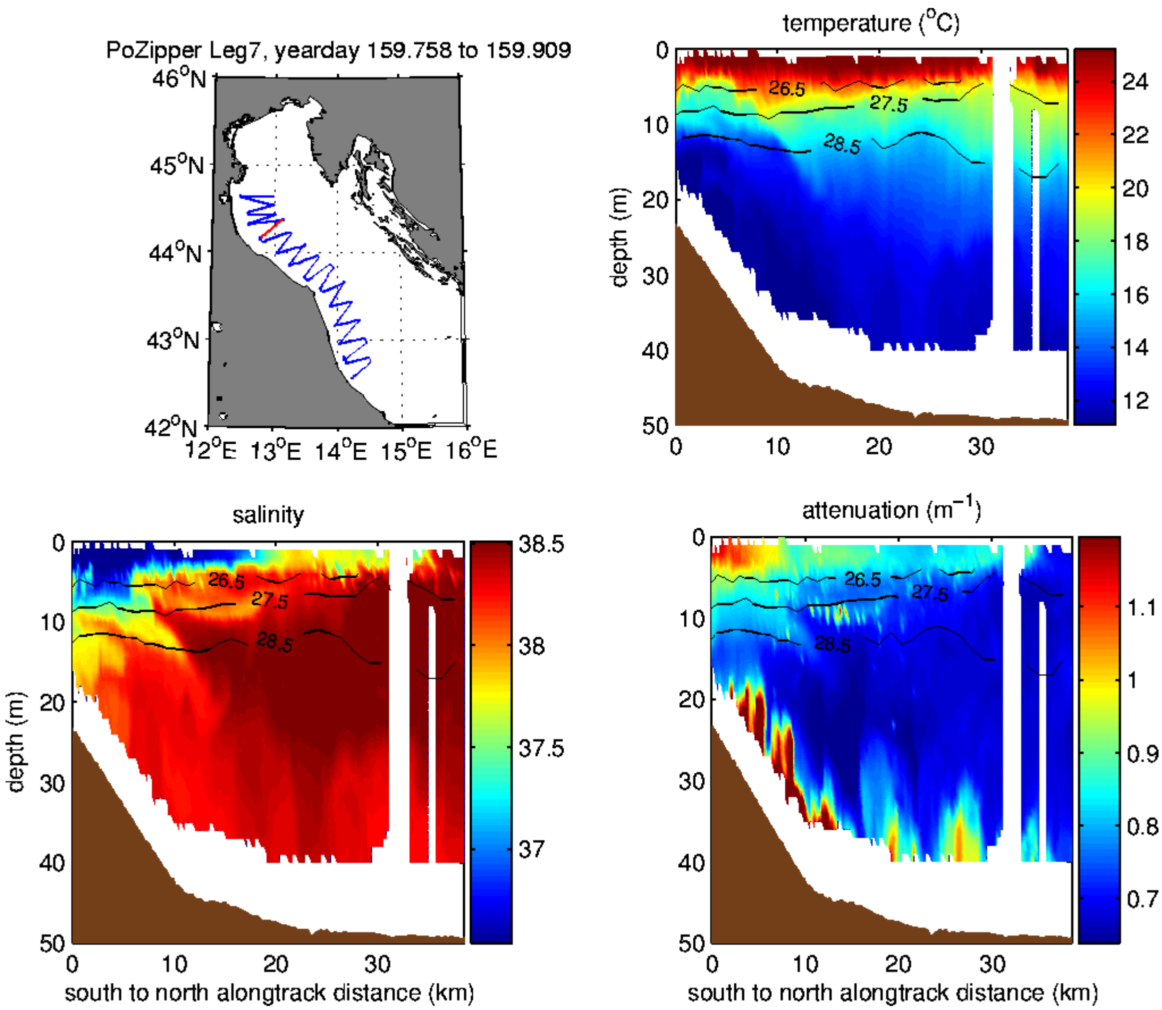


Figure 2.144: Temperature, salinity, and attenuation for PoZipper survey, Leg7 section. Overlaid contours are σ_θ.

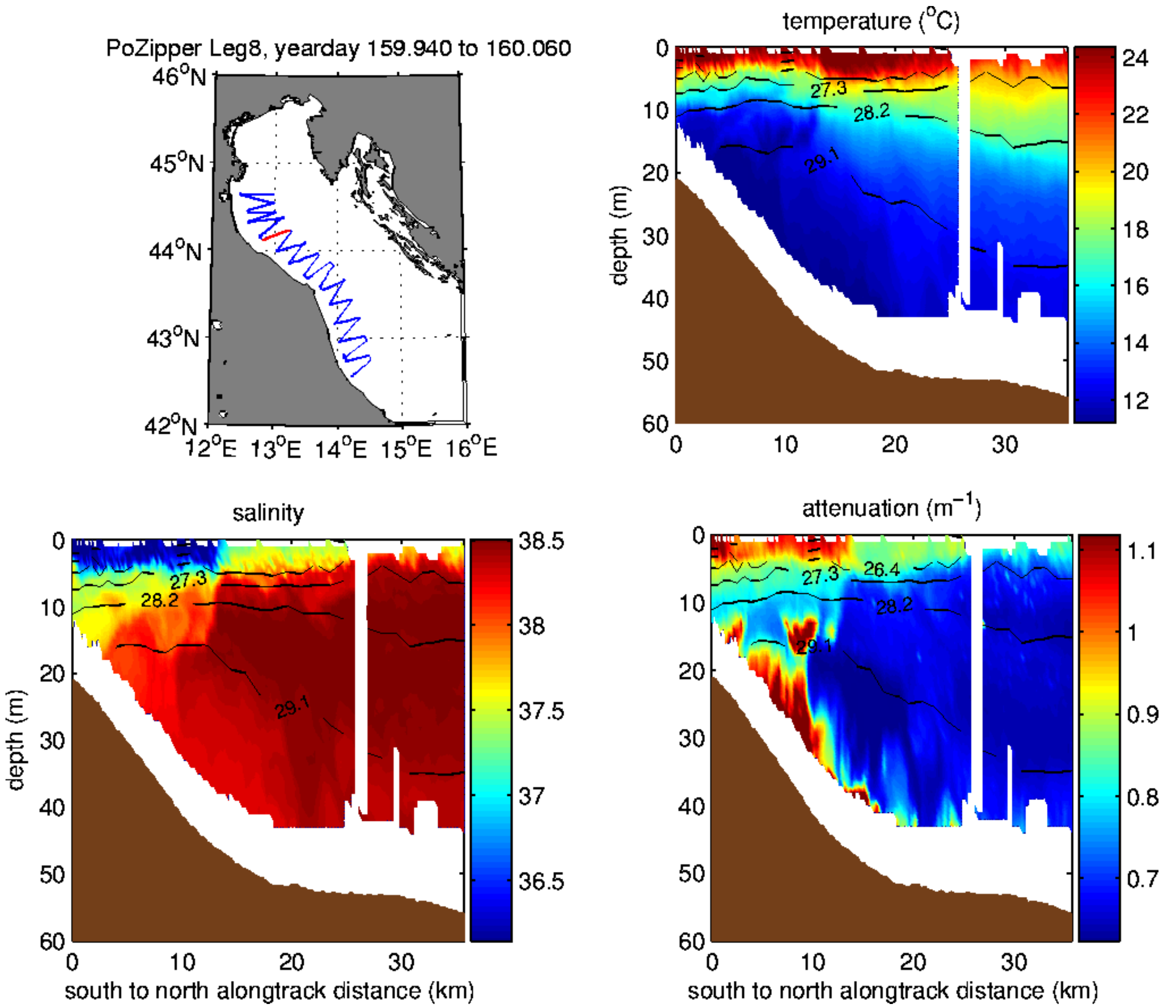


Figure 2.145: Temperature, salinity, and attenuation for PoZipper survey, Leg8 section. Overlaid contours are σ_θ.

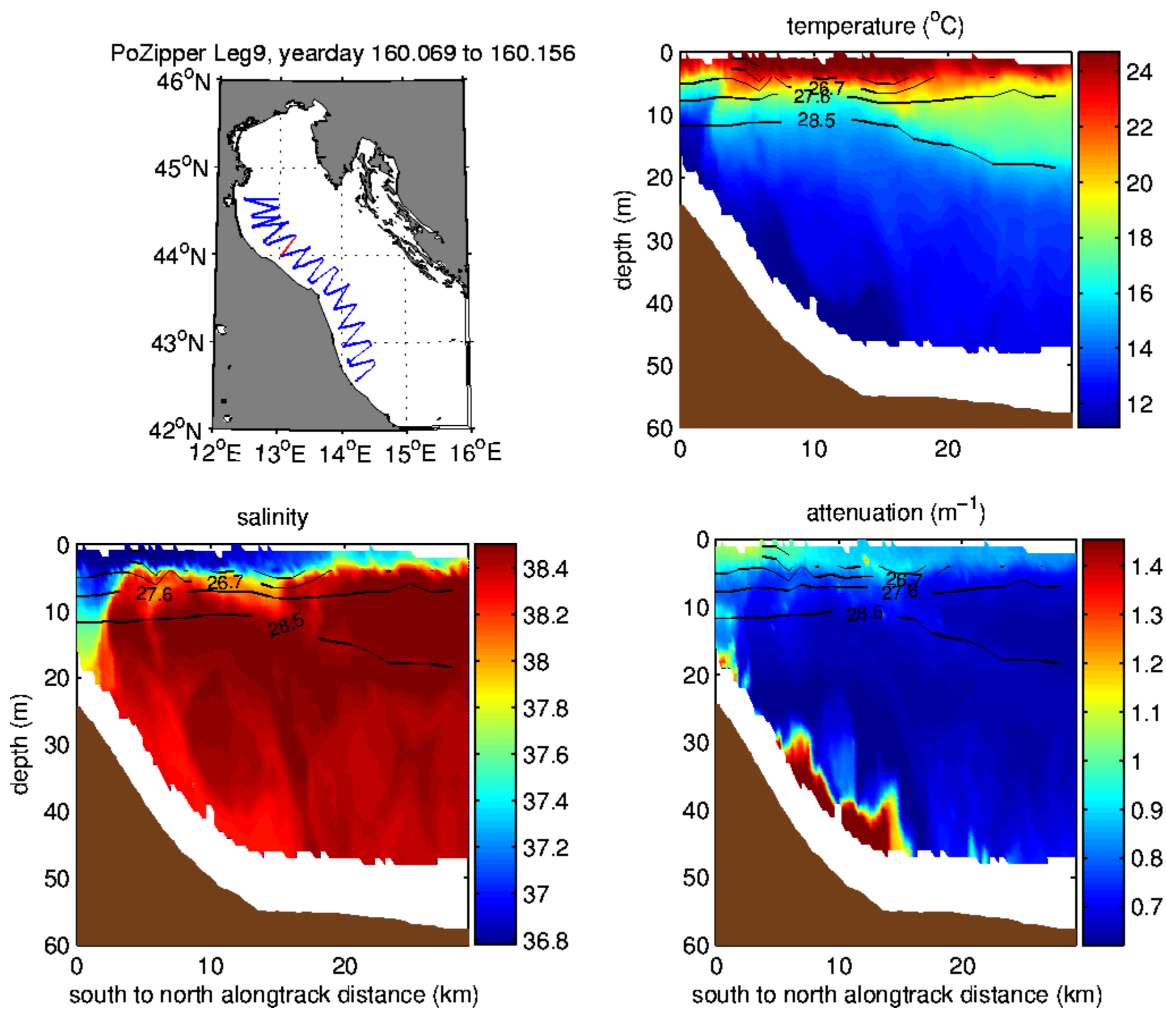


Figure 2.146: Temperature, salinity, and attenuation for PoZipper survey, Leg9 section. Overlaid contours are σ_θ.

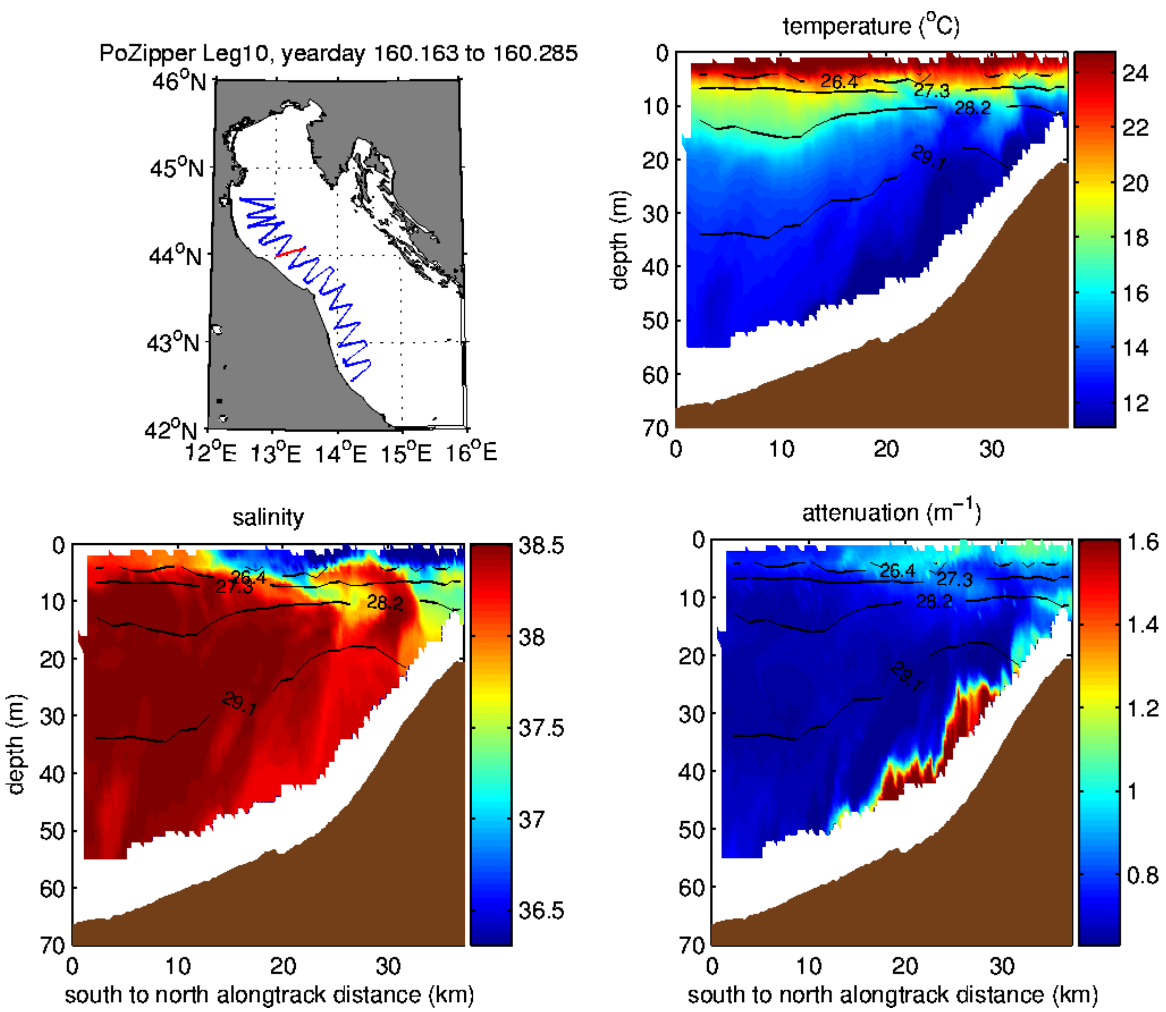


Figure 2.147: Temperature, salinity, and attenuation for PoZipper survey, Leg10 section. Overlaid contours are σ_θ.

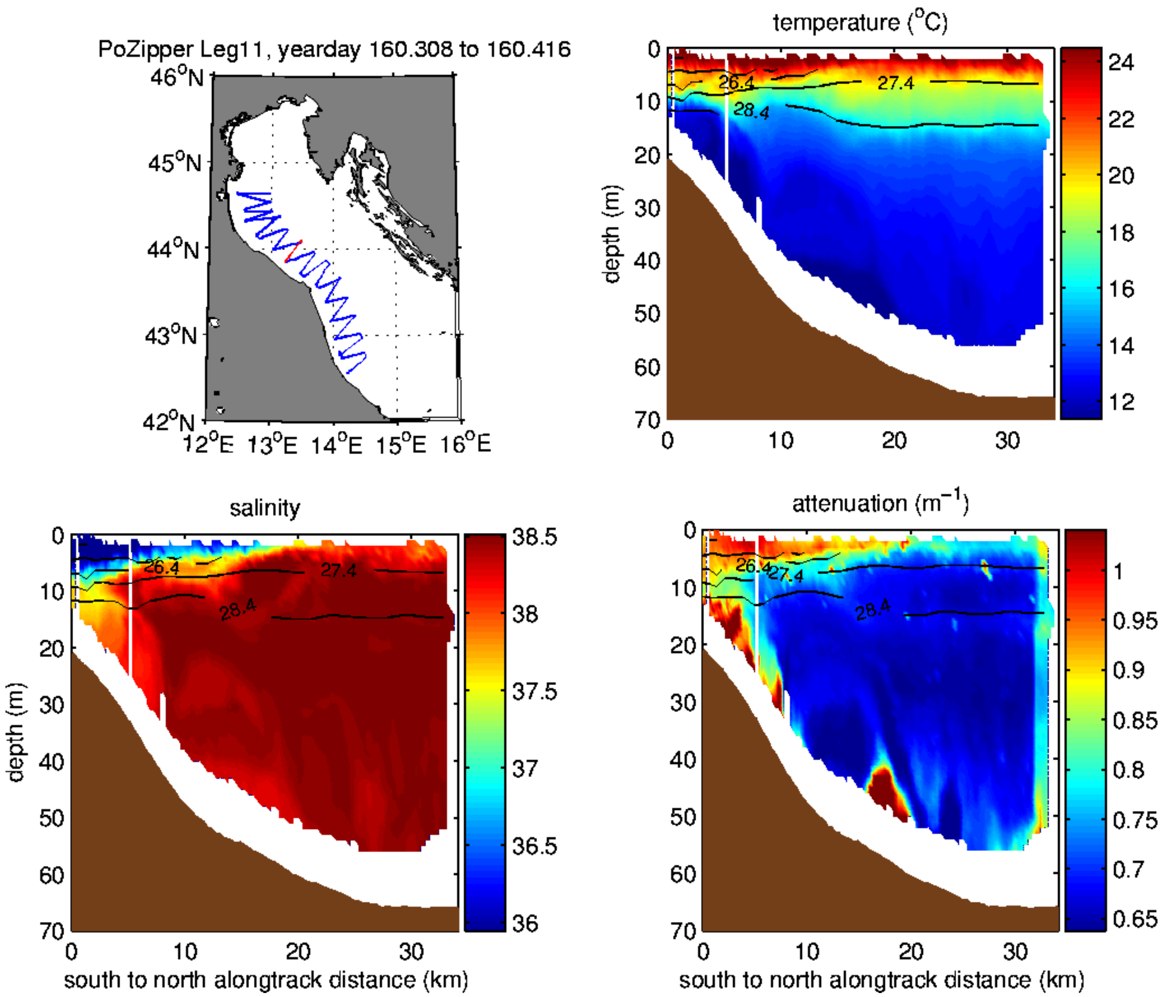


Figure 2.148: Temperature, salinity, and attenuation for PoZipper survey, Leg11 section. Overlaid contours are σ_θ.

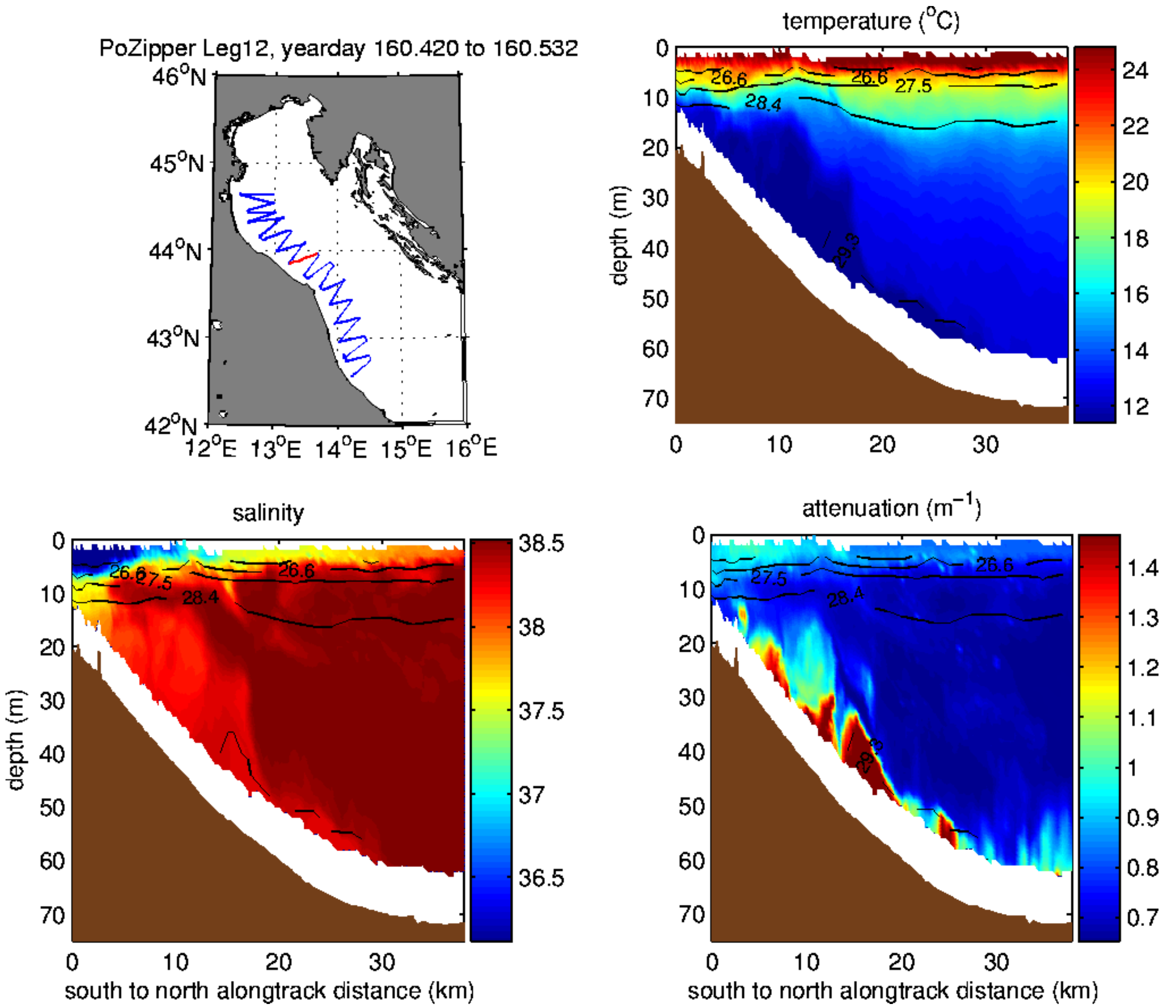


Figure 2.149: Temperature, salinity, and attenuation for PoZipper survey, Leg12 section. Overlaid contours are σ_θ.

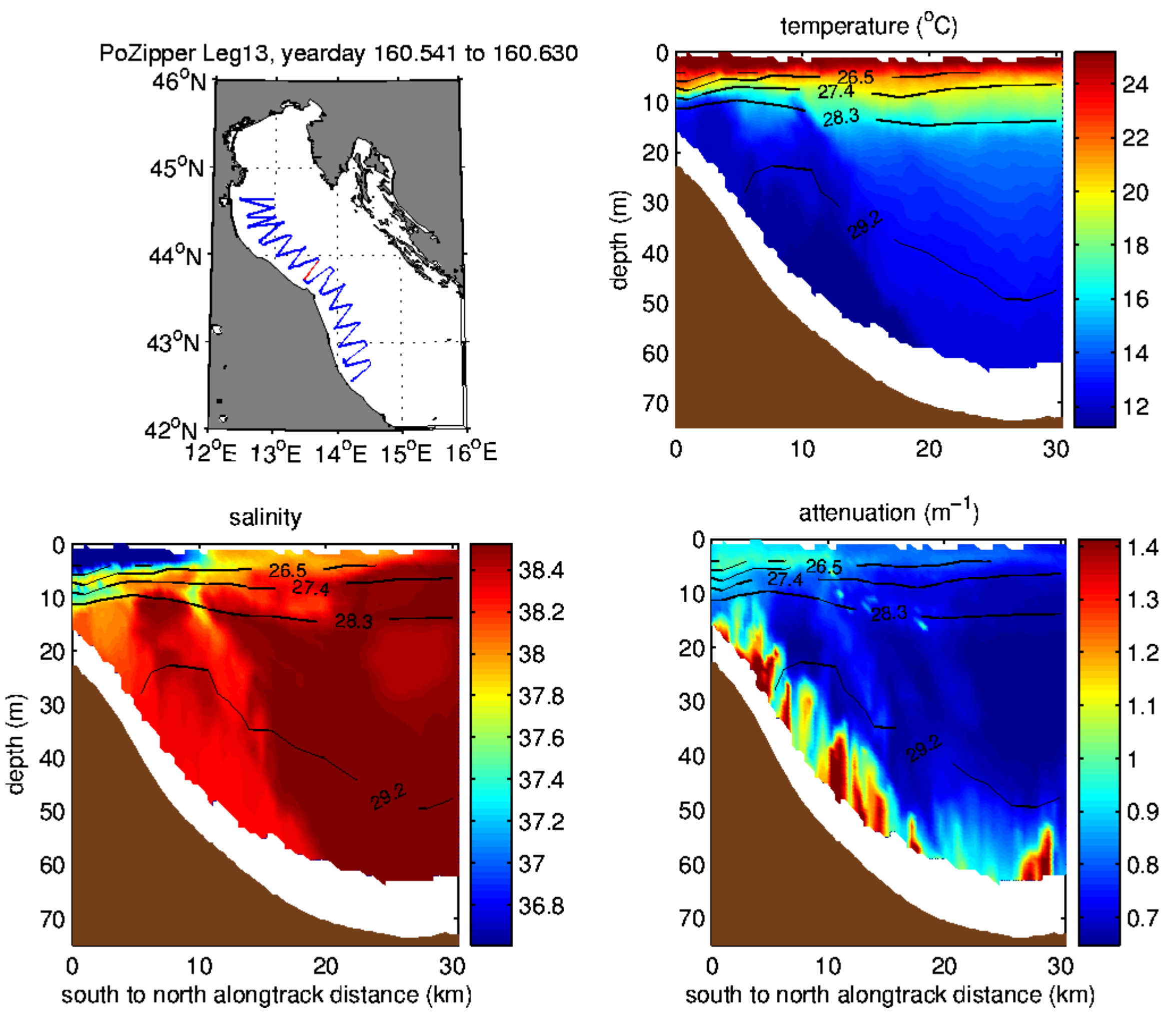


Figure 2.150: Temperature, salinity, and attenuation for PoZipper survey, Leg13 section. Overlaid contours are σ_θ.

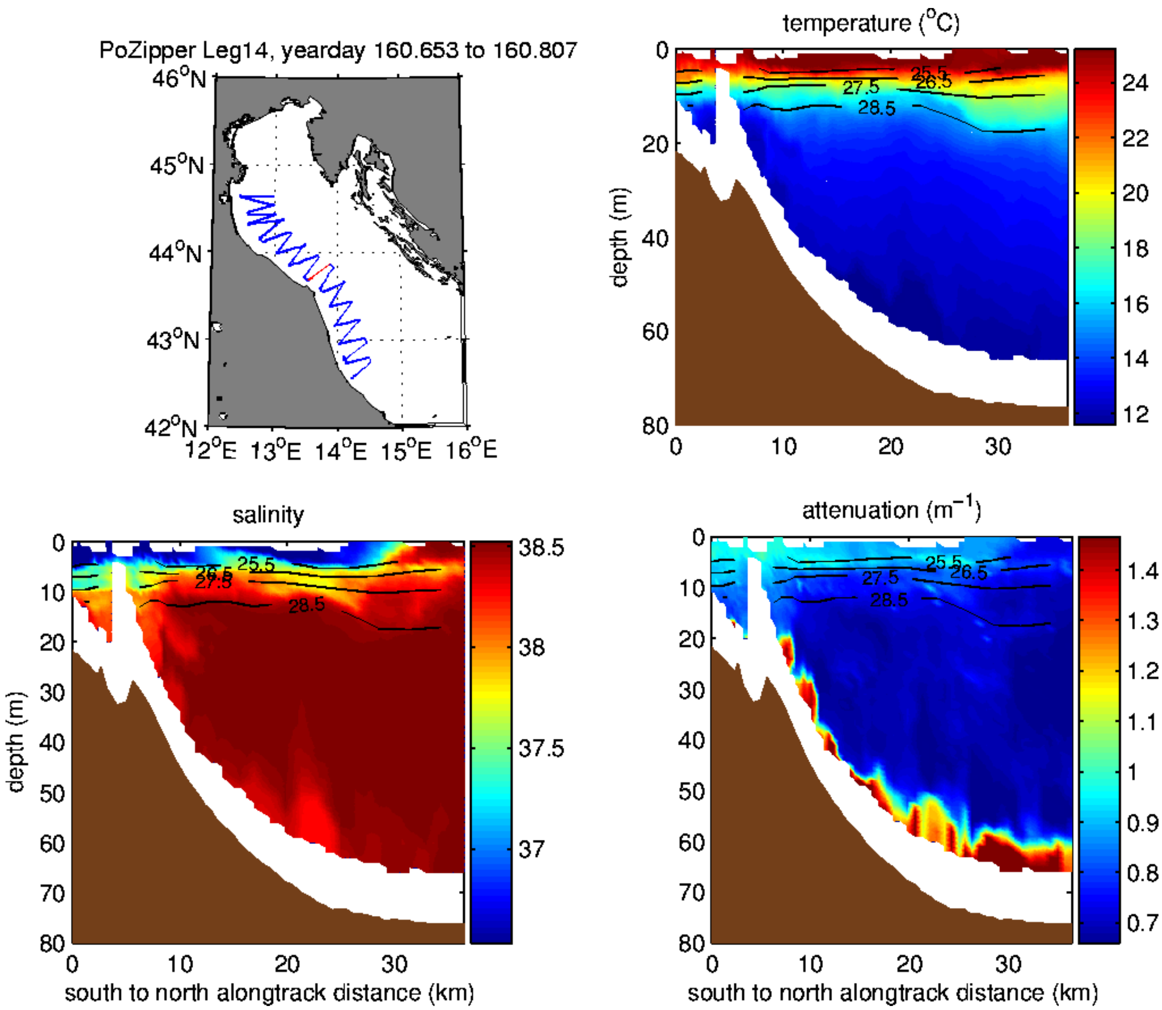


Figure 2.151: Temperature, salinity, and attenuation for PoZipper survey, Leg14 section. Overlaid contours are σ_θ.

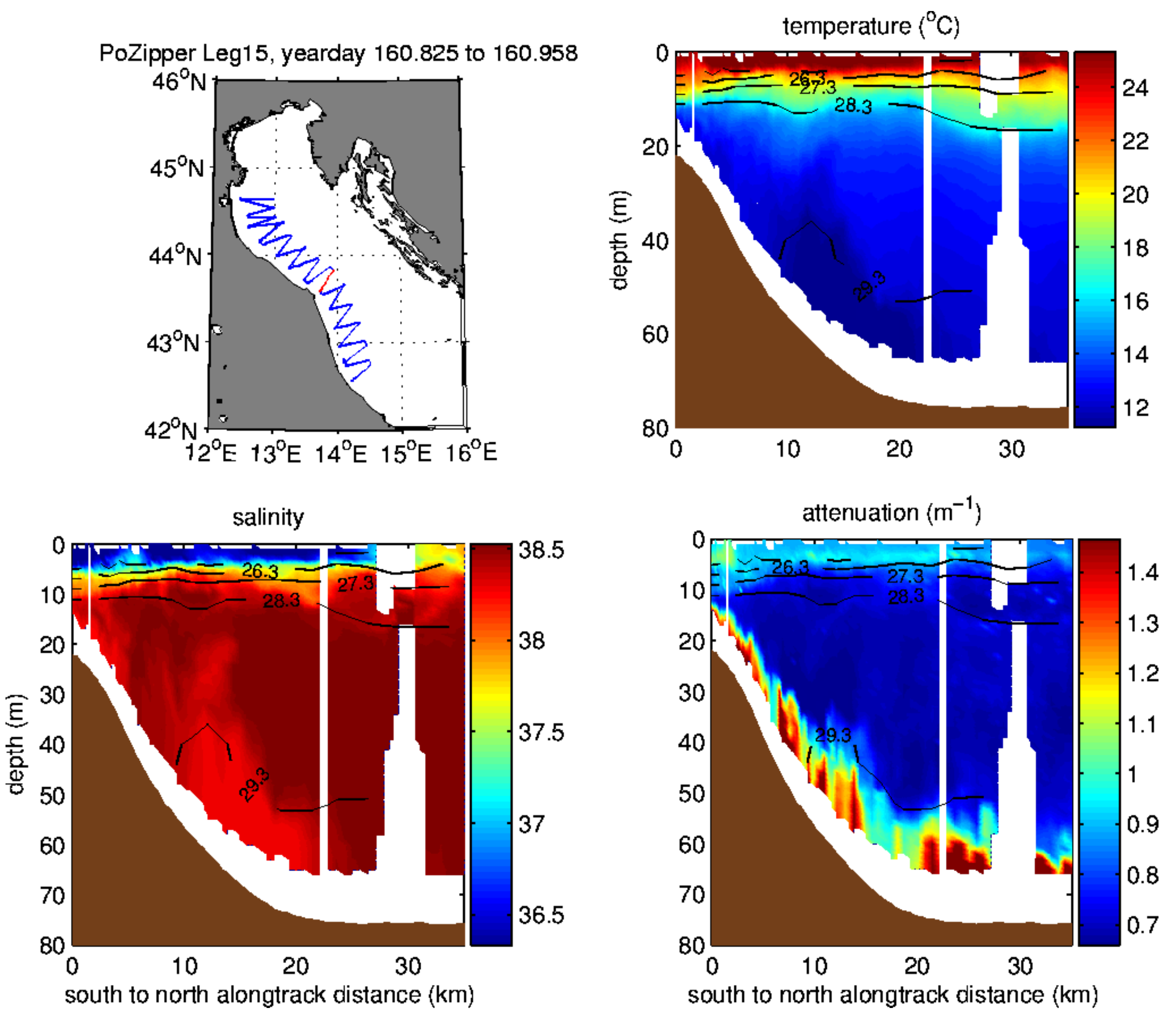


Figure 2.152: Temperature, salinity, and attenuation for PoZipper survey, Leg15 section. Overlaid contours are σ_θ.

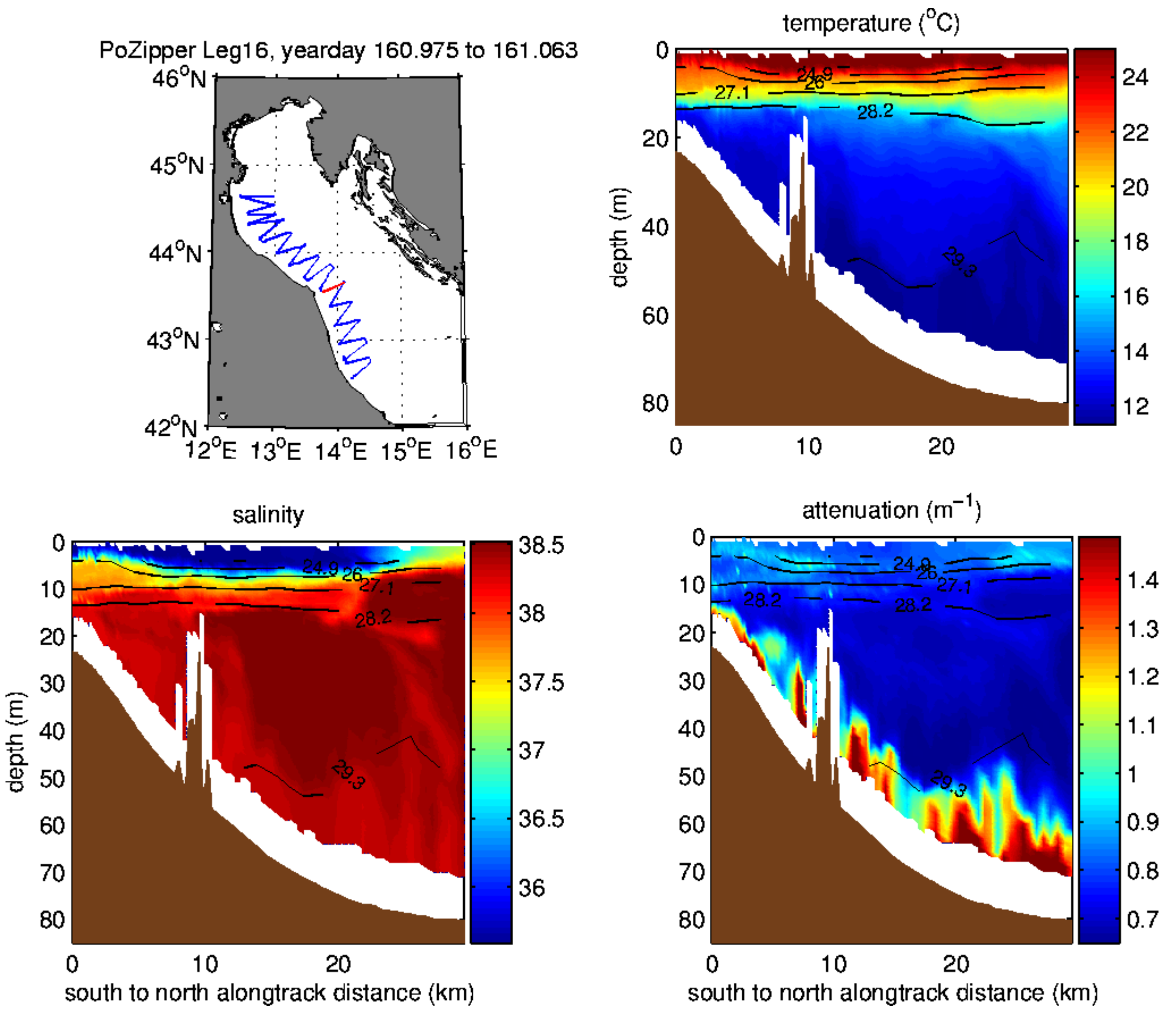


Figure 2.153: Temperature, salinity, and attenuation for PoZipper survey, Leg16 section. Overlaid contours are σ_θ.

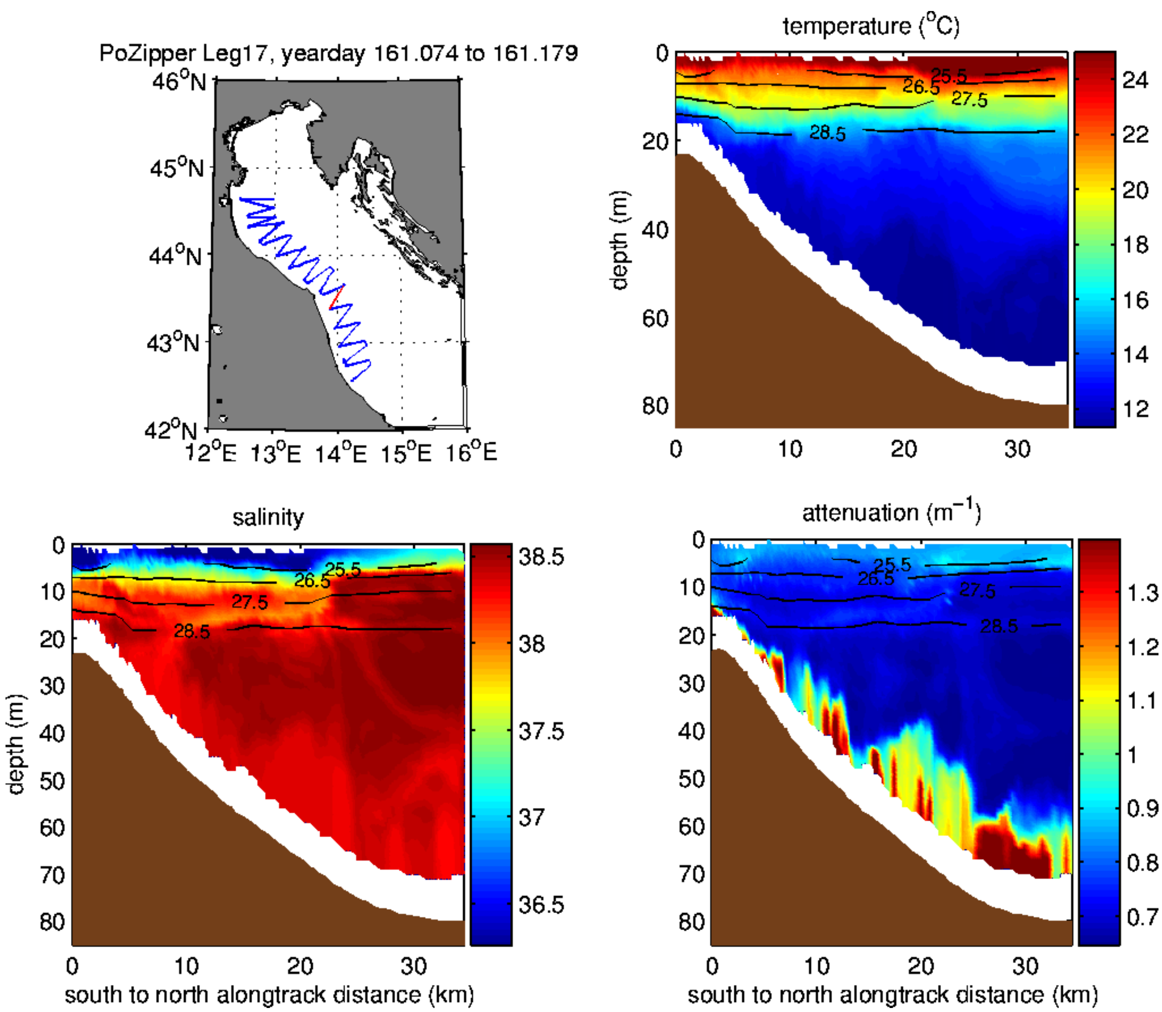


Figure 2.154: Temperature, salinity, and attenuation for PoZipper survey, Leg17 section. Overlaid contours are σ_θ.

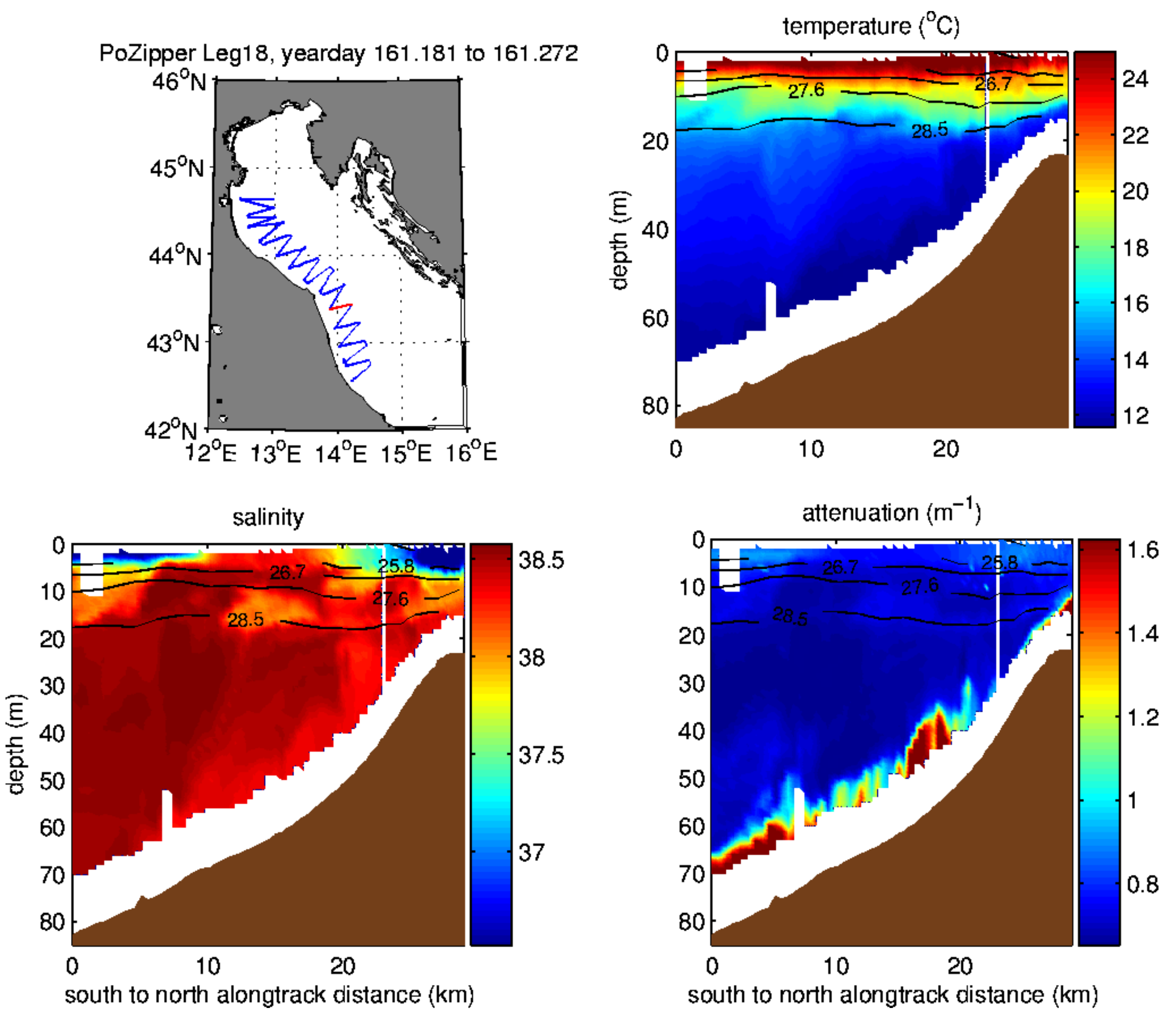


Figure 2.155: Temperature, salinity, and attenuation for PoZipper survey, Leg18 section. Overlaid contours are σ_θ.

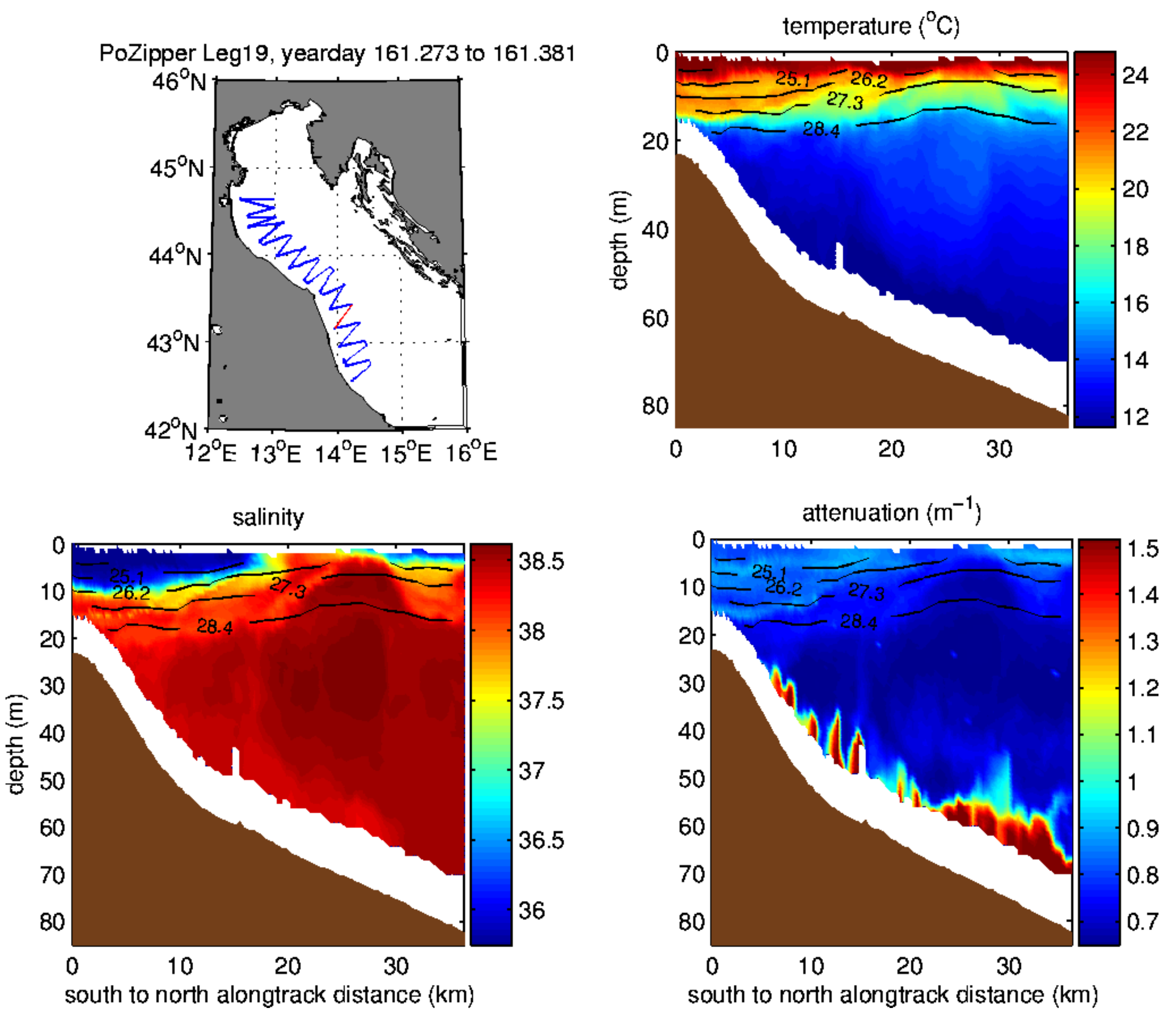


Figure 2.156: Temperature, salinity, and attenuation for PoZipper survey, Leg19 section. Overlaid contours are σ_θ.

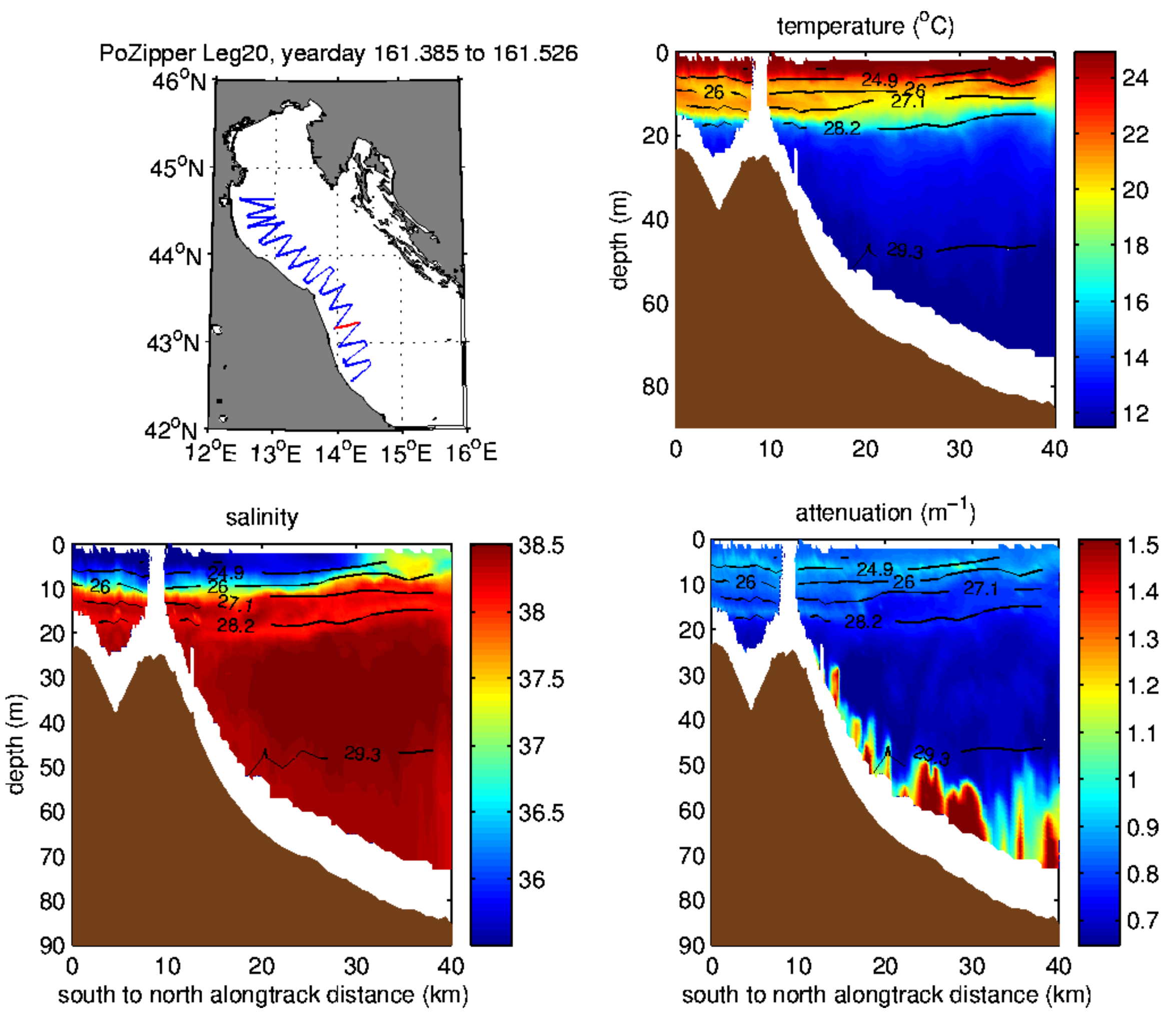


Figure 2.157: Temperature, salinity, and attenuation for PoZipper survey, Leg20 section. Overlaid contours are σ_θ.

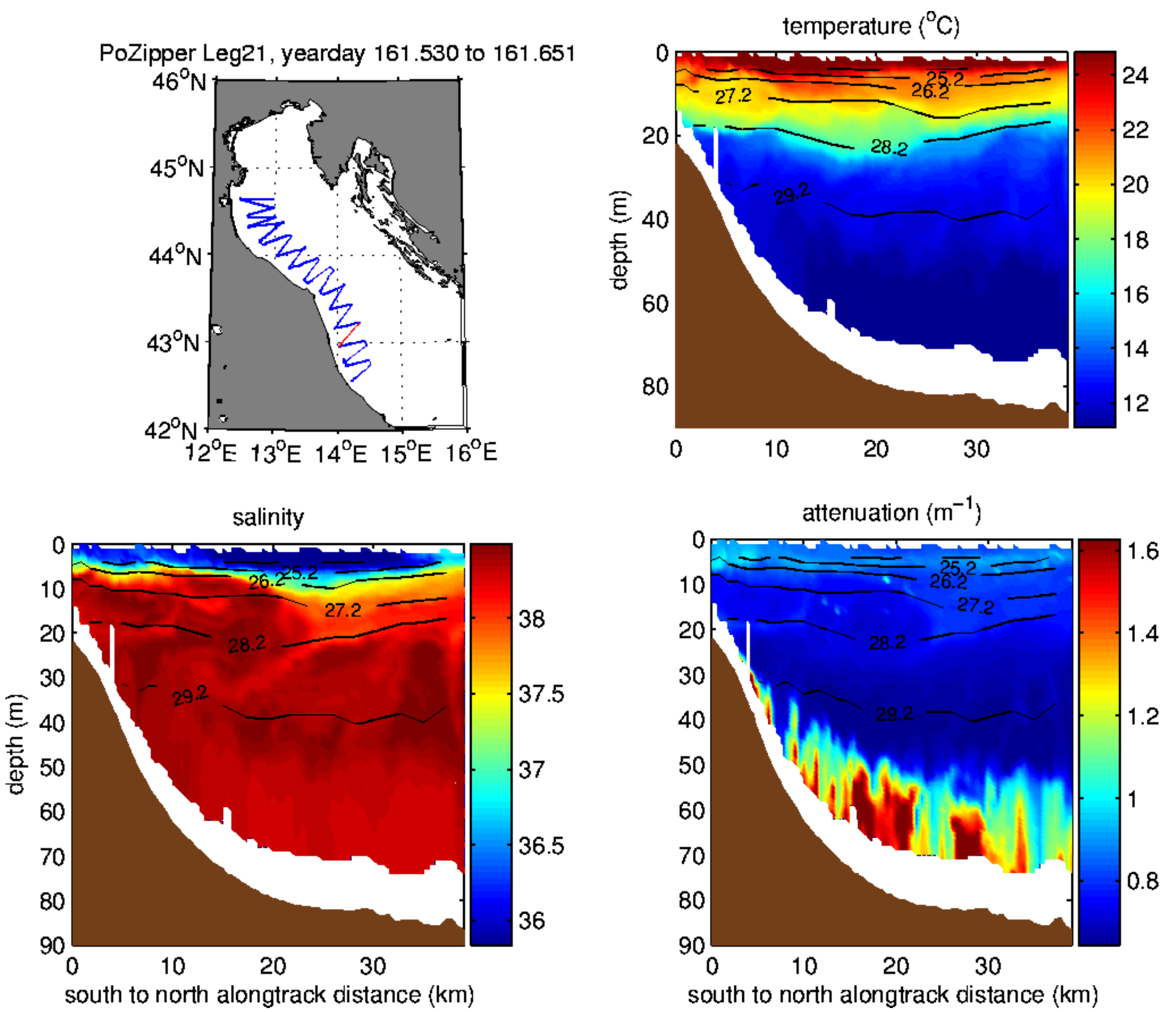


Figure 2.158: Temperature, salinity, and attenuation for PoZipper survey, Leg21 section. Overlaid contours are σ_θ.

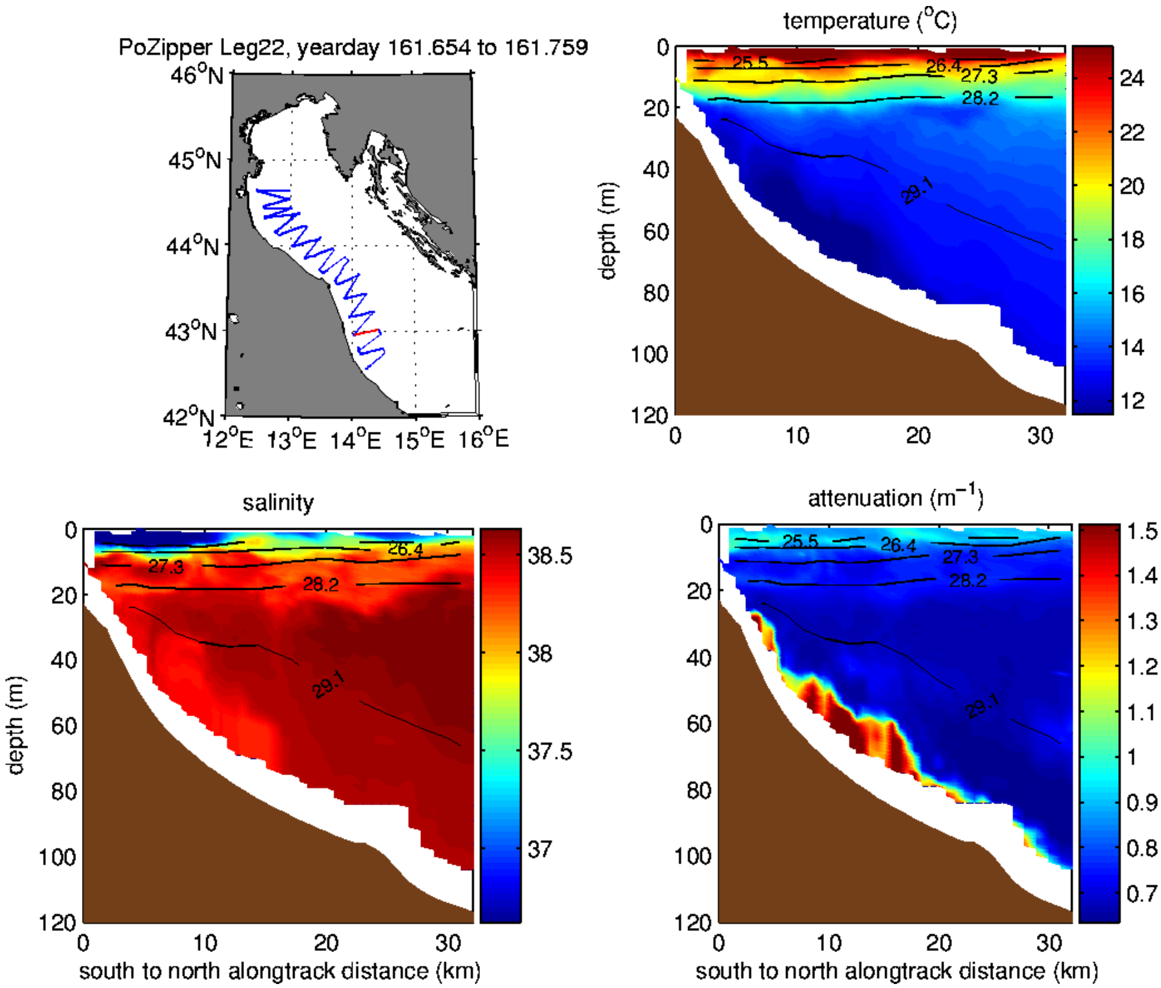


Figure 2.159: Temperature, salinity, and attenuation for PoZipper survey, Leg22 section. Overlaid contours are σ_θ.

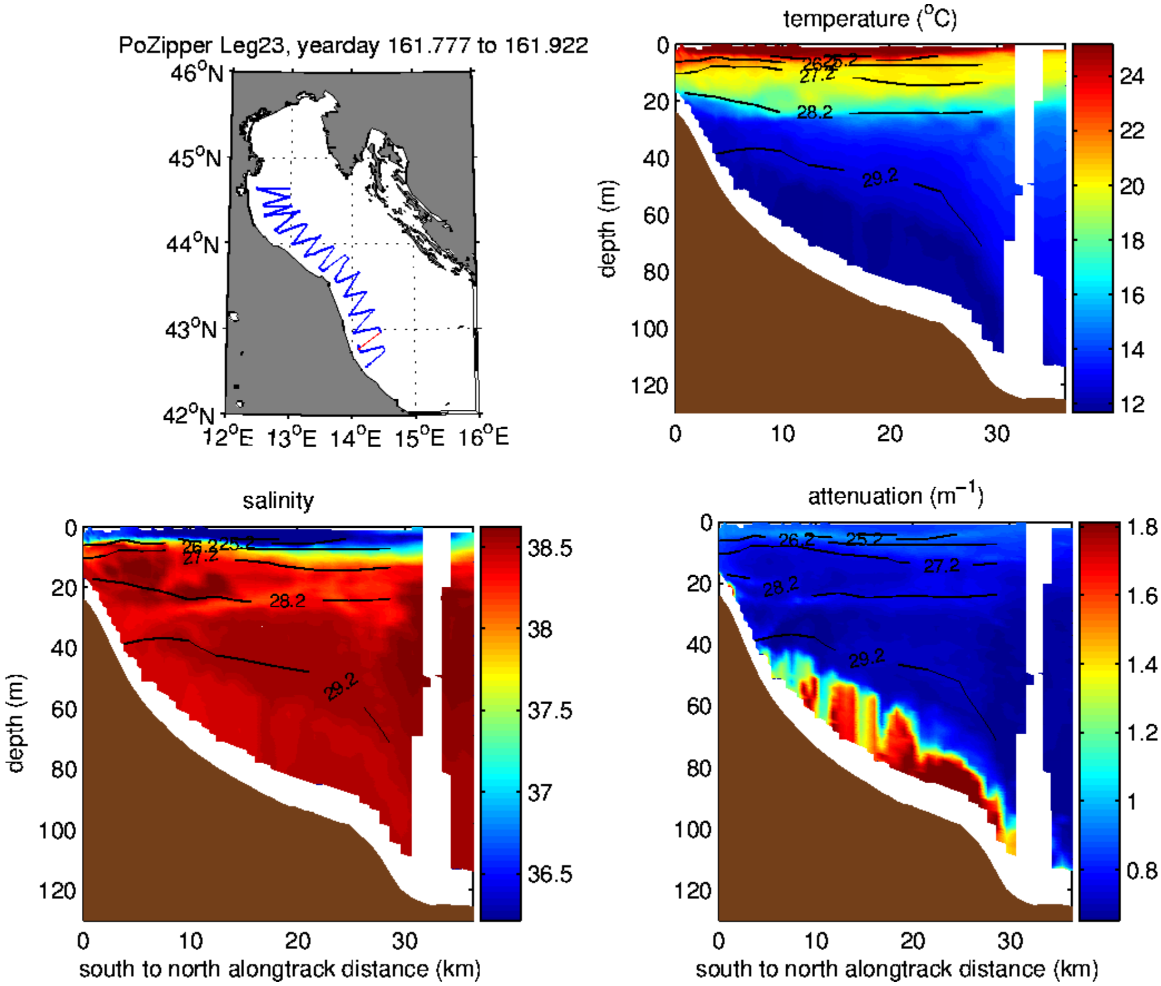


Figure 2.160: Temperature, salinity, and attenuation for PoZipper survey, Leg23 section. Overlaid contours are σ_θ.

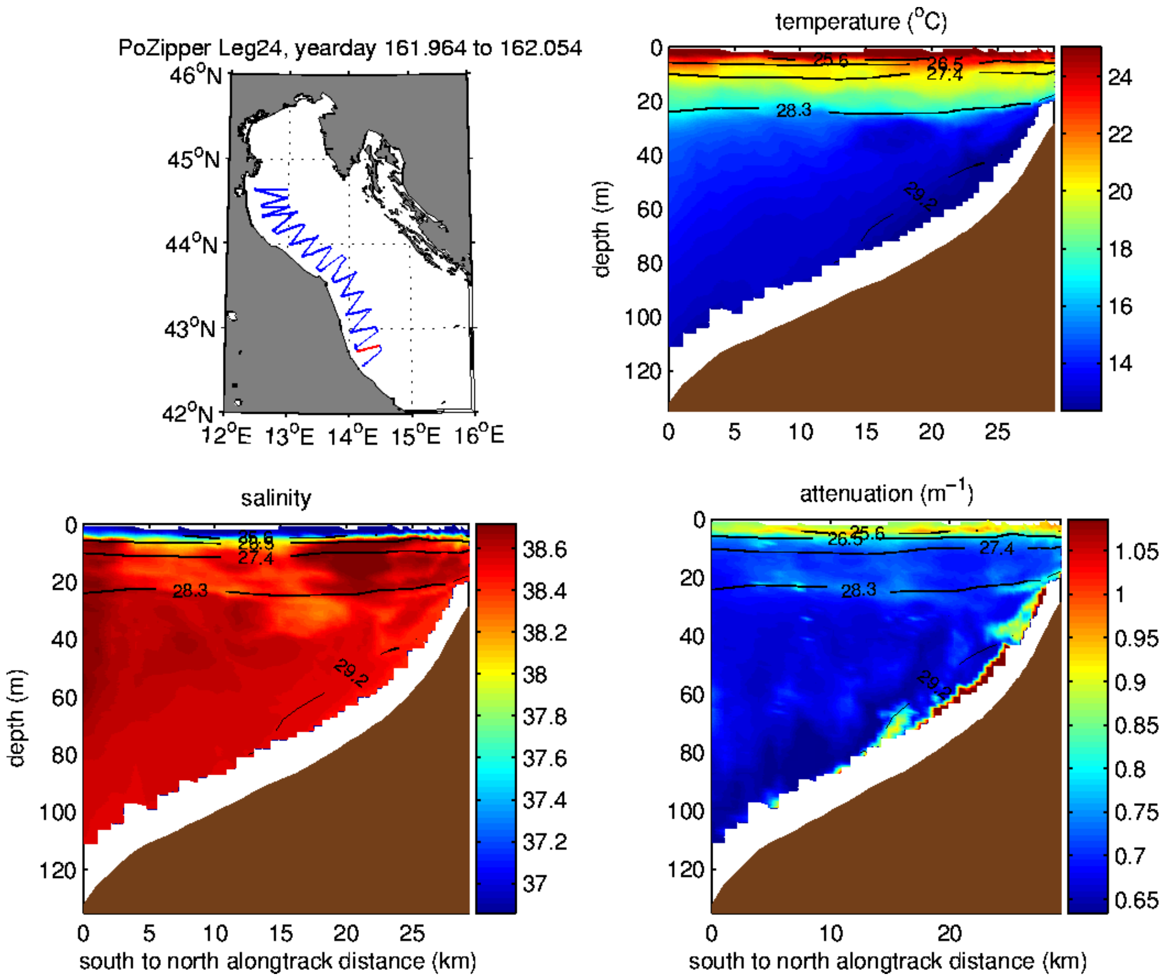


Figure 2.161: Temperature, salinity, and attenuation for PoZipper survey, Leg24 section. Overlaid contours are σ_θ.

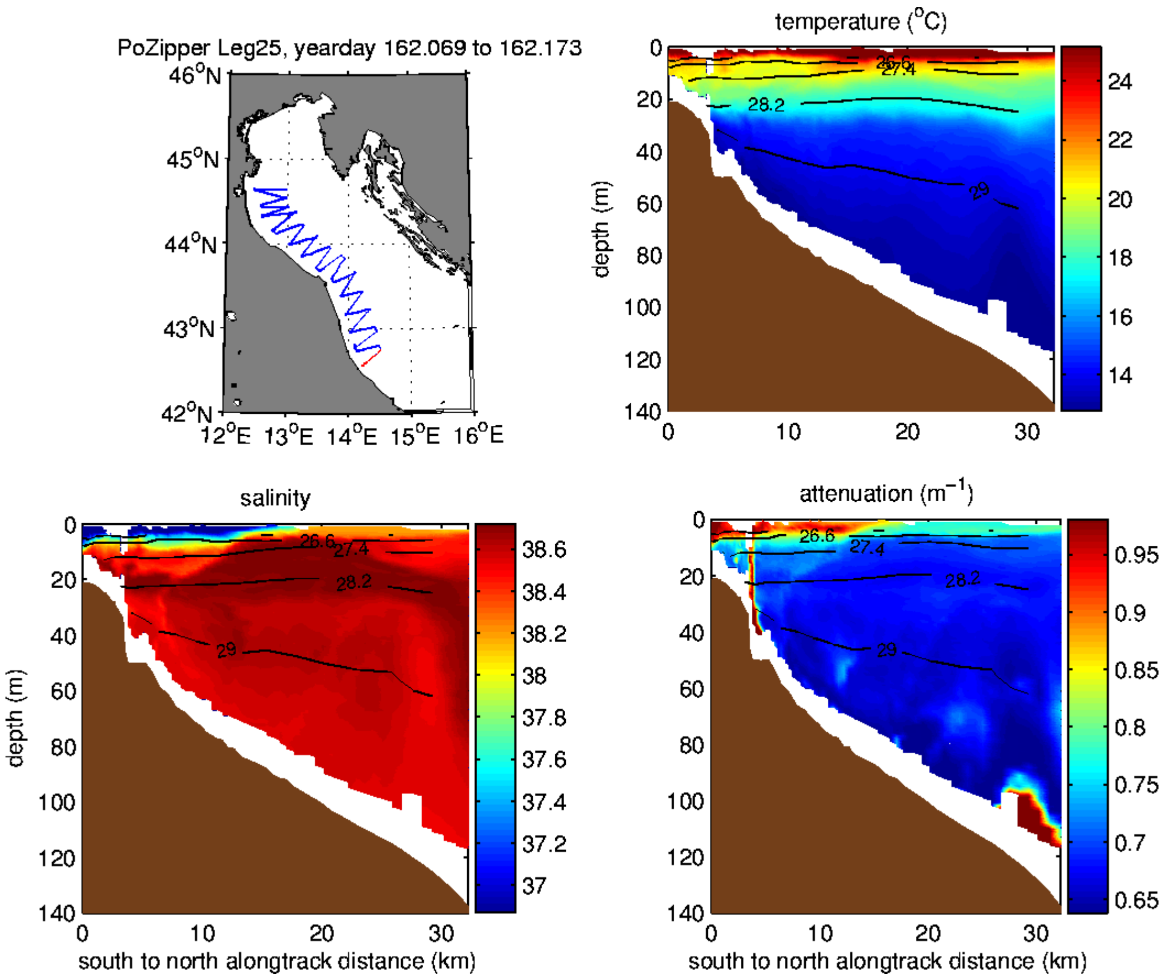


Figure 2.162: Temperature, salinity, and attenuation for PoZipper survey, Leg25 section. Overlaid contours are σ_θ.

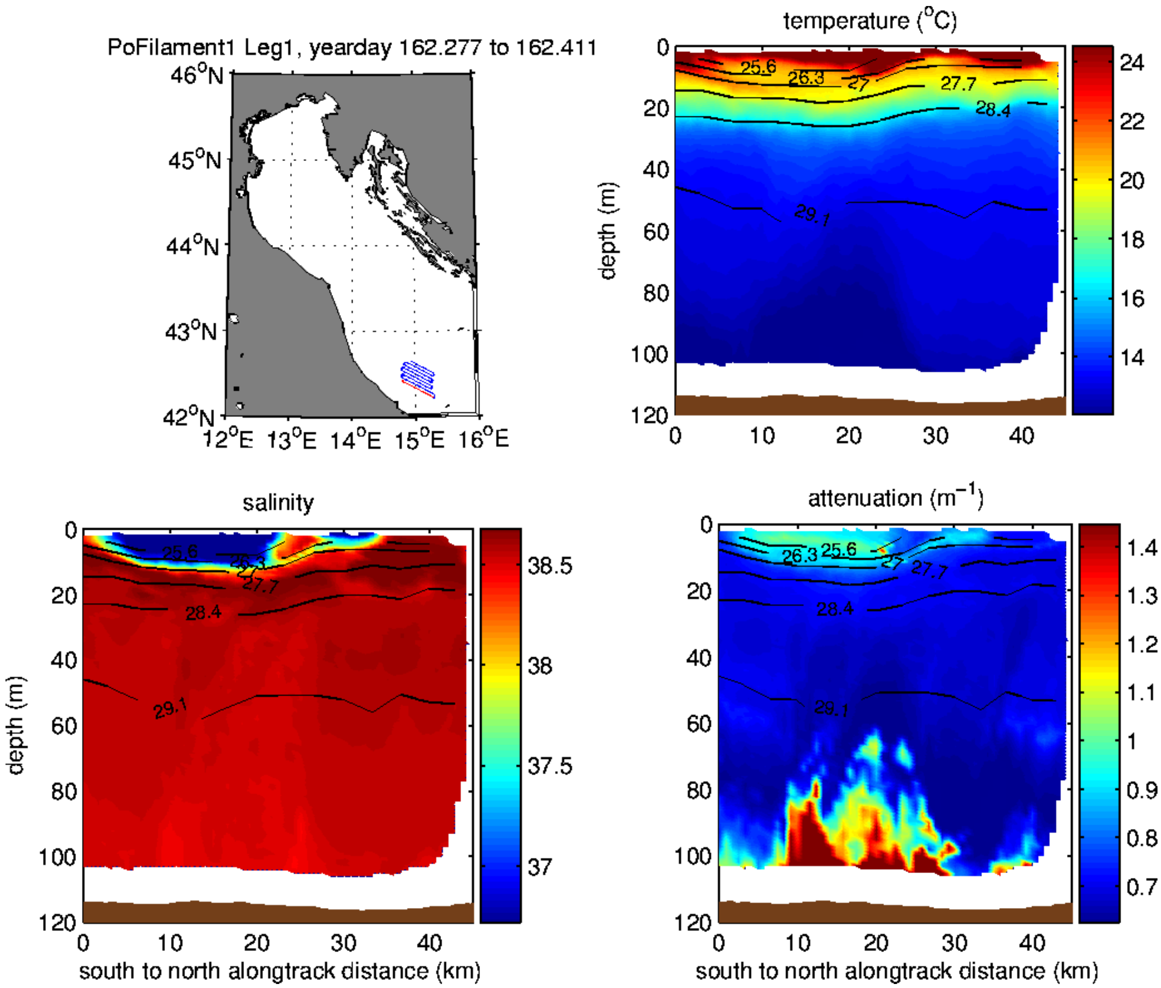


Figure 2.163: Temperature, salinity, and attenuation for PoFilament1 survey, Leg1 section. Overlaid contours are σ_θ.

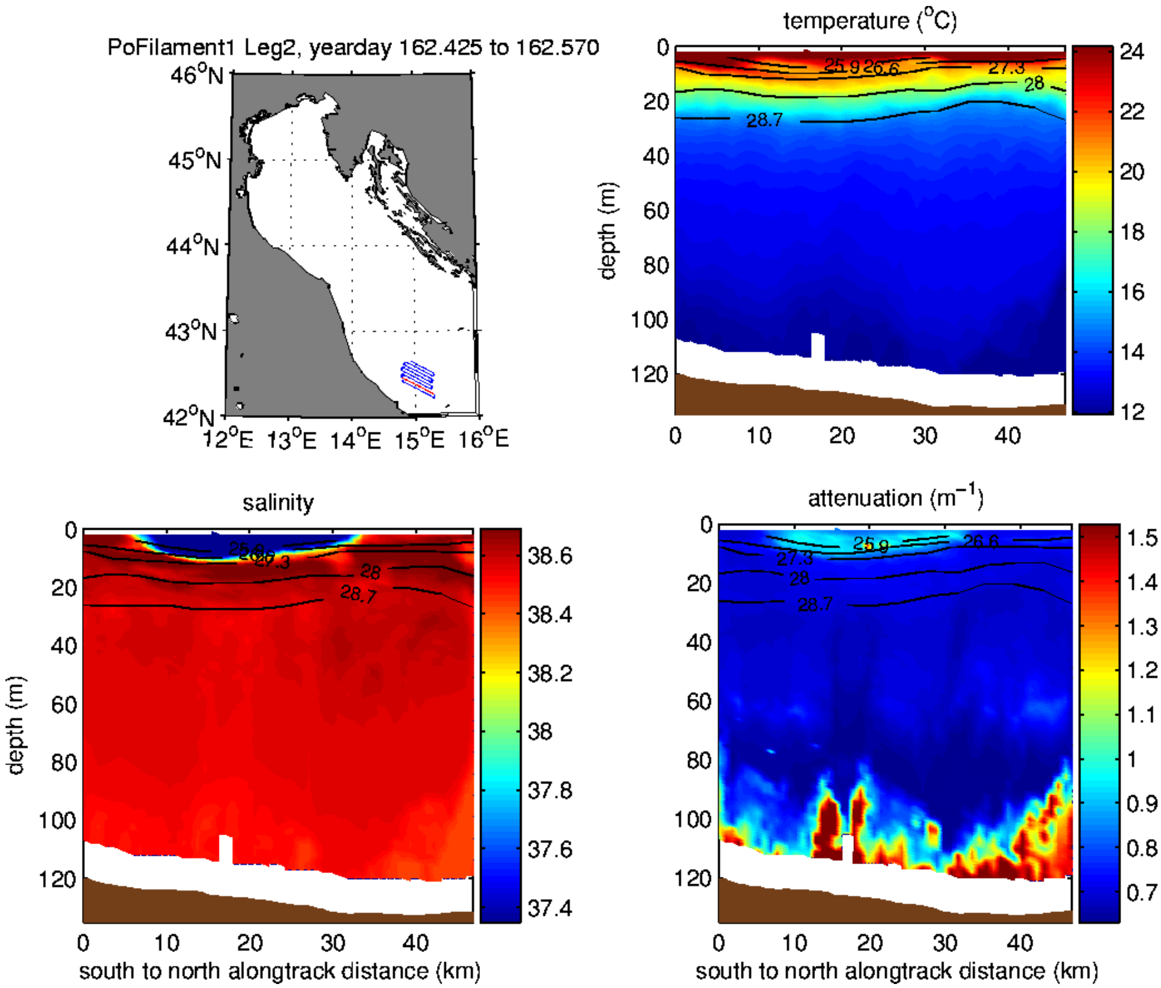


Figure 2.164: Temperature, salinity, and attenuation for PoFilament1 survey, Leg2 section. Overlaid contours are σ_θ.

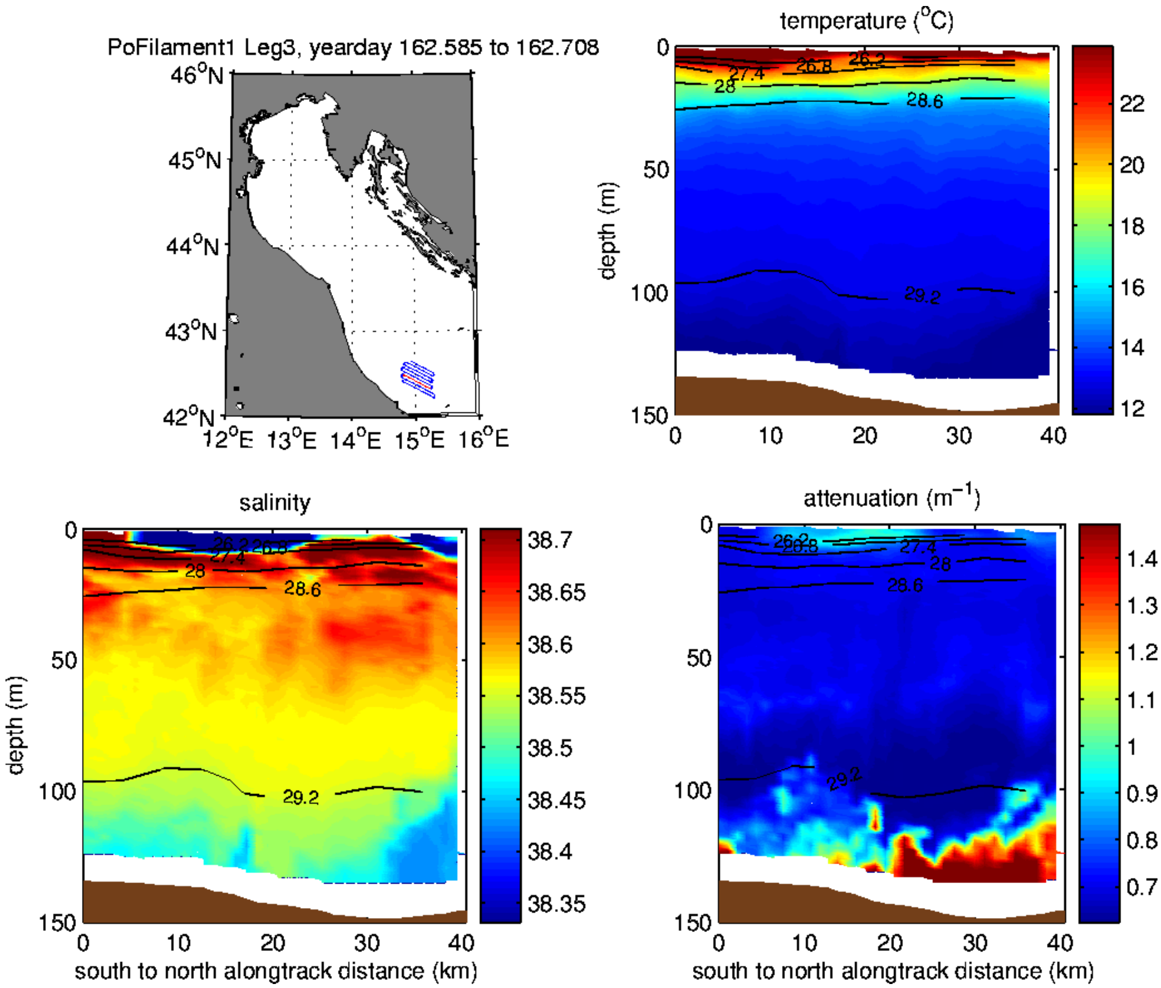


Figure 2.165: Temperature, salinity, and attenuation for PoFilament1 survey, Leg3 section. Overlaid contours are σ_θ.

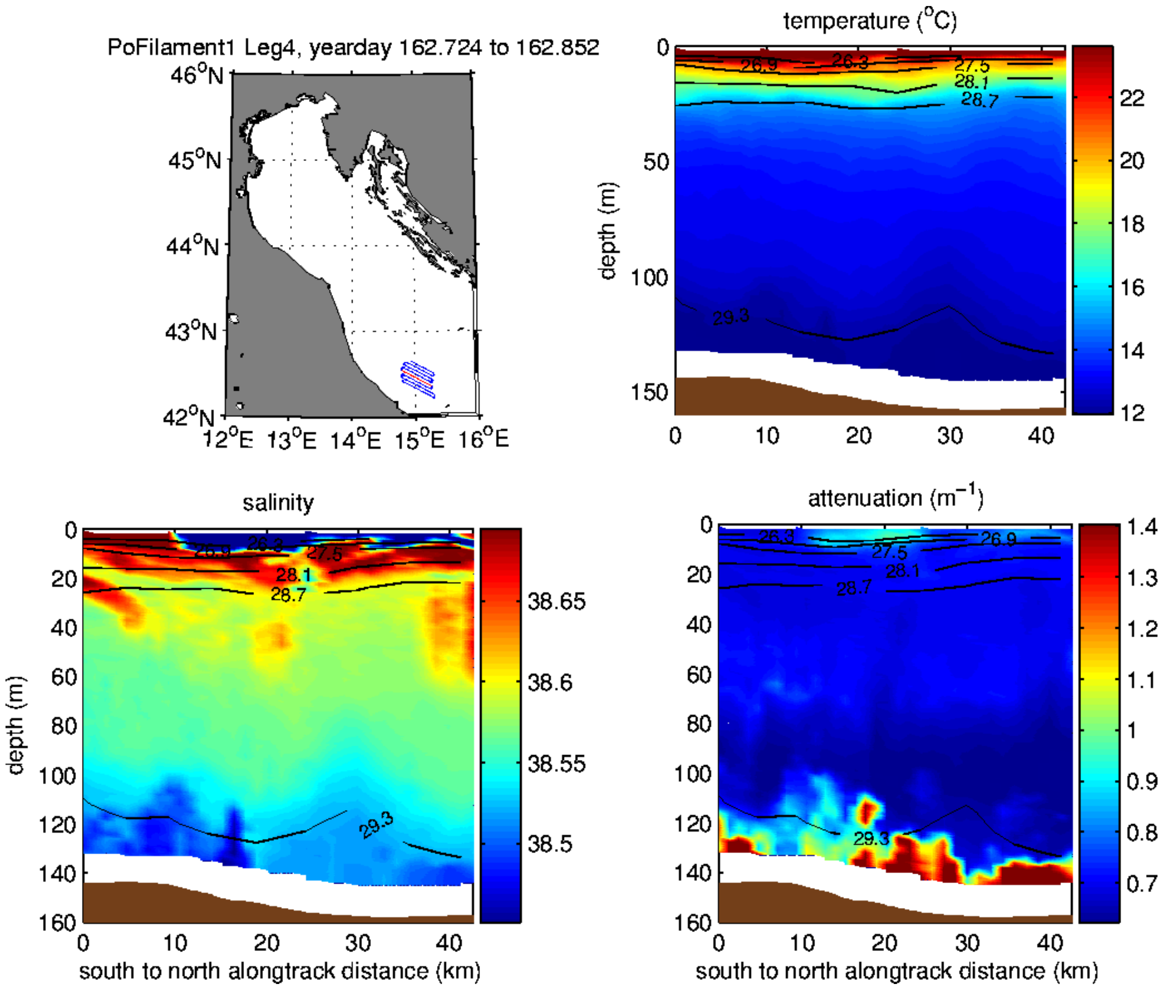


Figure 2.166: Temperature, salinity, and attenuation for PoFilament1 survey, Leg4 section. Overlaid contours are σ_θ.

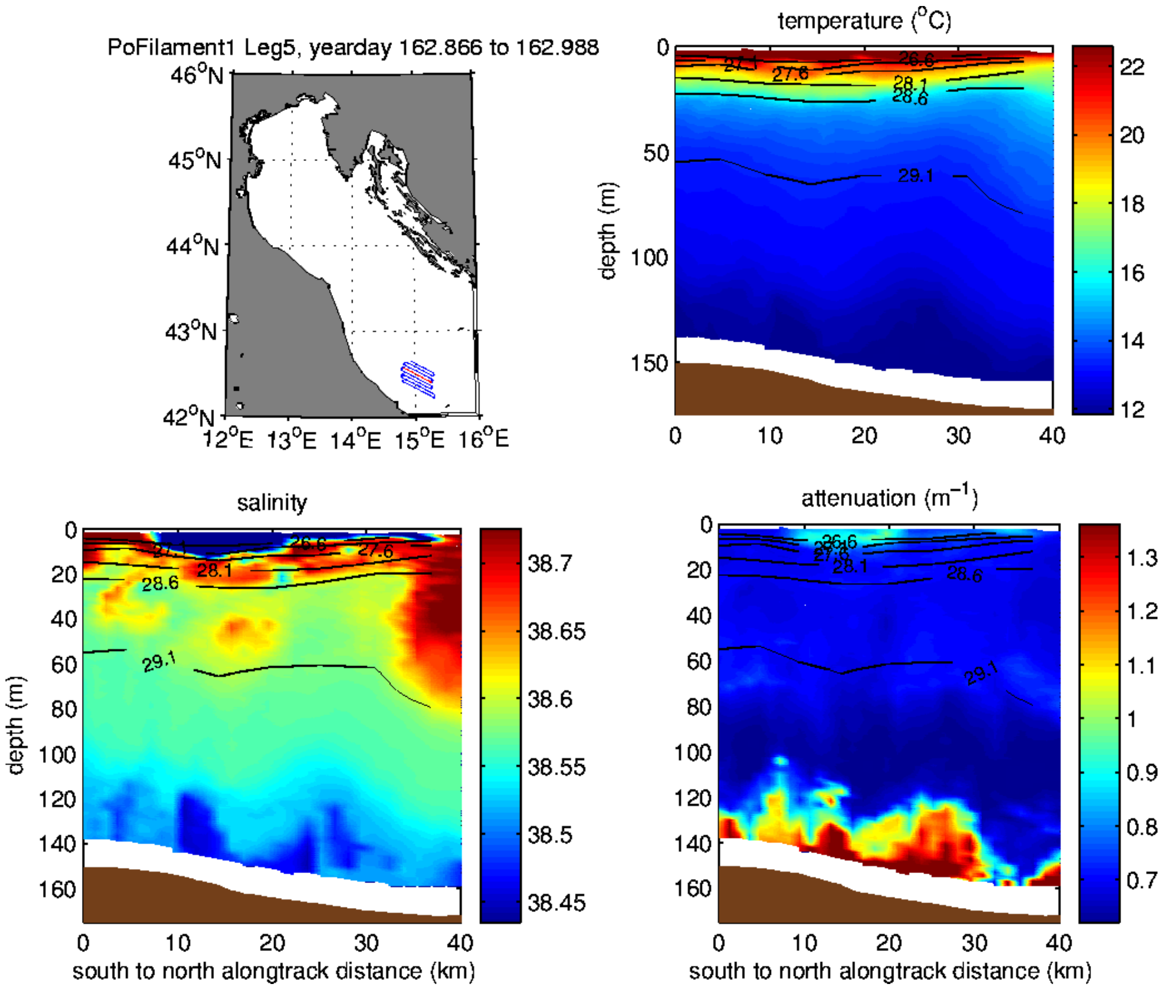


Figure 2.167: Temperature, salinity, and attenuation for PoFilament1 survey, Leg5 section. Overlaid contours are σ_θ.

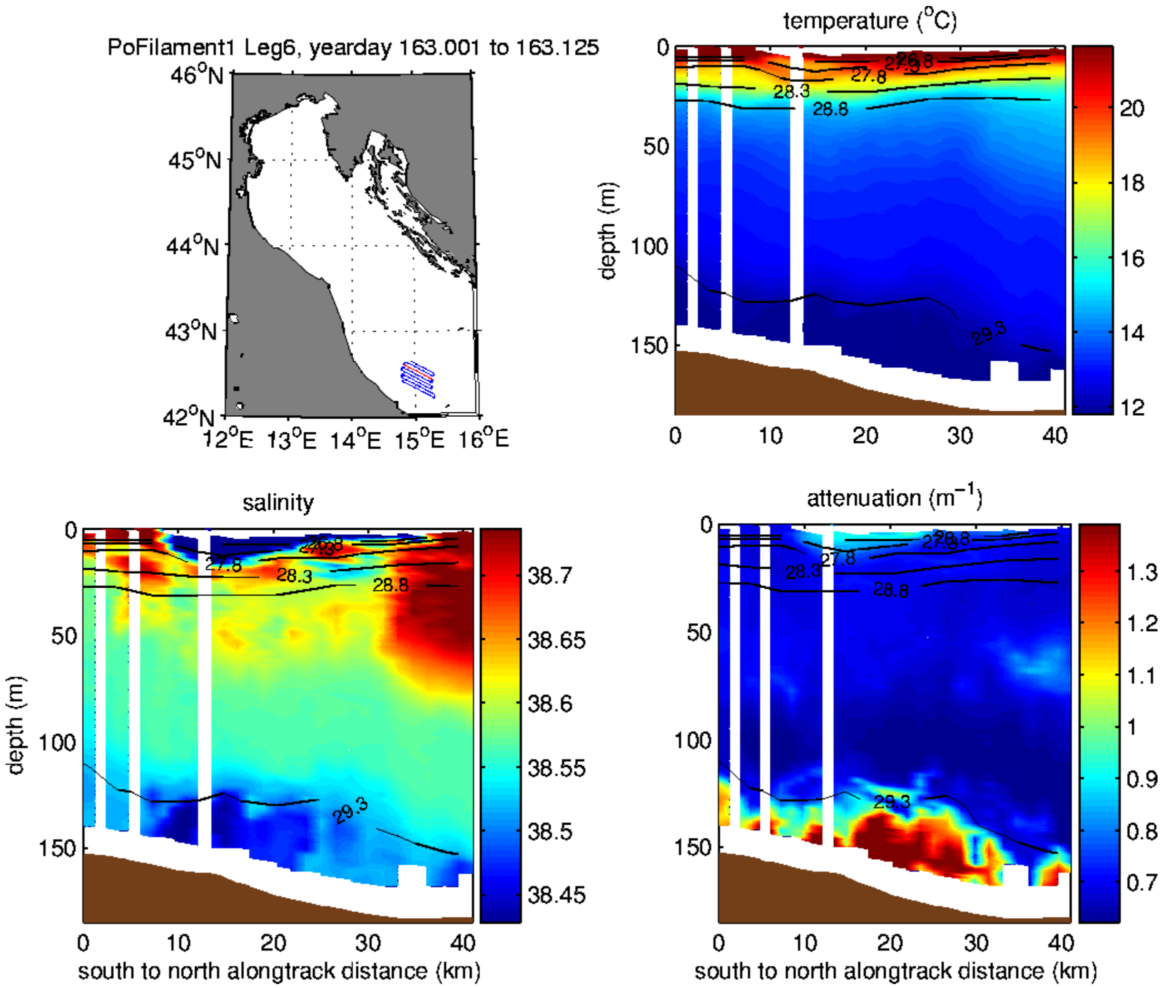


Figure 2.168: Temperature, salinity, and attenuation for PoFilament1 survey, Leg6 section. Overlaid contours are σ_θ.

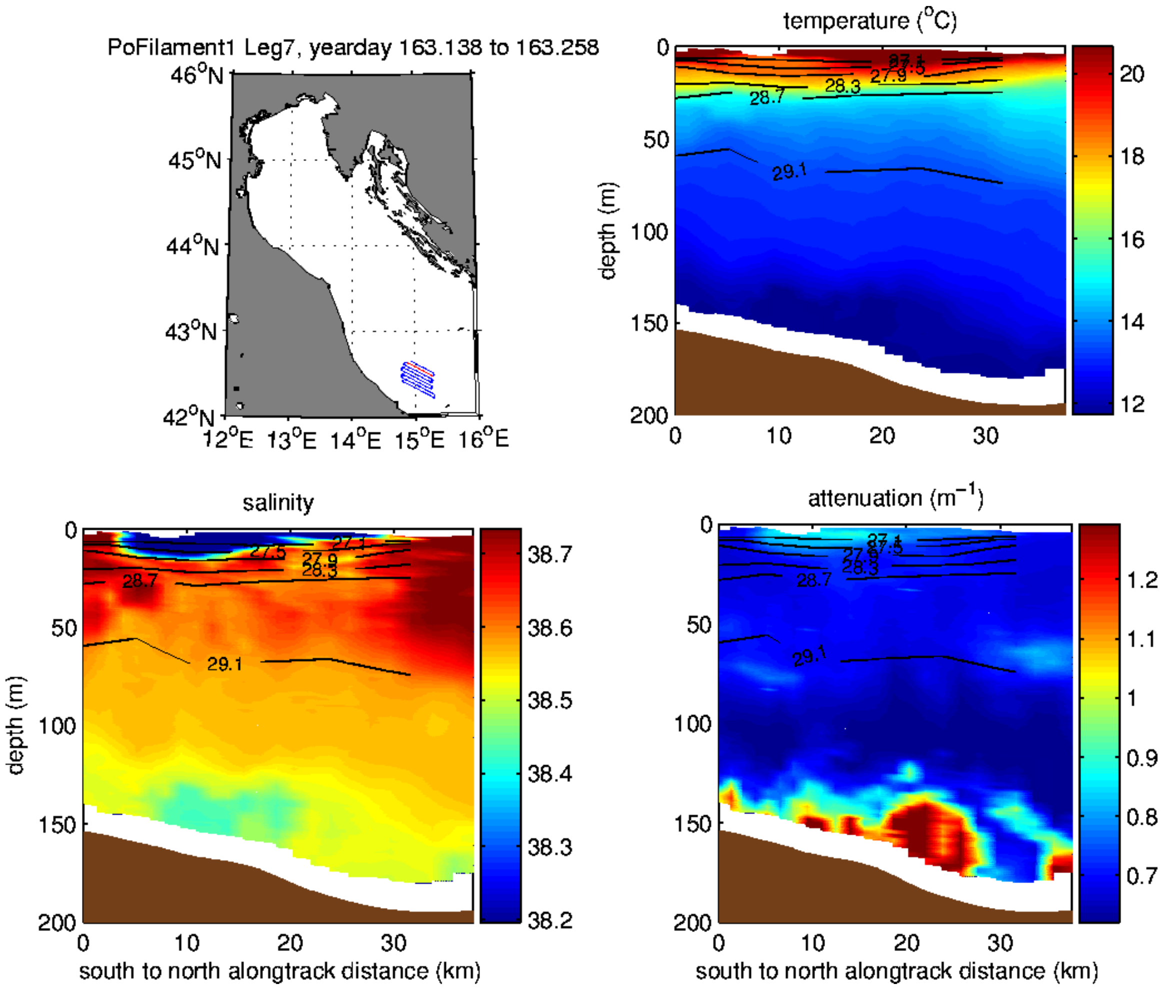


Figure 2.169: Temperature, salinity, and attenuation for PoFilament1 survey, Leg7 section. Overlaid contours are σ_θ.

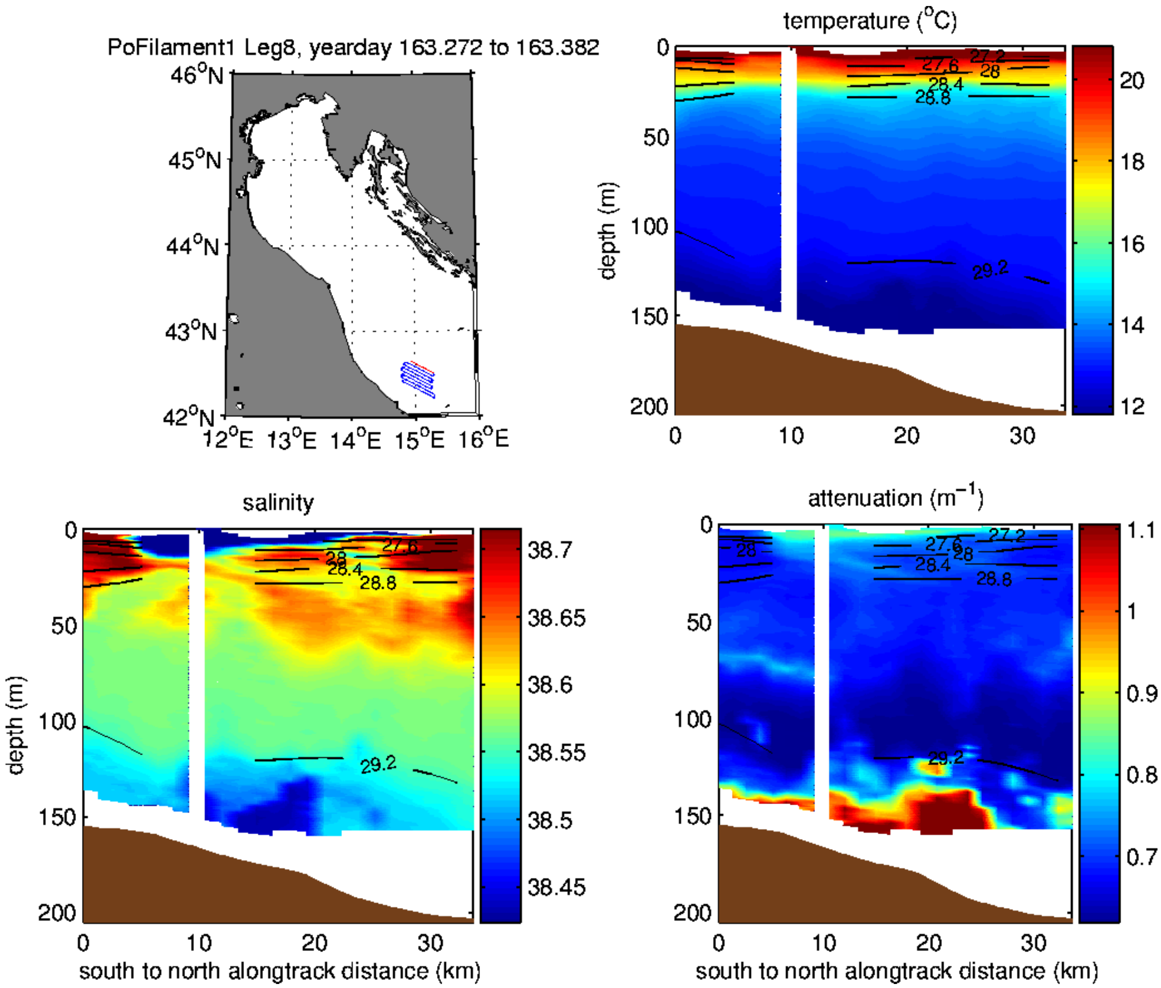


Figure 2.170: Temperature, salinity, and attenuation for PoFilament1 survey, Leg8 section. Overlaid contours are σ_θ.

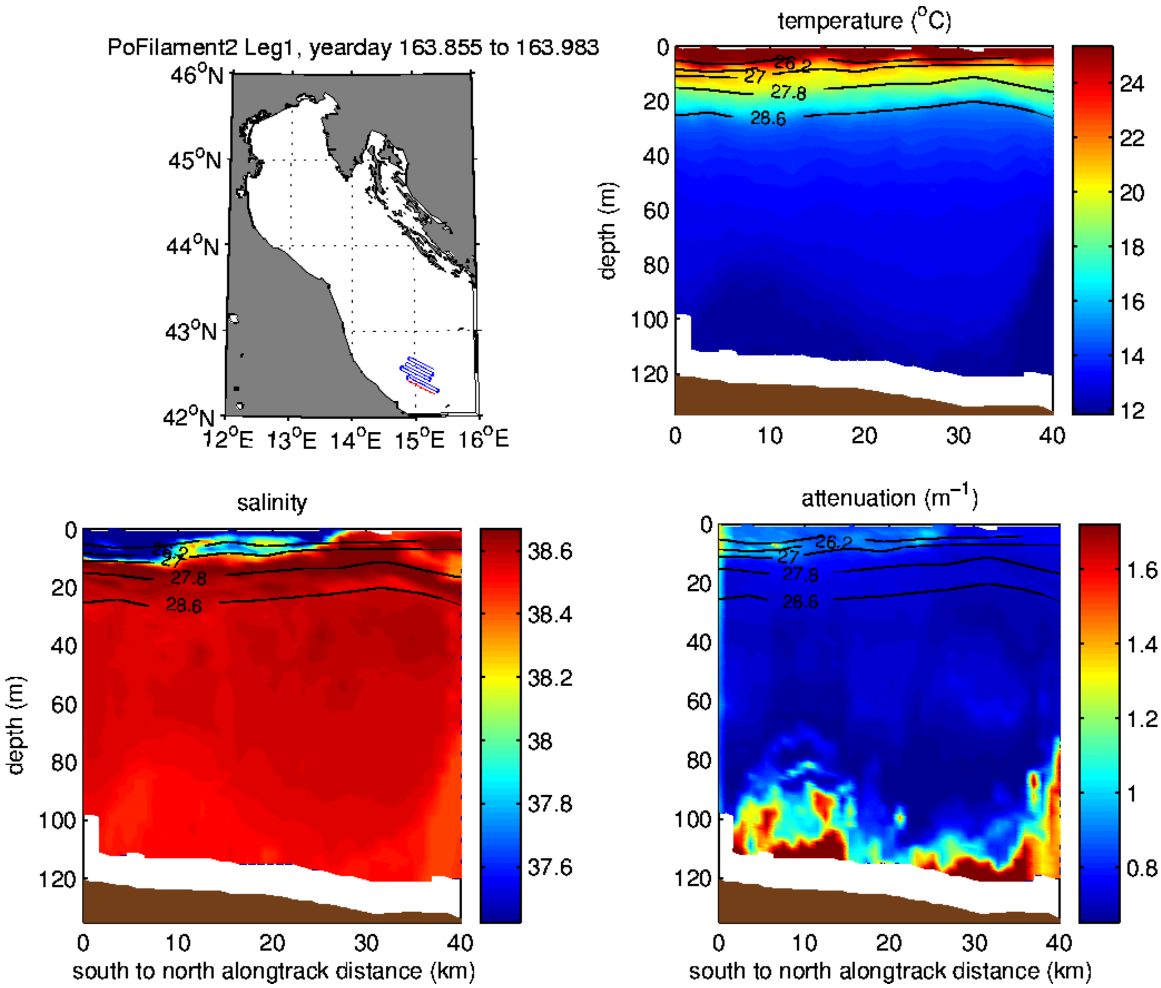


Figure 2.171: Temperature, salinity, and attenuation for PoFilament2 survey, Leg1 section. Overlaid contours are σ_θ.

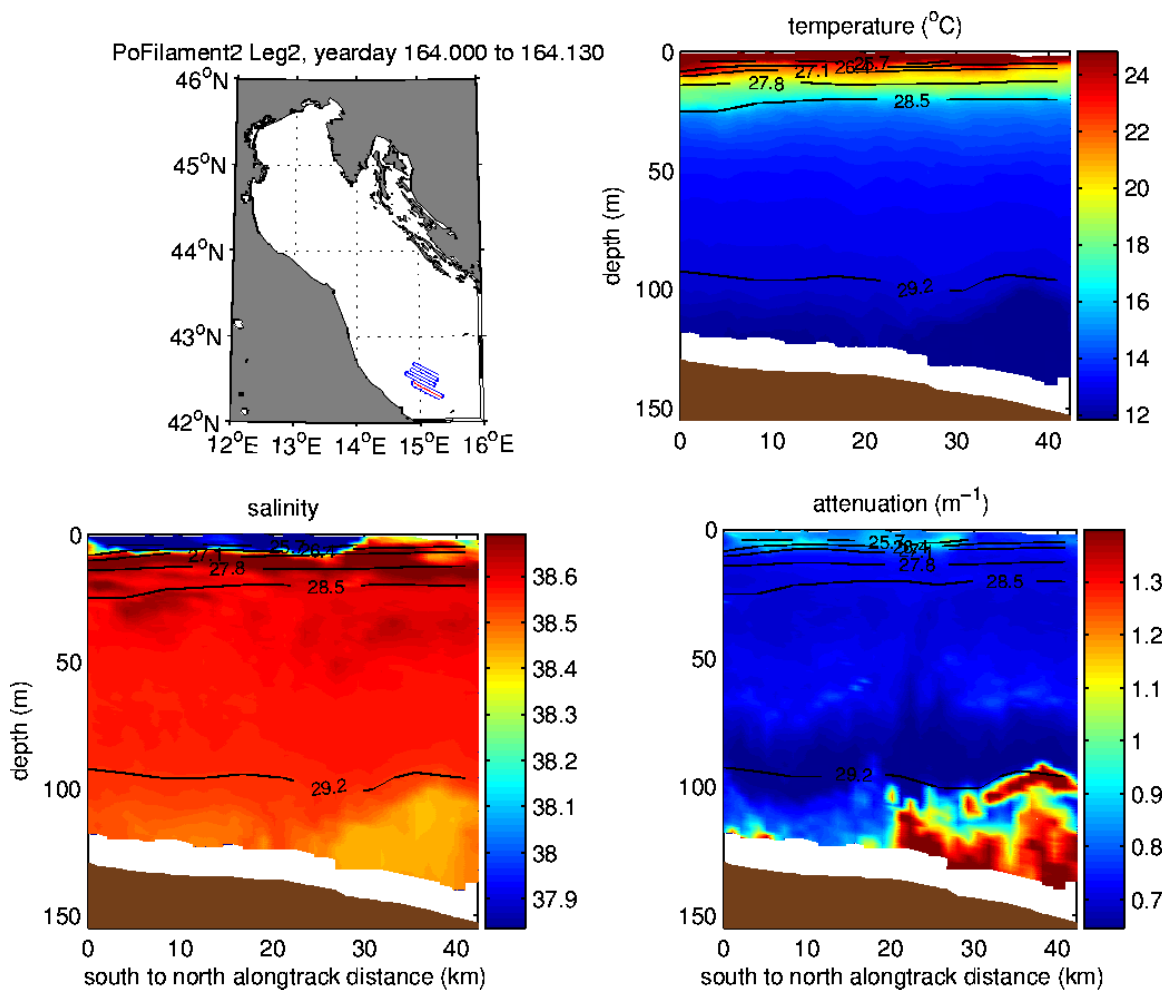


Figure 2.172: Temperature, salinity, and attenuation for PoFilament2 survey, Leg2 section. Overlaid contours are σ_θ.

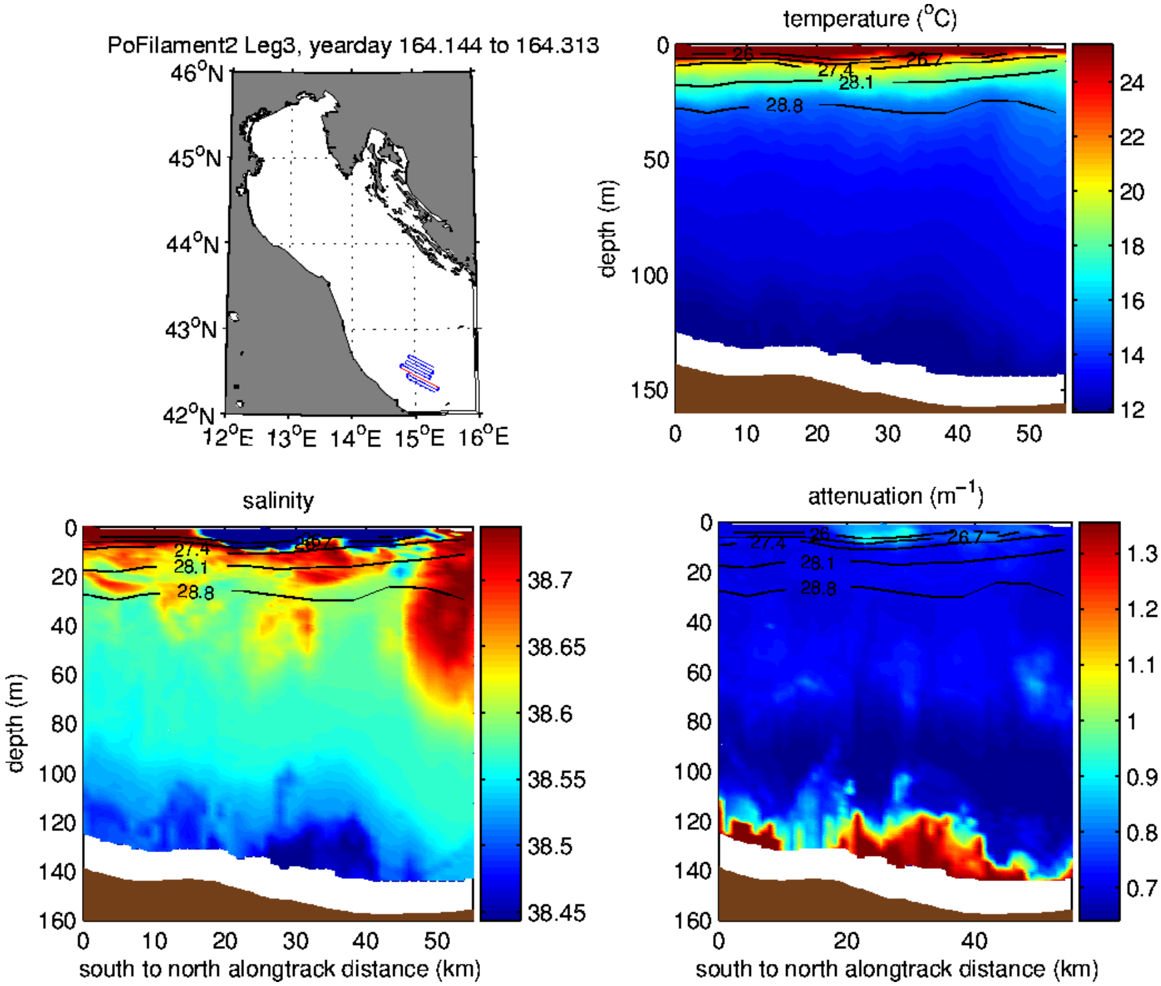


Figure 2.173: Temperature, salinity, and attenuation for PoFilament2 survey, Leg3 section. Overlaid contours are σ_θ.

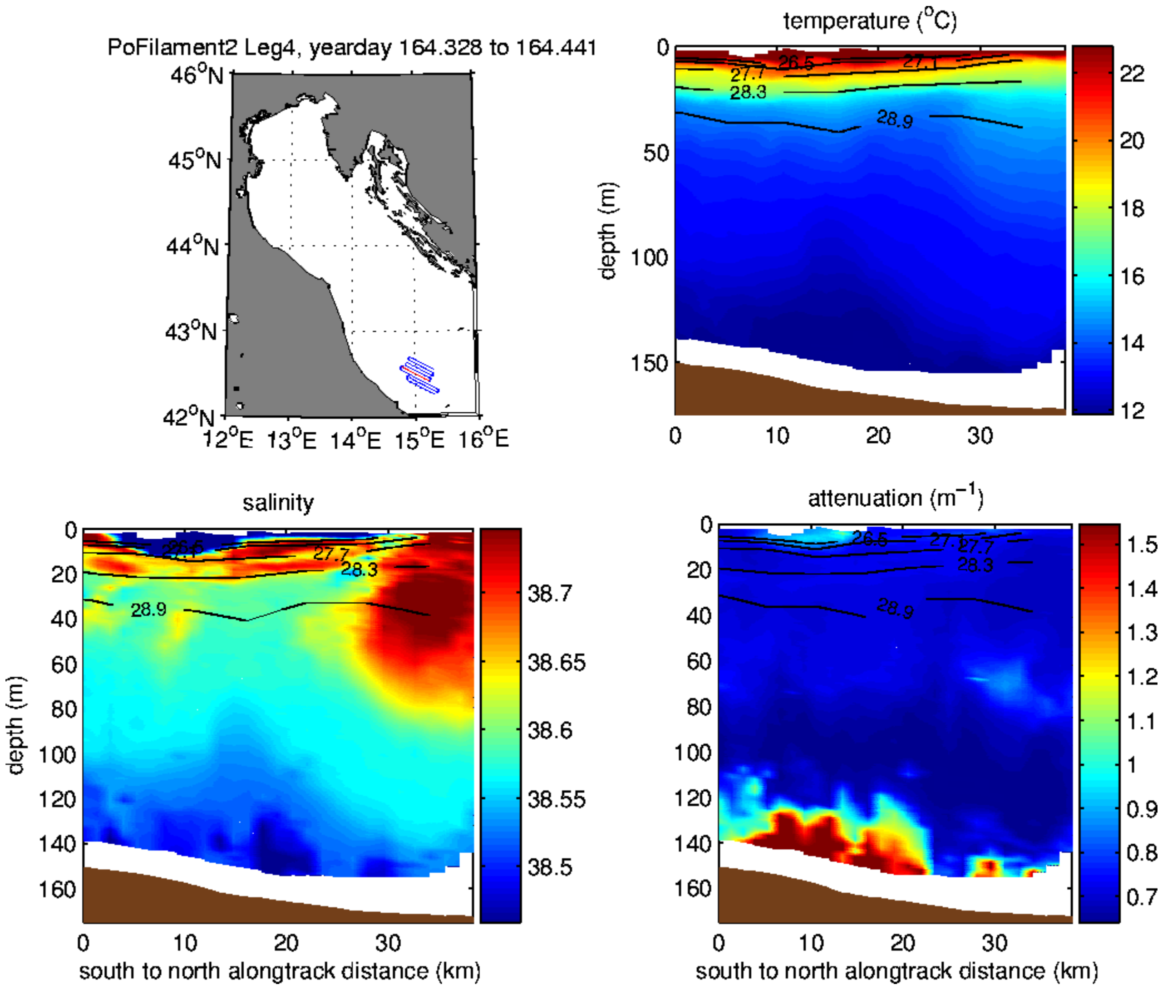


Figure 2.174: Temperature, salinity, and attenuation for PoFilament2 survey, Leg4 section. Overlaid contours are σ_θ.

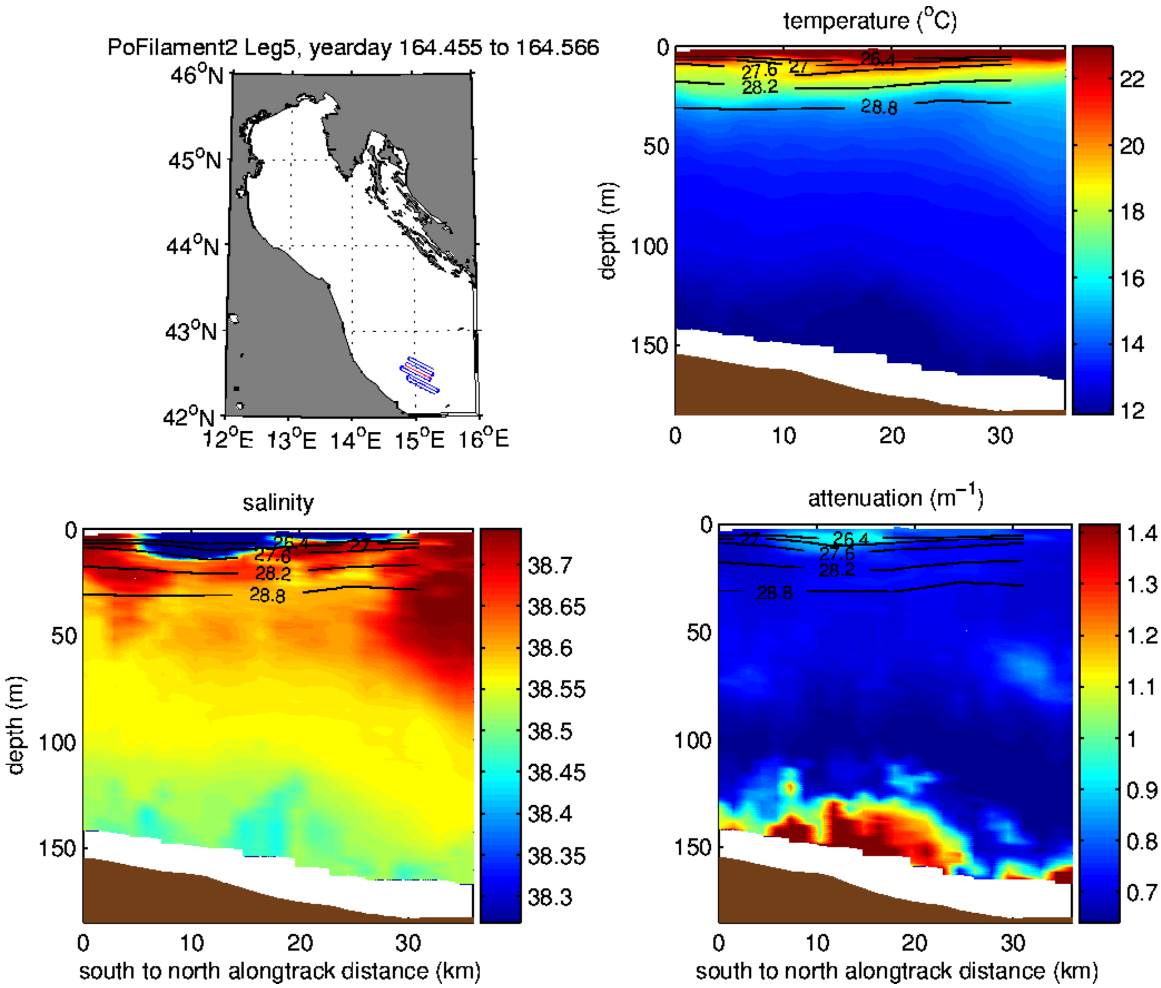


Figure 2.175: Temperature, salinity, and attenuation for PoFilament2 survey, Leg5 section. Overlaid contours are σ_θ.

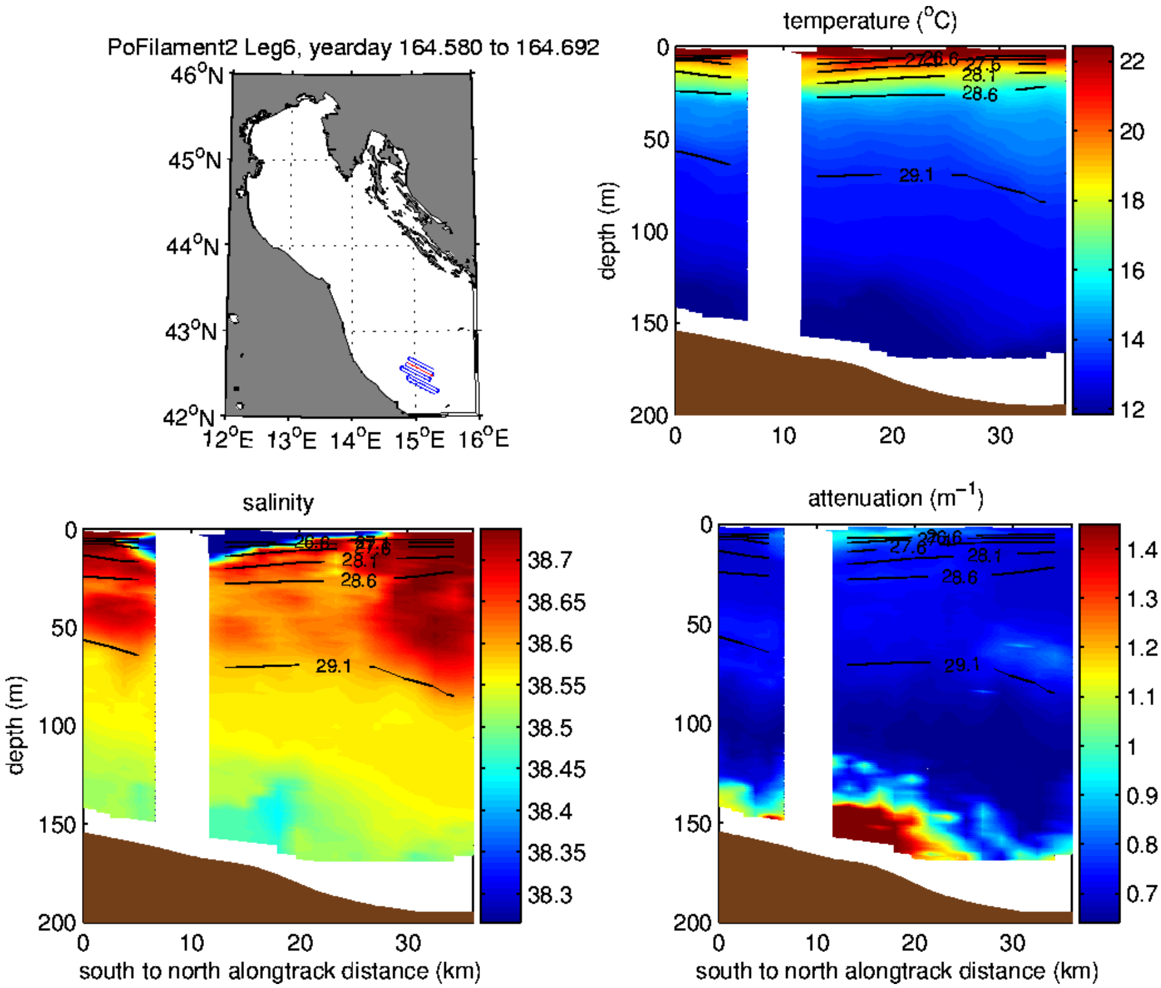


Figure 2.176: Temperature, salinity, and attenuation for PoFilament2 survey, Leg6 section. Overlaid contours are σ_θ.

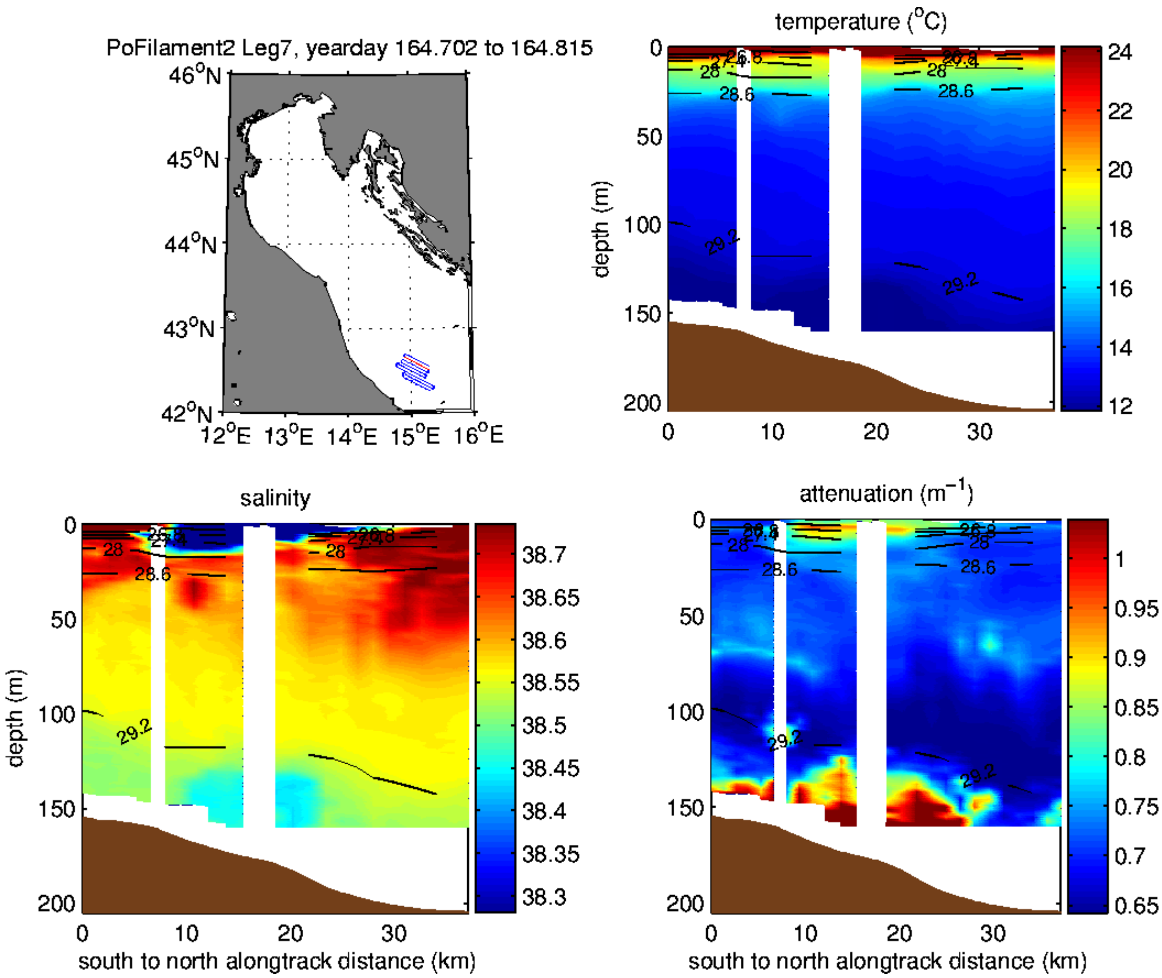


Figure 2.177: Temperature, salinity, and attenuation for PoFilament2 survey, Leg7 section. Overlaid contours are σ_θ.

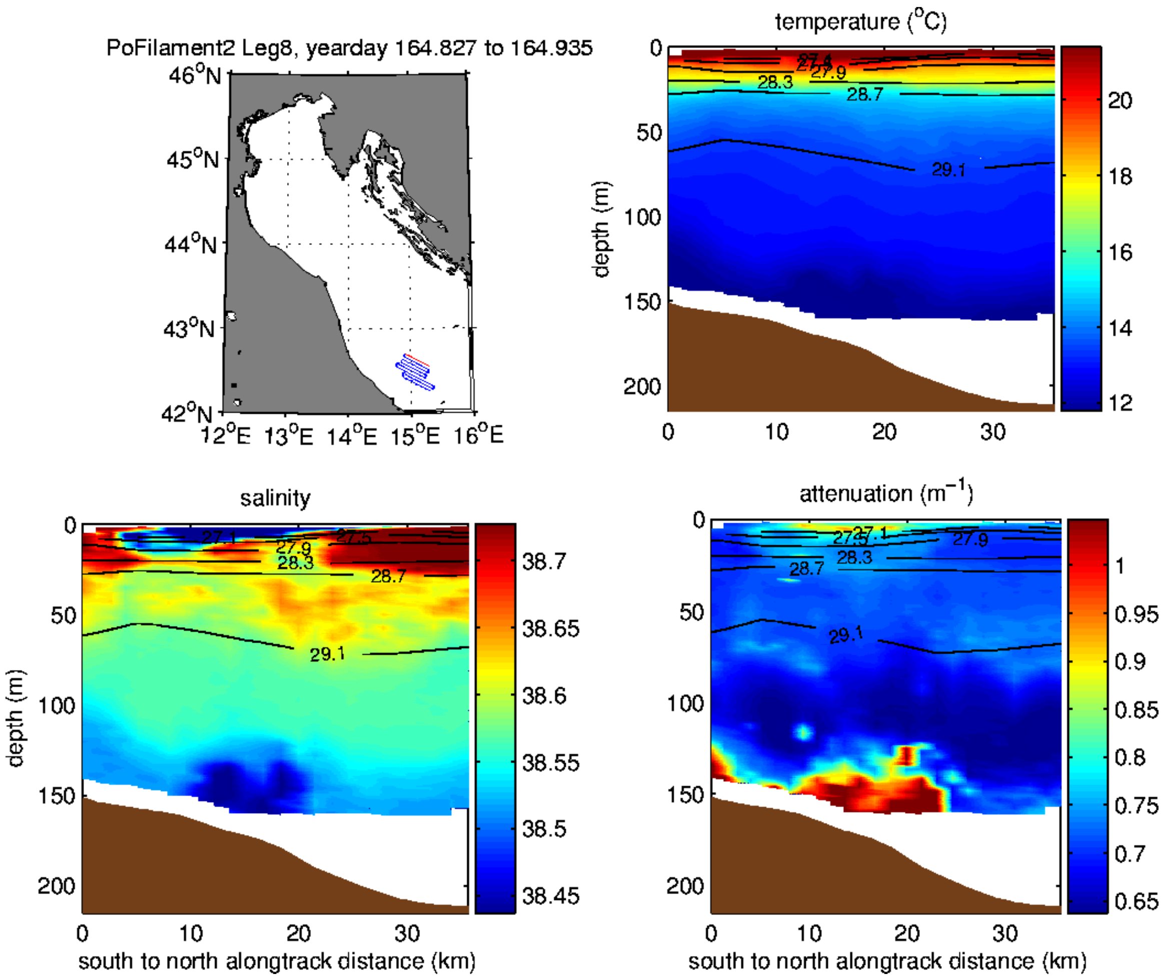


Figure 2.178: Temperature, salinity, and attenuation for PoFilament2 survey, Leg8 section. Overlaid contours are σ_θ.

Cruise Report

for

Optical Dynamics in the Adriatic Sea

Dolce Vita Cruise 1
(January 31 – February 23, 2003)

and

Dolce Vita Cruise 2
(May 25 – June 15, 2003)

Prepared by

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University of Southern California

Supported by Office of Naval Research
Environmental Optics Program
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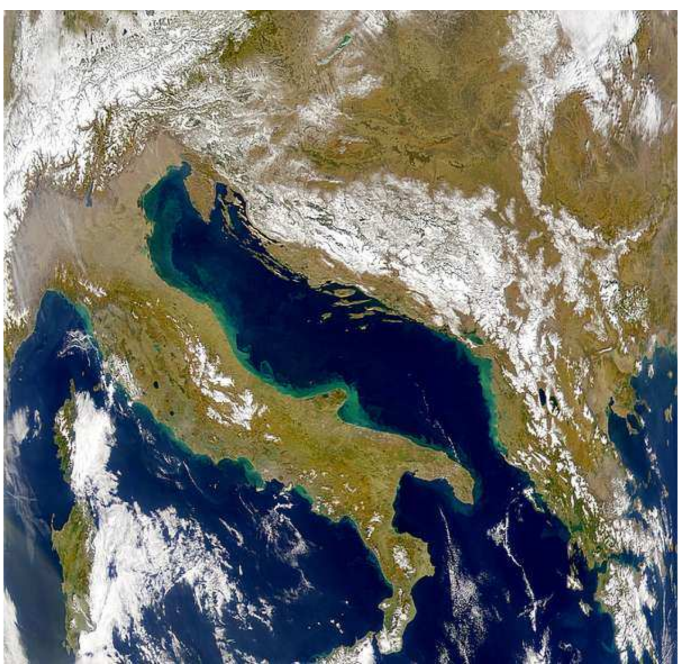

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Dolce Vita 1 & 2 Cruise Report: Bio-Optical Variability

Research Objectives

The objectives of this effort are to examine:

- The transitions of inherent optical properties across coastal/open ocean boundaries and their effect on apparent optical characteristics of the water column.
- The role of physical processes (river inflow, upwelling, coastal filaments, and frontal processes) in the production, distribution and flux of optical properties between the coastal and the offshore zones.
- The relationship between the surface expression of three-dimensional ocean processes and the interior processes.

Bio-Optical Measurement Systems

Several measurement systems were used to address the objectives listed above. Two of the bio-optical systems focused on underway measurements and two were directed toward station mode operations.

Underway Mode

Trisoarus Mode

The underway mode of sampling consists of an AC-9 mounted on the Trisoarus vehicle for measuring inherent properties three-dimensionally. The AC-9 is mounted externally near the bottom of the Trisoarus (Figure 1).

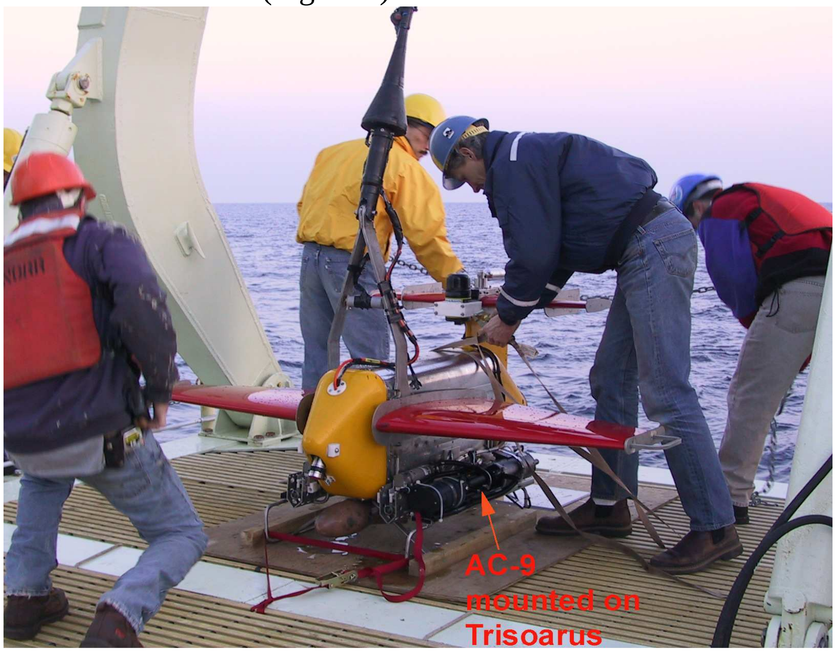


Figure 1. Trisoarus recovered from tow with AC-9 mounted on the lower right side of the vehicle. Other measurements include T, S, dissolved oxygen, beam transmission at 660 nm, chlorophyll and CDOM fluorescence.

MicroSAS Measurements

Continuous measurements of upwelling radiance are obtained with a Satlantic MicroSAS system that provides ship-mounted remote sensing of ocean color along the cruise track during daylight (Figure 2). The system consists of three radiometric sensors. One measures the downwelling irradiance. A radiance sensor measures the upwelling radiance coming from the sea surface at a downward angle of about 45 degrees below the horizon, and a second radiance sensor measures the sky radiance coming toward the sensor at an angle of about 45-50 degrees above the horizon. The second radiance sensor is for the purpose of removing sun glint from the upwelling radiance signal. The seven wavelengths for the MicorSAS include 412, 444, 490, 510, 555, 665, and 705 nm.

Figure 2. Satlantic MicroSAS system used to continuously measure upwelling radiance and reflectance during daylight.

Profile Mode

Bio-Optical Profiler (BOP)

Vertical profiles of physical variables (T, S, and pressure), inherent optical properties (IOPs), and apparent optical properties (AOPs) were obtained with the Bio-Optical Profiler (BOP, Figure 3). The profiler was equipped with a Seabird 9/11+ CTD, two Wetlabs AC-9s that measured beam attenuation and absorption at 9 visible wavelengths (412, 440, 488, 512 532, 555, 650, 676 and 715 nm), a Hydroscat-6 that measures optical backscatter at 6 visible wavelengths (442, 488, 532, 589, 620, and 671 nm) , and a Satlantic downwelling irradiance and upwelling radiance sensor system that has 7 wavelengths (412, 443 490, 510, 555, 666, and 700 nm). The water that was pumped through one of the two AC9s on the BOP was filtered through a 0.2 micron cartridge filters to remove particles larger than 0.2 micron. The absorption signal measured by the filtered AC-9 is thus primarily due to dissolved material in the water.

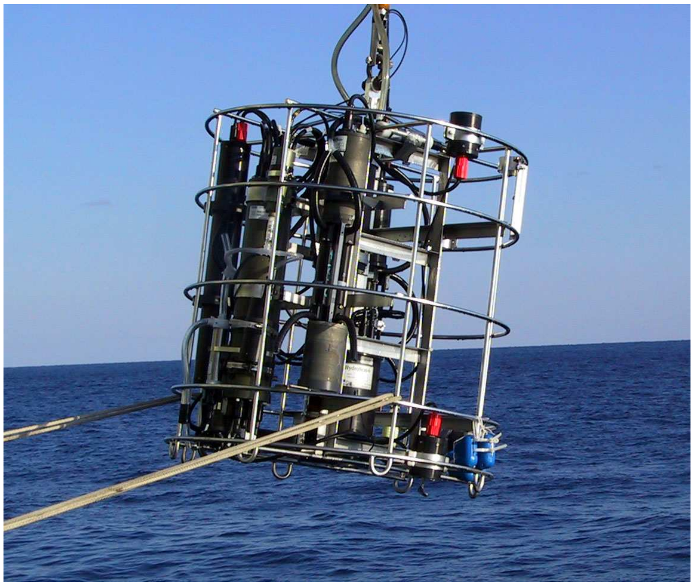


Figure 3. The Bio-Optical Profiler being deployed from the R/V Knorr in the Adriatic Sea during the Dolce Vita 1 cruise.

CTD/Rosette System

A CTD/Rosette system was used to obtain vertical profiles of variables at selected locations and to collect water samples for calibration and interpretation of the bio-optical measurements. This was a standard system equipped with the instrumentation listed in Table 1. An altimeter enabled sampling within 2 meters of the bottom. In addition to the instrumentation measurements, batch samples were analyzed for inorganic nutrients (NO_3, NO_2, NH_4, PO_4, and SiO_4; Marini, IRPEM-Ancona), fluorescent chlorophyll and phaeopigment measurements (Jones - USC), HPLC pigment measurements (Marini, IRPEM-Ancona), suspended particulate material (Jones, USC), and phytoplankton taxonomy (Vilicic, University of Zagreb).

Figure 4. CTD/rosette on deck of ship after recovery from profile.

Instrumentation Summary

A summary of all the instrumentation is given in the table below.

Table 1. Summary of observational platforms and instrumentation.

	Platform			
Instruments – measurements	Trisoarus (Figure 1)	BOP (Figure 3)	MicroSAS (Figure 2)	CTD/Rosette (Figure 4)
CTD	√	√		√
Transmissometer (660 nm)	√	√		√
Dissolved Oxygen	√			√
Fluorometer Chlorophyll	√	√		√
Fluorometer CDOM	√	√		
AC-9 – absorption/attenuation (whole water)	√	√		
AC-9 – absorption/attenuation (0.2 micron filtered water)		√		
Satlantic OCI-200 or OCI-500 Downwelling irradiance		√	√	
Satlantic OCR-200 or OCR-500 Upwelling radiance		√	√ √ **(1 upwelling, 1 sun glint)**	
HobiLabs Hydroscat-6 – Backscatter		√		

Other Scientific Components of the Dolce Vita Cruises

Table 2. Other investigators responsible for measurements in the Dolce Vita cruises.

Investigator	Institution	Component	Measurements
Craig Lee (Chief Scientist)	APL/University of Washington	Physical Oceanography	CTD mounted on Trisoarus Tow Vehicle, ADCP
Hartmut Peters	University of Miami	Physical Oceanography	Turbulence and Microstructure
Clive Dorman	Scripps Institution of Oceanography	Meteorology	Nearsurface meteorology
Robert Arnone	Naval Research Laboratory - Stennis	Remote Sensing	AVHRR, SeaWiFs, MODIS
Pierre Poulain	OGS, Trieste, IT	Physical Oceanography	Drifters and remote sensing
Mauro Marini	IRPEM, Ancona, IT	Chemistry	HPLC pigments, dissolved oxygen, nutrients

Data Summary and Preliminary Results

Dolce Vita 1: Winter Cruise (January 31 – February 23, 2003)

BOP and CTD/ Rosette Sampling Stations and Cruise Track

Bio-Optical Profiler and typical Rosette/CTD system were sampled at 42 stations, covering the areas with the most important oceanographic features of the Adriatic Sea: Istria, Jabuka, Po River, Rimini, and broad scale of the region (see Table 3 and Figure 5). On Figure 5, color symbols represent hydro stations with different colors of lines representing different areas. The numeric numbers correspond to hydro station numbers. The light gray lines indicate the Trisoarus track.

Table 1: DV1 Hydro and BOP Sampling Stations

Location	Station #	Date (GMT)	Time (GMT)	Longitude (°E)	Latitude (°N)	Zbot (m)	BOP	Rosette/CTD
Broad Scale	1	2/1/2003	9:25	13.7498	44.1111	70	√	
	2	2/1/2003	10:46	13.7979	44.1408	70	√	
	3	2/1/2003	11:50	13.8382	44.1728	67	√	
	4	2/1/2003	13:15	13.8893	44.2025	67	√	
	5	2/1/2003	15:16	13.9320	44.2313	67	√	
	6	2/1/2003	16:39	13.9753	44.2646	64	√	
	7	2/1/2003	17:40	14.0222	44.2940	62	√	
	8	2/1/2003	18:31	14.0709	44.3266	58	√	
	9	2/1/2003	19:19	14.1150	44.3567	62	√	
	10	2/1/2003	20:07	14.1613	44.3881	58	√	
	11	2/1/2003	20:44	14.2069	44.4174	58	√	
	12	2/1/2003	21:36	14.2534	44.4470	56	√	
	13	2/1/2003	22:17	14.2982	44.4772	51	√	
	14	2/4/2003	6:26	13.3627	44.6194	44	√	√
	15	2/4/2003	8:38	13.4417	44.5541	49	√	
	16	2/4/2003	9:38	13.5275	44.4888	50	√	
	17	2/4/2003	10:32	13.6110	44.4246	56	√	
	18	2/4/2003	13:42	13.8682	44.2227	65	√	√
	19	2/4/2003	20:03	14.4929	43.7426	77	√	√
	20	2/6/2003	1:27	14.8937	42.8725	228	√	√
Jabuka	21	2/9/2003	9:39	15.4854	43.3094	191	√	√
	22	2/9/2003	12:52	15.3817	43.3639	224	√	√
	23	2/9/2003	14:44	15.3331	43.3857	237	√	√
	24	2/9/2003	17:12	15.2839	43.4093	229	√	√
	25	2/9/2003	18:46	15.2317	43.4373	176	√	√
	26	2/9/2003	20:37	15.1212	43.4886	129	√	√
	27	2/9/2003	23:01	15.0294	43.5423	112	√	
Istria	28	2/13/2003	10:25	14.0608	44.5969	47	√	√
	29	2/13/2003	14:45	14.0103	44.6966	47	√	√
	30	2/13/2003	16:02	14.0294	44.6798	49	√	√
	31	2/13/2003	17:57	14.0337	44.6638	48	√	√
	32	2/13/2003	19:04	14.0175	44.7070	47	√	√
Rimini	33	2/18/2003	3:30	13.2322	44.2731	55	√	√
	34	2/18/2003	6:00	13.0102	44.1610	49	√	√
	35	2/18/2003	7:49	12.9564	44.1335	40	√	√
	36	2/18/2003	9:10	12.9057	44.1067	28	√	√
	37	2/18/2003	10:48	12.8000	44.0530	13	√	√
Po Plume	38	2/21/2003	8:33	12.9075	44.9034	35.9	√	√
	39	2/21/2003	10:23	12.9643	44.8491	37	√	√
	40	2/21/2003	11:30	12.9879	44.8127	37.9	√	√

Figure 5. The locations of BOP and hydro Stations and the Trisoarus track for the Dolce Vita 1 cruise. Symbols indicate the locations of stations and the gray lines indicate the Trisoarus track.

Table 3. Summary of Hydro and BOP stations for the Dolce Vita Cruise 1.

DV1 Hydro and BOP Sampling Stations

Location	Station	Date (GMT)	Time (GMT)	Longitude (°E)	Latitude (°N)	Zbot (m)	BOP	CTD/ Rosette
Broad Scale	1	2/1/2003	9:25	13.7498	44.1111	70	√	
	2	2/1/2003	10:46	13.7979	44.1408	70	√	
	3	2/1/2003	11:50	13.8382	44.1728	67	√	
	4	2/1/2003	13:15	13.8893	44.2025	67	√	
	5	2/1/2003	15:16	13.9320	44.2313	67	√	
	6	2/1/2003	16:39	13.9753	44.2646	64	√	
	7	2/1/2003	17:40	14.0222	44.2940	62	√	
	8	2/1/2003	18:31	14.0709	44.3266	58	√	
	9	2/1/2003	19:19	14.1150	44.3567	62	√	
	10	2/1/2003	20:07	14.1613	44.3881	58	√	
	11	2/1/2003	20:44	14.2069	44.4174	58	√	
	12	2/1/2003	21:36	14.2534	44.4470	56	√	
	13	2/1/2003	22:17	14.2982	44.4772	51	√	
	14	2/4/2003	6:26	13.3627	44.6194	44	√	√
	15	2/4/2003	8:38	13.4417	44.5541	49	√	
	16	2/4/2003	9:38	13.5275	44.4888	50	√	
	17	2/4/2003	10:32	13.6110	44.4246	56	√	
	18	2/4/2003	13:42	13.8682	44.2227	65	√	√
	19	2/4/2003	20:03	14.4929	43.7426	77	√	√
	20	2/6/2003	1:27	14.8937	42.8725	228	√	√
Jabuka	21	2/9/2003	9:39	15.4854	43.3094	191	√	√
	22	2/9/2003	12:52	15.3817	43.3639	224	√	√
	23	2/9/2003	14:44	15.3331	43.3857	237	√	√
	24	2/9/2003	17:12	15.2839	43.4093	229	√	√
	25	2/9/2003	18:46	15.2317	43.4373	176	√	√
	26	2/9/2003	20:37	15.1212	43.4886	129	√	√
	27	2/9/2003	23:01	15.0294	43.5423	112	√	
Istria	28	2/13/2003	10:25	14.0608	44.5969	47	√	√
	29	2/13/2003	14:45	14.0103	44.6966	47	√	√
	30	2/13/2003	16:02	14.0294	44.6798	49	√	√
	31	2/13/2003	17:57	14.0337	44.6638	48	√	√
	32	2/13/2003	19:04	14.0175	44.7070	47	√	√
Rimini	33	2/18/2003	3:30	13.2322	44.2731	55	√	√
	34	2/18/2003	6:00	13.0102	44.1610	49	√	√
	35	2/18/2003	7:49	12.9564	44.1335	40	√	√
	36	2/18/2003	9:10	12.9057	44.1067	28	√	√
	37	2/18/2003	10:48	12.8000	44.0530	13	√	√
Po Plume	38	2/21/2003	8:33	12.9075	44.9034	35.9	√	√
	39	2/21/2003	10:23	12.9643	44.8491	37	√	√
	40	2/21/2003	11:30	12.9879	44.8127	37.9	√	√
	41	2/21/2003	12:43	13.0275	44.7685	40	√	√
	42	2/21/2003	13:55	13.0743	44.7258	40.8	√	√

Hydro/Bio-Optical Properties Obtained from CTD and AC9 on Trisoarus

The R/V Knorr sailed from Ancona, Italy on January 31, 2003 to begin the winter study of the northern Adriatic Sea. The Trisoarus towed profiling vehicle was used to continuously survey the area while the BOP package and Rosette/CTD system were deployed at selected locations, as described above.

There were five distinct surveys carried out during cruise DV1. A large scale survey was carried out initially to survey the broad scale distributions of physical and optical variables in the northern Adriatic. Four smaller scale surveys focused on specific features observed in remote sensing images obtained during the cruise. These features included the mid-Adriatic filament off Sibenik, Croatia, the Istrian front south of the Istrian Peninsula, the Po River plume immediately off the mouth, and the Rimini survey that studied the front between the Po River plume and the central northern basin. We will show examples of the data from two of these regions – the Istrian front and the Po River plume.

Example from Istrian Front

The Istrian front was mapped four times between 11 and 15 February. It was sampled during a strong Bora wind event. A curtain plot of physical and optical properties shows a sharp vertical Istrian front along the northern part of the surveyed radiator (Figure 6). Physical properties are highly correlated with optical properties with cool, fresher water containing high values of inherent optical properties including a_{412}, c_{650} and CDOM (indicated by a_{412}-a_{440}). South of the front the water is warmer and saltier with low values for the inherent optical properties. The water column appears to be well mixed on either side of the front. The cooler, fresher water appears to have its origins within the islands northeast of the study area. The water on the northern side of the front may have a significant contribution from land runoff.

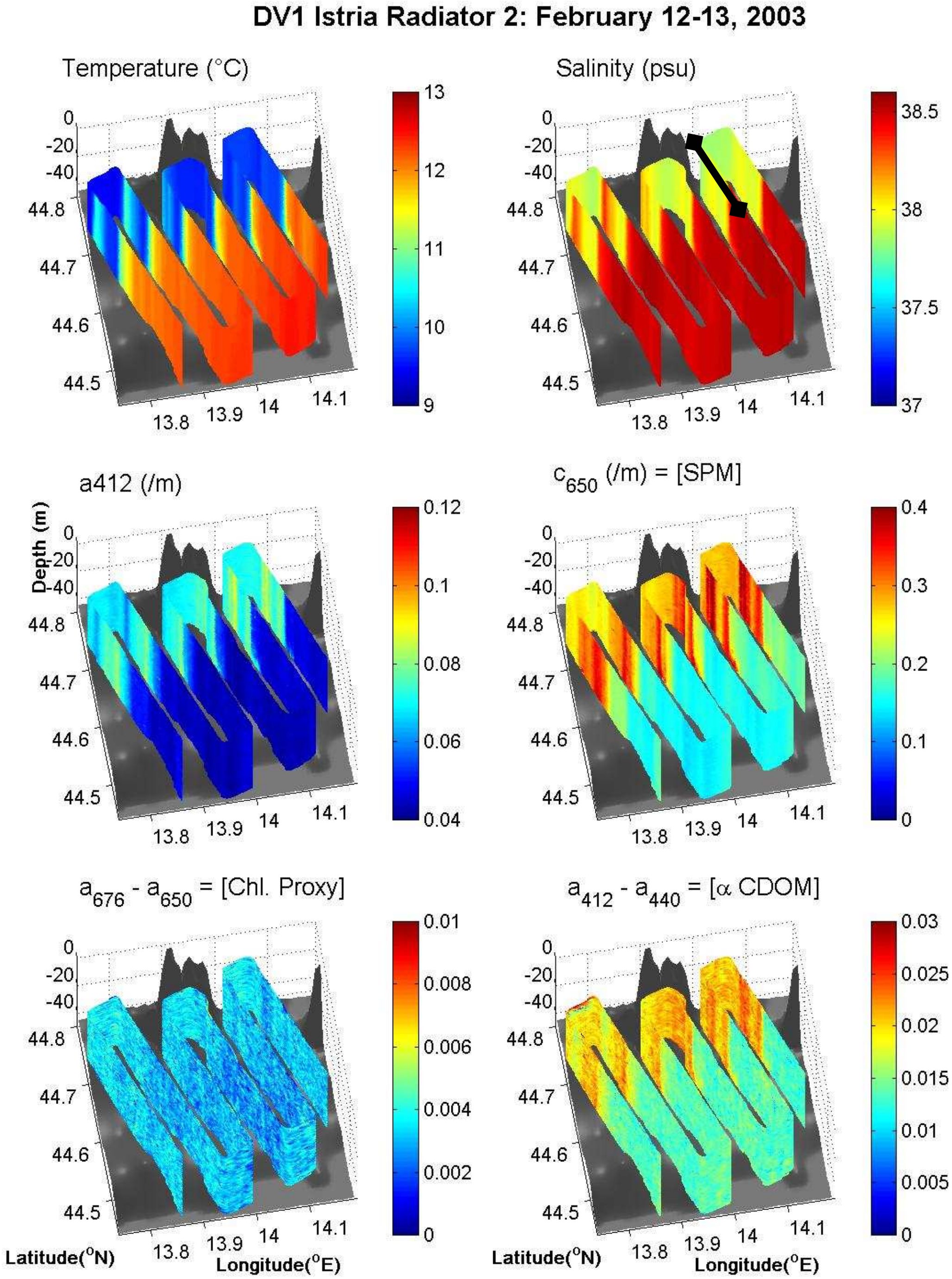


Figure 6. Curtain plots of temperature, salinity, a_{412}, c_{650}, a_{412}-a_{440} and a_{676}-a_{650} are shown for the second of four surveys of the front south of Istria, February . a_{412}-a_{440} is a proxy for CDOM and a_{676}-a_{650} is correlated with chlorophyll concentration. The viewing perspective of these curtain plots is that we are looking down on the pattern from the south-southwest at a significant elevation. The black bar in the a_{412} panel indicates the region where 5 Hydro/BOP stations were placed. The section of this data is shown in Figure 5.

Example from Po River Plume

The other example that is shown from cruise DV1 is the Trisoarus mapping of the Po River plume extending seaward from near the mouth of the river. Curtain plots of the Po plume region show a strong narrow plume coming from Po River and extending northeastward to the northern basin of Adriatic Sea (Figure 7). This plume is characterized by low temperature, salinity, chlorophyll and high inherent optical properties and CDOM. The concentrations of CDOM and suspended particulate matters at surface appear high near the mouth of Po River and decrease offshore while high concentrations of these matters are found at the bottom offshore within the surveyed radiator.

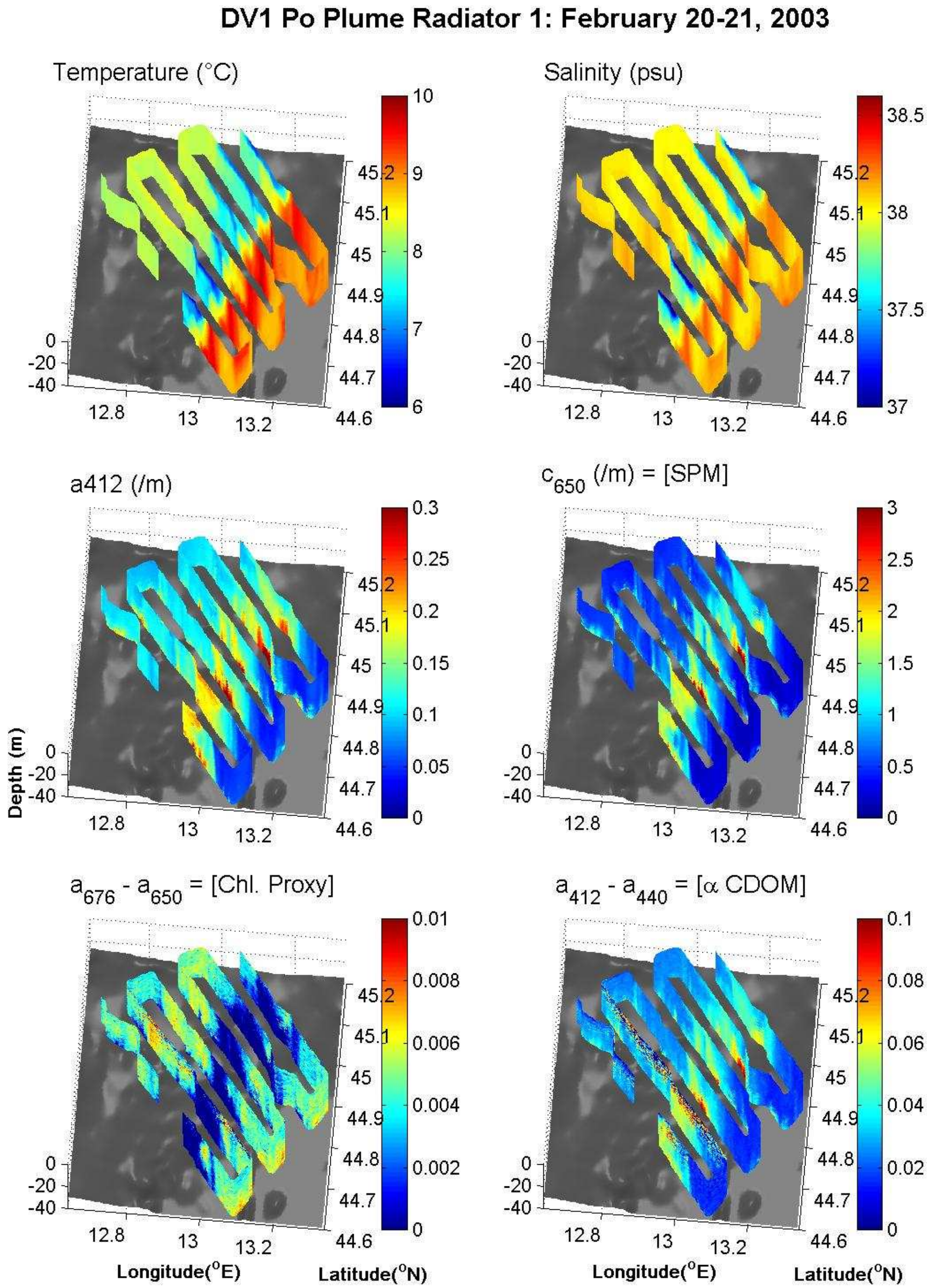


Figure 7. Curtain plot of Po Plume, Radiator 1, February 20-21, 2003 The variables are the same as shown in Figure 6.

Example of Hydro/Bio-Optical Properties Obtained with BOP

During the four-day study of the Istrian front, 5 stations (28-32) were sampled using BOP and CTD/Rosette. The stations were chosen based on the Trisoarus transect of the front along the second line from the east on the second survey. The vertical sections of T, S, a_{440}, c_{650}, and bb_{442} are shown in Figure 8. Consistent with the cross-section shown in Figure 6, northern cooler, fresher water that is also higher in suspended particulate matter and CDOM can be seen near the bottom of stations 29 and 30 where the southern water has been displaced northward as the front propagates northward. It appears this cooler, fresher and denser water at the base of profiles 29 and 30 may be “left behind” as the front proceeds northward.

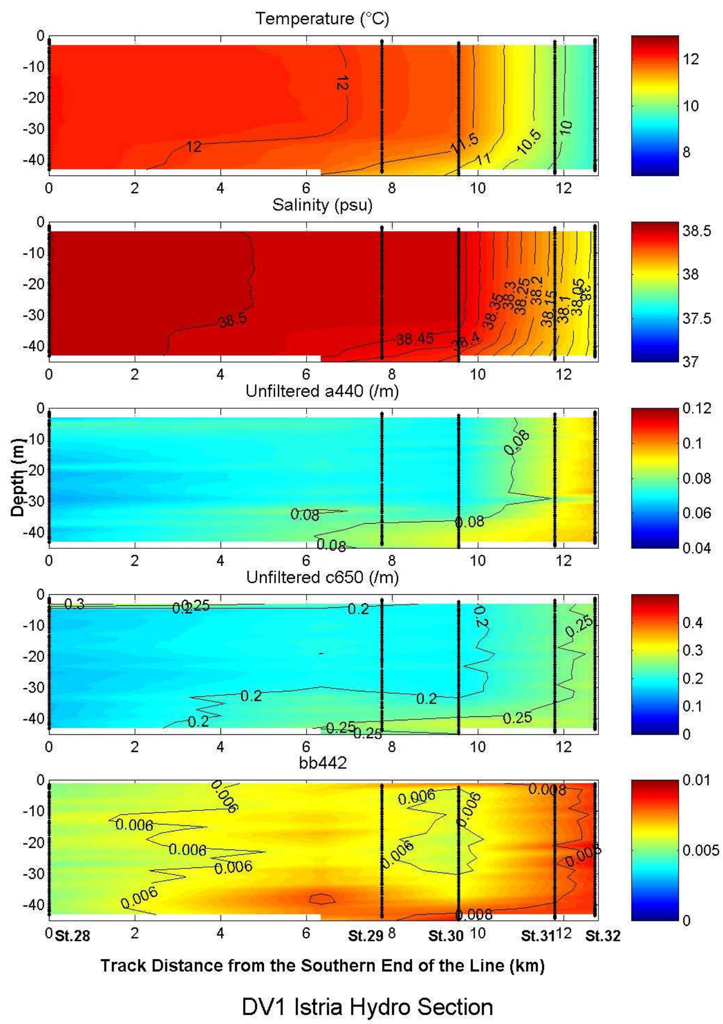


Figure 8. BOP cross-section of the Istrian Front obtained on February 13, 2003. The location of this section is indicated by the black line in Figure 6 showing the second Trisoarus map of the front.

Relationship between Remote Sensing Reflectance and In Situ Inherent Optical Properties

Remote sensing reflectance, which is calculated from irradiance and radiance measured with the MicroSAS system, is expected to be highly correlated with inherent optical properties of the underlying water column. An example from the Po River survey illustrates this relationship (Figures 9 and 10). High values of remote sensing reflectance correspond with high concentrations of particles in the water column as indicated by a_{440} and c_{440} in Figure 9. The transition in remote sensing reflectance not only reflects decreases in the absolute values of the IOPs, but also coincides with deepening of the particle maxima as suggested in the region between 35 and 40 km where the upper water column becomes clearer and the particle maximum deepens.

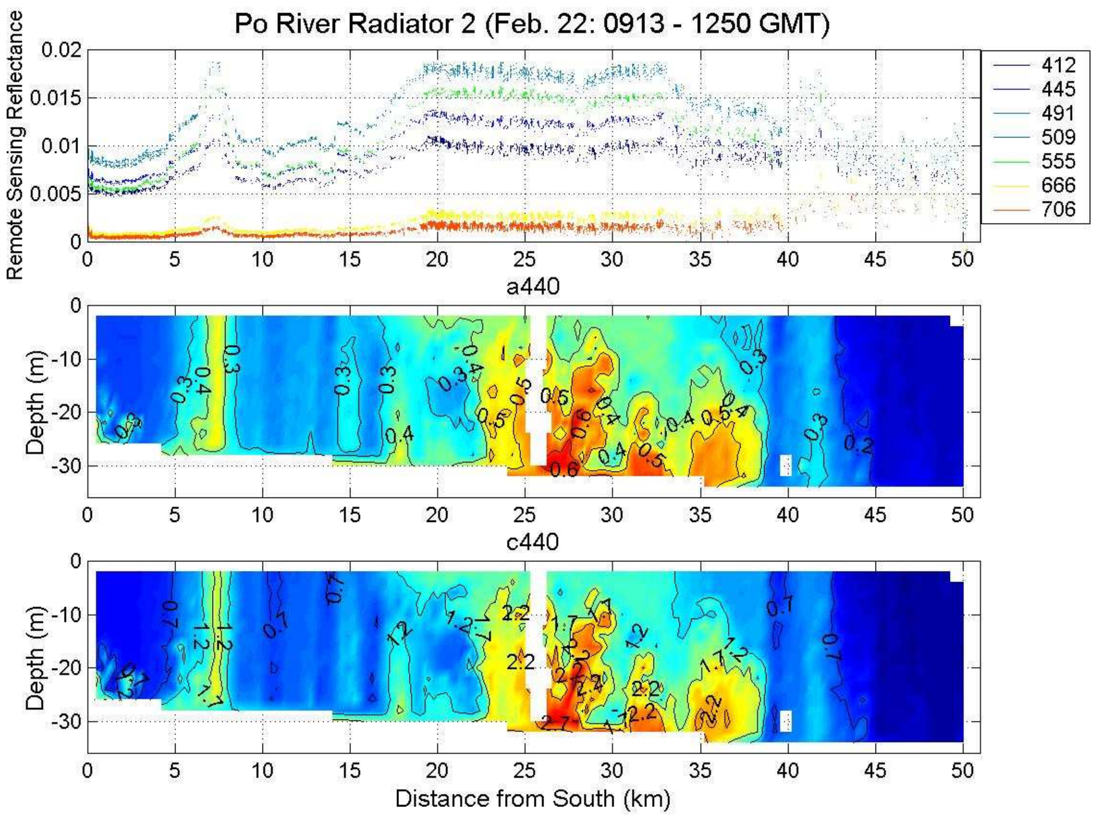


Figure 9. DV1 Sectional Plot of Remote Sensing Reflectance vs. Optical properties during Po Plume Survey

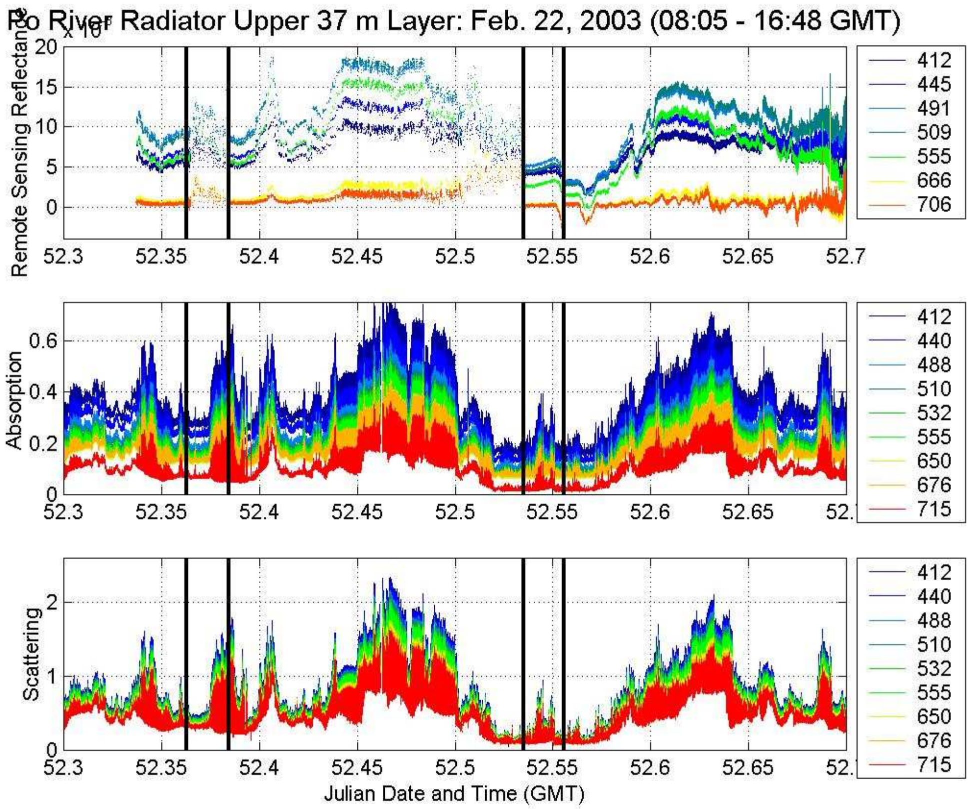


Figure 10. DV1 Time Series of Remote Sensing Reflectance vs. Optical Properties during Po Plume Survey

Dolce Vita 2: Spring Cruise (May 26 – June 15, 2003)

In contrast to the winter time condition where strong atmospheric forcing was dominant, the spring cruise occurred during a period when atmospheric forcing was expected to be less than in winter and when the spring freshet of the Po River would provide a significant forcing from the riverine buoyancy flux on the northern and central Adriatic Sea. During this period wind forcing was almost non-existent and although the river discharge was clearly a significant feature in the northern and western Adriatic, the discharge was about one third of its normal spring time flow.

BOP and CTD/Rosette Sampling Stations and Trisoarus Track

A total of 55 BOP and CTD/Rosette stations were occupied during this cruise (Table 4 and Figure 11). On Figure 11, plus (+) symbols represent BOP stations, circled ones correspond to CTD/Rosette stations, and the light gray lines represent cruise track. Hydrographic stations were occupied near the Po River mouth, Istria, mid Adriatic filament near Sibenik, Croatia, the Jabuka line, and a Po Filament line at the southwestern end of the Jabuka line (Figure 11).

Table 4. Summary of stations occupied during the Dolce Vita 2 cruise between May 26 and June 15, 2003.

DV2 BOP and CTD/Rosette Sampling Stations							
Station	Date (GMT)	Time (GMT)	Longitude (°E)	Latitude (°N)	Zbot (m)	BOP	CTD/ Rosette
1	05/27/03	11:41	13.1468	44.5213	41	√	
2	05/27/03	14:01	13.1265	44.6117	39	√	
3	05/27/03	15:05	13.1136	44.7023	40	√	
4	05/27/03	16:04	13.0936	44.7906	41	√	
5	05/27/03	17:10	13.0807	44.8834	38	√	
6	05/27/03	18:10	13.0732	44.9684	35	√	
7	05/27/03	19:15	13.0600	45.0534	37	√	
8	05/27/03	20:20	12.9686	44.9821	35	√	
9	05/27/03	21:20	12.8836	44.9140	35	√	
10	05/27/03	21:11	12.7993	44.8459	55	√	
11	05/30/03	18:04	15.6070	43.3838	186	√	√
12	05/30/03	19:25	15.4984	43.4348	205	√	√
13	05/30/03	22:45	15.3940	43.4890	231	√	√
14	05/31/03	23:57	15.2952	43.5463	132	√	√
15	05/31/03	3:38	15.1843	43.5980	117	√	√
16	05/31/03	3:41	15.0758	43.6584	101	√	√
17	05/31/03	13:43	15.6218	43.6117	113	√	√
18	05/31/03	14:25	15.5828	43.5830	233	√	√
19	05/31/03	21:50	15.4998	43.5405	204	√	√
20	05/31/03	23:01	15.3885	43.4898	216		√
21	06/01/03	0:18	15.3334	43.3945	240	√	√
22	06/01/03	3:15	15.2515	43.2865	233	√	√
23	06/01/03	4:32	15.1953	43.1850	221		√
24	06/01/03	5:59	15.1037	43.0890	269	√	√
25	06/01/03	9:06	15.0975	43.0057	247	√	√
26	06/01/03	10:30	15.0628	42.9188	193		√
27	06/01/03	12:07	14.9227	42.8565	226	√	√
28	06/01/03	14:57	14.7311	42.8400	255	√	√
29	06/01/03	16:32	14.6484	42.6983	165		√
30	06/01/03	18:09	14.5074	42.5894	110		√
31	06/01/03	19:05	14.4445	42.5347	87	√	√
32	06/01/03	21:20	14.3753	42.4802	42	√	√
33	06/05/03	19:13	13.8280	44.6582	45.7	√	√
34	06/05/03	20:49	13.7878	44.6945	44.4	√	√
35	06/06/03	22:37	13.7560	44.7317	44.3	√	√
36	06/06/03	0:43	13.7282	44.7703	42.6	√	√
37	06/06/03	1:54	13.6884	44.8089	43.4	√	√
38	06/08/03	9:05	12.5228	44.8573	15.9	√	√
39	06/08/03	9:52	12.5826	44.8483	24.1	√	
40	06/08/03	10:54	12.6212	44.8466	27	√	√
41	06/08/03	11:31	12.6547	44.8426	29	√	
42	06/08/03	12:30	12.6952	44.8416	31.7	√	√
43	06/08/03	13:18	12.7299	44.8361	32.7	√	
44	06/08/03	14:17	12.7688	44.8346	33.3	√	√
45	06/08/03	14:53	12.8058	44.8295	34.2	√	
46	06/08/03	15:50	12.8442	44.8282	35.8	√	√
47	06/08/03	16:32	12.8824	44.8244	36.7	√	
48	06/08/03	17:31	12.9223	44.8213	37.5	√	√
49	06/08/03	18:23	12.9820	44.8161	37.9	√	
50	06/13/03	11:08	14.9585	42.5163	168	√	√
51	06/13/03	11:58	15.0291	42.4928	164.6	√	√
52	06/13/03	13:55	15.0878	42.4695	160	√	√
53	06/13/03	14:50	15.1905	42.4282	151.8	√	√
54	06/13/03	17:08	15.0103	42.3779	129.4	√	√
55	06/13/03	18:21	15.1142	42.3375	126.8	√	√

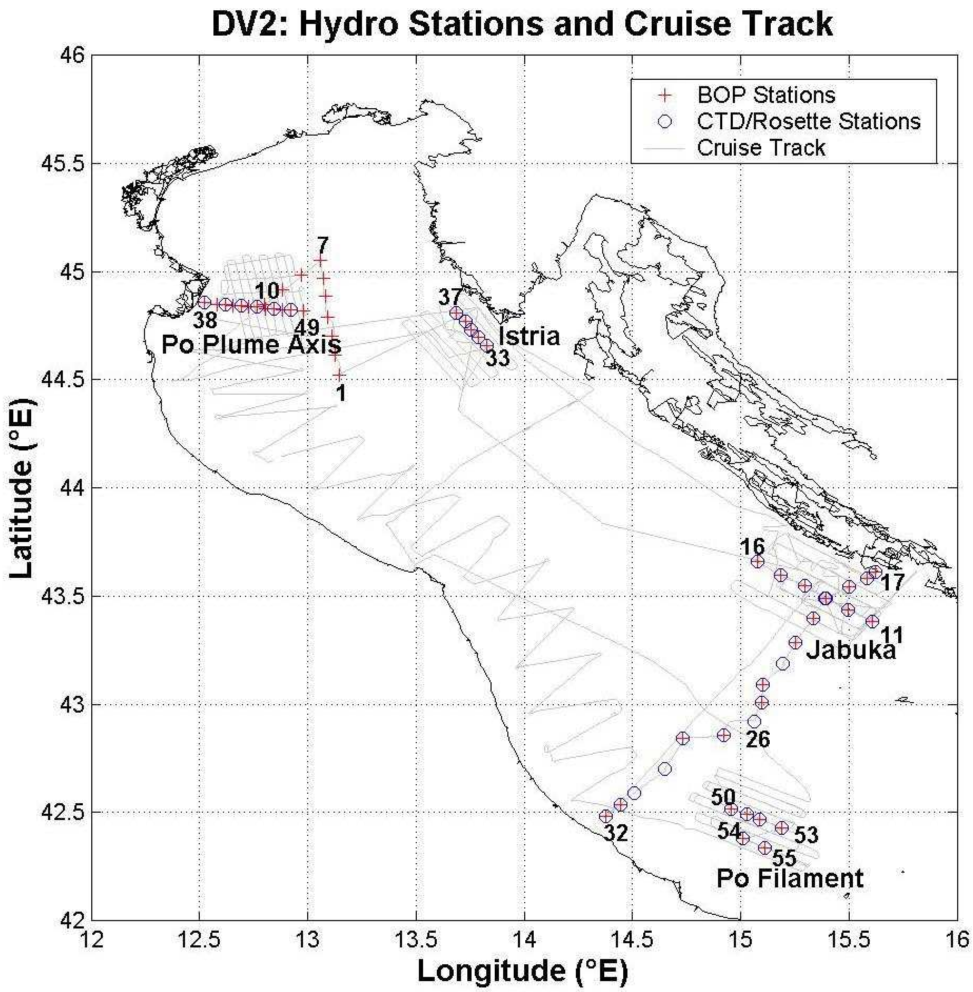


Figure 11. Location of BOP and hydrographic stations, and the Trisoarus tow track for the Dolce Vita 2 cruise between May 26 and June 15, 2003. The gray lines indicate the Trisoarus tow tracks. Plus symbols indicate the location of BOP profiles, and open circles indicate where CTD/Rosette profiles were obtained. Stations 1-10 were BOP profiles used to fill the large scale Trisoarus survey while the Trisoarus was being serviced. All other BOP and CTD/Rosette were targeted on specific features associated with targeted Trisoarus surveys.

Hydro/Bio-Optical Properties Obtained from CTD and AC9 on Trisoarus

The science team sailed on board R/V Knorr on May 26, 2003 from Ancona, Italy to the calm Adriatic Sea. Again the Trisoarus was used to study the response of the northern Adriatic to the riverine flux and forcing processes during this period of very weak or no winds. We present in the section that follows two examples from the Trisoarus surveys of the cruise. The first example is from the mid-Adriatic filament survey, and the second example is from the survey of the Po River plume, similar to the survey performed in February 2003.

Example from the Mid-Adriatic Filament Survey

Because wind forcing was very weak during the spring/summer cruise, the water column was strongly stratified and this was reflected in the distribution of the chlorophyll maximum as observed in the Trisoarus surveys. The curtain plot of salinity and bio-optical properties in Figure 12 shows a subsurface chlorophyll maximum throughout the region. The central depth of the maximum chlorophyll varied from as shallow as 70 meters north of the Jabuka pit, to as deep as 100 meters. In addition to the particulate maximum associated with the chlorophyll maximum, the concentration of suspended particulate material indicated by c_{650} was also high near bottom particularly over the Jabuka Pit. CDOM, as indicated by the absorption difference between 412 and 440 nm (a_{412}-a_{440}) was low in the nearsurface layer and appeared to maximal nearbottom where the high particle concentrations were also observed. The subsurface chlorophyll maximum was not observed in the winter time when strong Bora winds caused significant vertical mixing of the upper layer. The primary evidence of the filament during this period was the low nearsurface salinity shown in Figure 12.

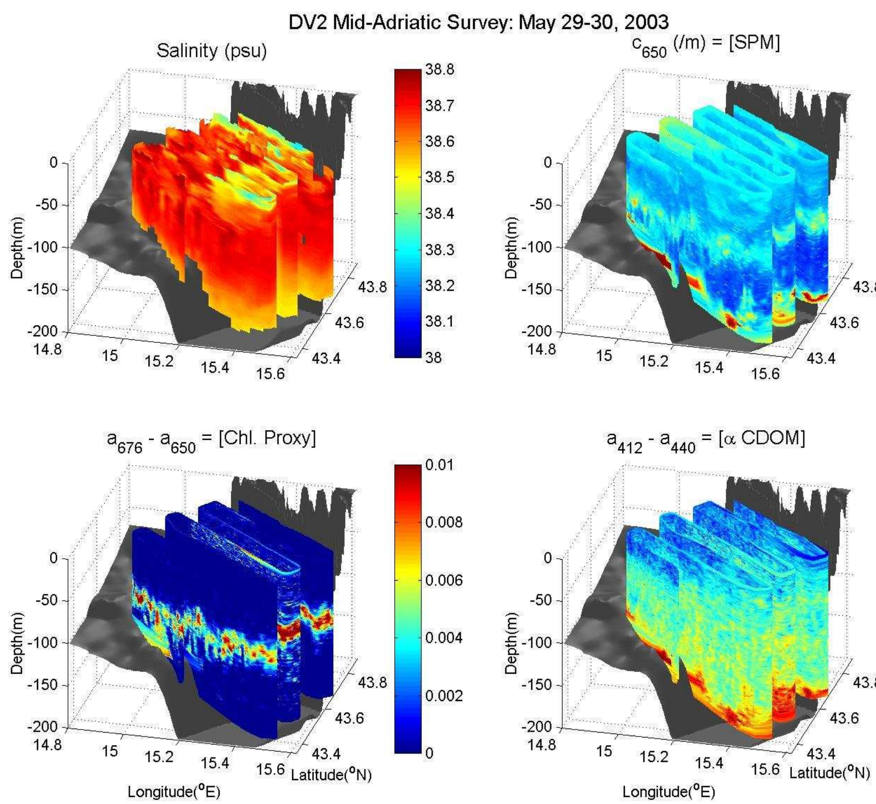


Figure 12. Curtain plots of Mid-Adriatic Filament Survey on May 29-30, 2003. As can be seen in the bottom hydrography (gray area in plots) this survey spanned the northern lip of the Jabuka pit.

Example from the Po River Plume

Originally, we expected a strong riverine buoyancy flux in the northern and central Adriatic. However, the discharge rates at this time were only about 30% of the normal spring discharge. However, the Po River plume still had a large signature in the northern Adriatic. The curtain plots from the two Po plume surveys in June show a significant surface plume coming from the river despite the anomalously low flow (Figures 13 and 14). The plume is characterized by low salinity, high chlorophyll, high suspended particle concentrations and high CDOM with the intensity of the signals decreasing offshore. Low salinity water extended from the river mouth northeastward across the entire Trisoarus survey. While CDOM (a_{412}-a_{440}) was initially high nearshore, it decreased in the offshore region of the plume even though the salinity was still quite low. Presumably, this is due to photo-bleaching of the CDOM. In contrast to winter, when the chlorophyll concentrations were apparently low in the plume, the highest chlorophyll concentrations were within the low salinity nearsurface water of the plume. Both high particulate and CDOM concentrations were also apparent within the nearbottom layer. At this level of analysis, a separation of the nearbottom particle maxima and the surface plume has not been observed.

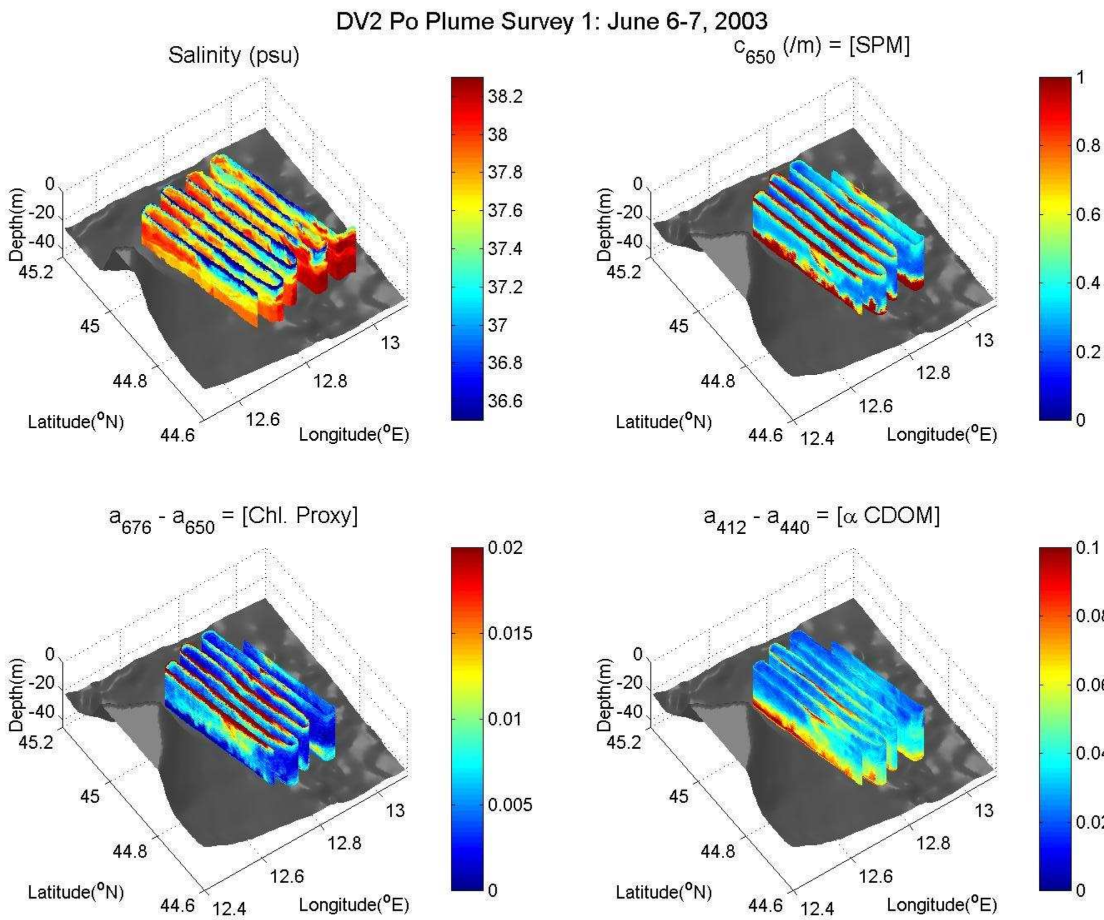


Figure 13. Curtain plots of Po Plume Radiator 1: June 6-7, 2003. The transects are oriented approximately perpendicular to the plume axis.

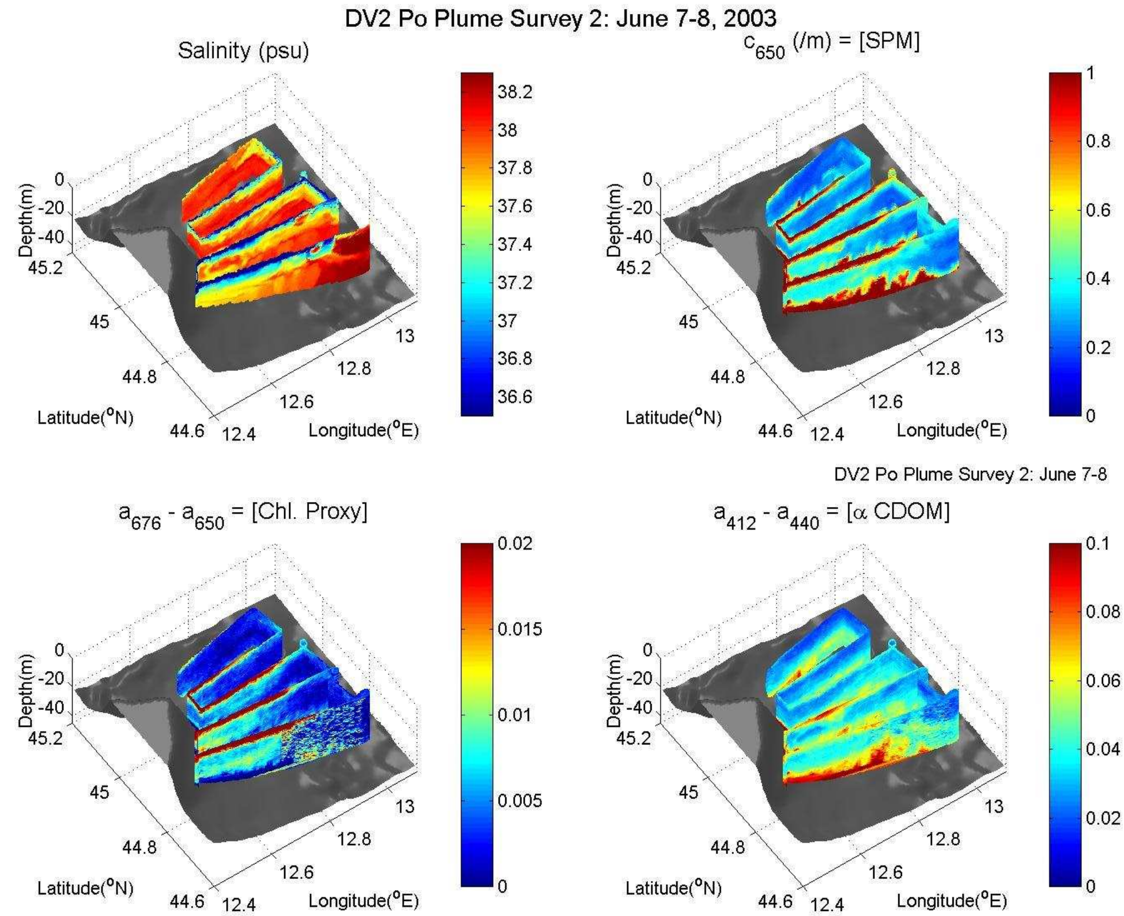


Figure 14. Curtain plots of the second Po Plume survey: June 7-8, 2003. In this case the transects are oriented approximately perpendicular to coastline and are more aligned with the plume axis.

Example from Po filament Survey

The last feature survey of the cruise focused on a fresh filament that extended offshore from the Italian coast over the region of Jabuka pit (labeled Po Filament, Figure 11). A filament with salinity of 38 psu was found at surface and associated with both suspended particulate material and CDOM (Figure 15). High concentrations of particles and CDOM were also present at the bottom. The water of this filament originated from the coastal plume of Po River. Both CDOM and salinity suggest that there was a component of this filament that extended throughout the water column underneath the stronger nearsurface salinity minimum. A weak subsurface chlorophyll maximum was also found on either side of the filament.

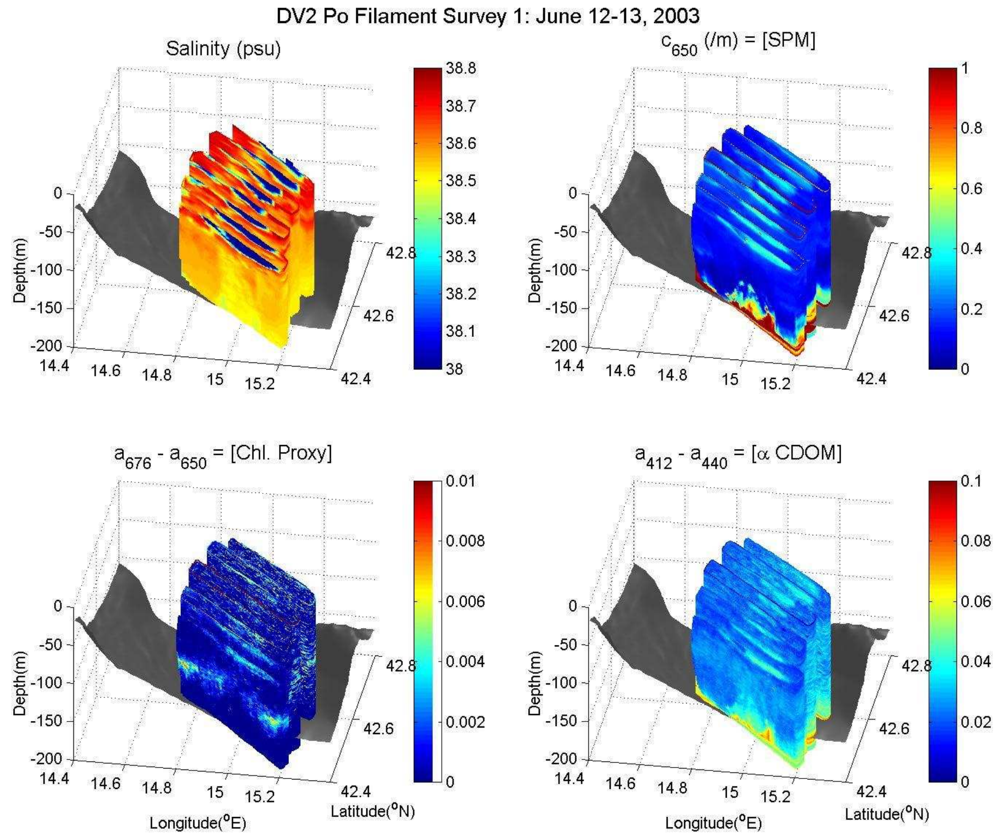


Figure 15. Curtain plots of first Po Filament survey on June 12-13, 2003. The primary survey transects are oriented approximately parallel with coast line (see Figure 11).

Hydro/Bio-Optical Properties

During the second Dolce Vita cruise, we occupied the Jabuka/Pomo hydrographic line that is frequently sampled in the regional routine hydrographic surveys of the northern Adriatic (Stations 17-32, see Figure 11). A sectional plot of hydro/bio-optical distributions on a line running southwestward from Sibenik, Croatia to Pescara, Italy is shown in Figure 16. The nearsurface water on the Italian side is characterized by lower temperature, lower salinity and higher suspended particulate loads (indicated by beam attenuation) along Italian side compared to Croatia side, indicating the influence of the Po plume. Suspended particulate concentrations were particularly high near the bottom along the slope from the Italian coast. The highest salinity water is found between the surface and about 125 meters except for lower salinity water surface water near both the Italian and Croatian coast. The subsurface chlorophyll maximum spanned most of the transect and ranged in depth from approximately 60 to 90 meters.

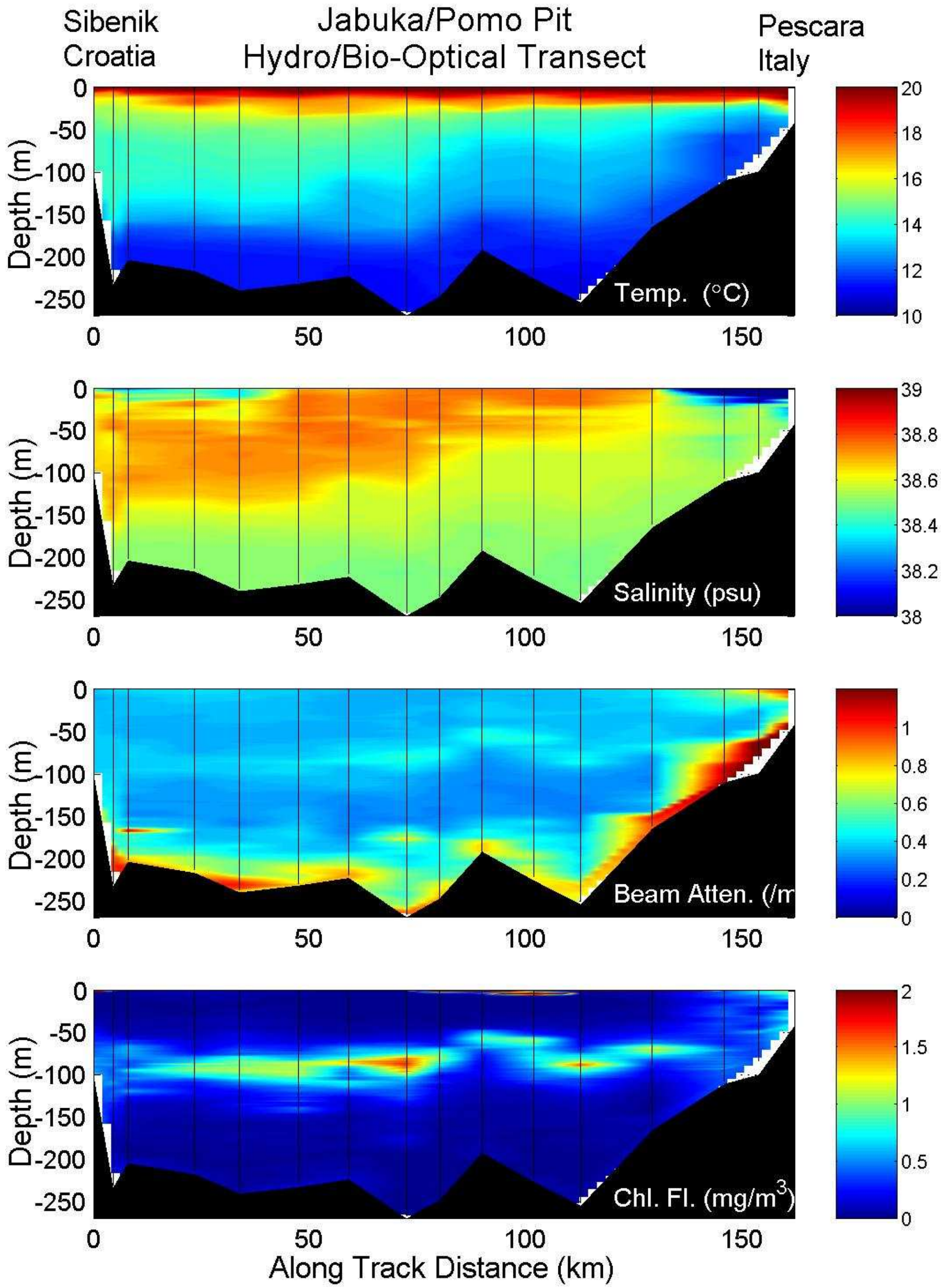


Figure 16. Cross-basin hydrographic transect over the Jabuka-Pomo Pit on May 31 – June 1, 2003 (. Both CTD/Rosette and BOP casts were obtained along this section.

Remote Sensing Reflectance from MicroSAS

As in the first cruise, downwelling irradiance and upwelling radiance were measured continuously during the Dolce Vita 2 cruise. A typical day-long time series of remote sensing reflectance during the survey off of Istria is shown in Figure 13. The remote sensing reflectance is the strongest in the mid-day. Both early in the day and late in the day higher values result from the low sun angle and thus are less useful than the values from midday.

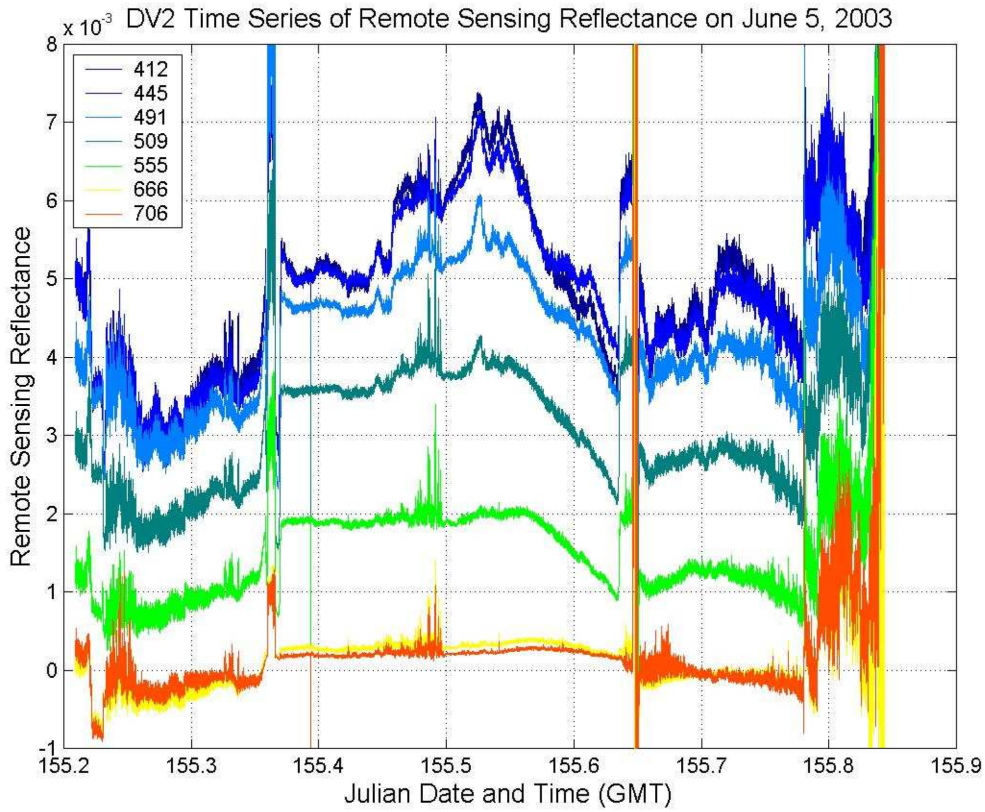


Figure 17. An example of a day-long time series of remote sensing reflectance during the Istria Survey on June 5, 2003.

Summary

We were very successful in accomplishing the goals that we had laid out for the two Dolce Vita cruises. We were able to obtain a full sweet of optical measurements from the predominant features of the northern Adriatic Sea. An important part of the analysis will be to couple the optical properties and their variability with the physical processes. This will require a strong collaborative effort with the other investigators participating in the cruises (see Table 2 for a list of the scientist responsible for other measurements).

We have provided examples of the data within this report that highlight some of the features and processes that we observed. However, this report is neither a comprehensive data report nor a detailed scientific analysis of the data sets.

The success of this effort was due to quality of the entire research team and, in particular, to the leadership of the chief scientist, Dr. Craig Lee.

ISTITUTO NAZIONALE
di Oceanografia e di Geofisica Sperimentale

DOLCEVITA-1 CRUISE

31 January – 24 February 2003

REPORT OF DRIFTER-RELATED ACTIVITIES

by

P.-M. POULAIN, L. URSELLA, E. MAURI AND D. DEPONTE

OGS TECHNICAL REPORT N0 ???

Project sponsored by the Office of Naval Research (ONR)

TABLE OF CONTENTS:

1. Introduction

As part of the ONR-sponsored DOLCEVITA project, releases of drifters were conducted in the northern Adriatic during the DOLCEVITA-1 cruise onboard R/V Knorr between 31 January and 24 February 2003. The drifter measurements were concentrated in selected mesoscale circulation features and were made in concert with towed vehicle, hydrographic, optical and turbulence measurements. This report contains a brief description of the drifter systems used, details about their deployments and recoveries, and a preliminary description and interpretation of the drifter results.

2. Instruments and Methods

2.1 *Drifter Systems*

Various drifter types were used during the cruise. They include:

1) CODE and CODE-GPS (Figure 1) surface drifters manufactured by Technocean, Cape Coral, FL, USA. which provide surface currents and sea surface temperature (SST). The GPS upgrade on some of the drifters allows positioning at hourly intervals.
2) SVP surface drifters (Figure 2) with a holey-sock drogue centered at 50-m nominal depth manufactured by Clearwater, Watertown, MA, USA. These instruments provide currents at 50 m and SST. For operations in shallow waters, the tether was reduced to center the drogue at 30-m depth. They are equipped with GPS receivers that sample position every half hour.
3) MINIMET (WOTAN) surface drifters with a holey-sock drogue centered at 15-m nominal depth manufactured by Pacific Gyre, Carlsbad, CA, USA. These drifters measure near-surface mixed-layer currents, SST, wind speed and direction.
4) SVP/OCM surface drifters (Figure 3) with a drogue centered at 15-m depth produced by Metocean Data Systems Limited, Dartmouth, Nova Scotia, Canada. These drifters measure near-surface currents, SST, upwelling radiance and downwelling irradiance at visible wavelengths. They also have GPS positioning at half-hour intervals.
5) CODE/Tz surface drifters (Figure 4) with a thermistor chain manufactured by Metocean. They have 10 thermistors to measure the water temperature at 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 m. They also measure surface currents and SST. GPS fixes are sampled every half hour. For the applications in shallow water, the chain length was reduced to 30 m.

6) CMOD (XAN-3) surface drifters (Figure 5) with a thermistor chain manufactured by Metocean. In addition to the temperatures at various depths, these instruments measure surface currents, SST and surface air pressure. For the applications in shallow water, the chain length was reduced to 30 m.

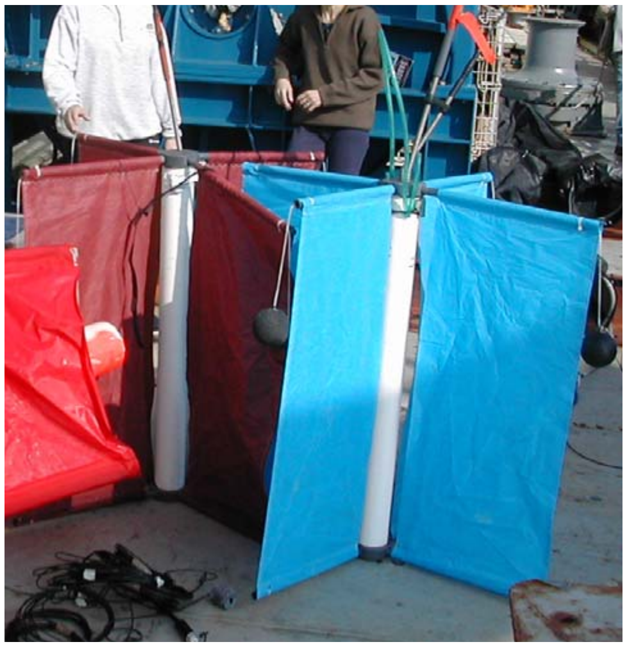


Figure 1. CODE (left) and CODE-GPS (right) drifters.

Figure 2. SVP drifter with holey-sock drogue, intermediate float and surface ball.

Figure 3. SVP/OCM drifter with sock drogue. The irradiance meter can be seen on the top of the red surface ball.

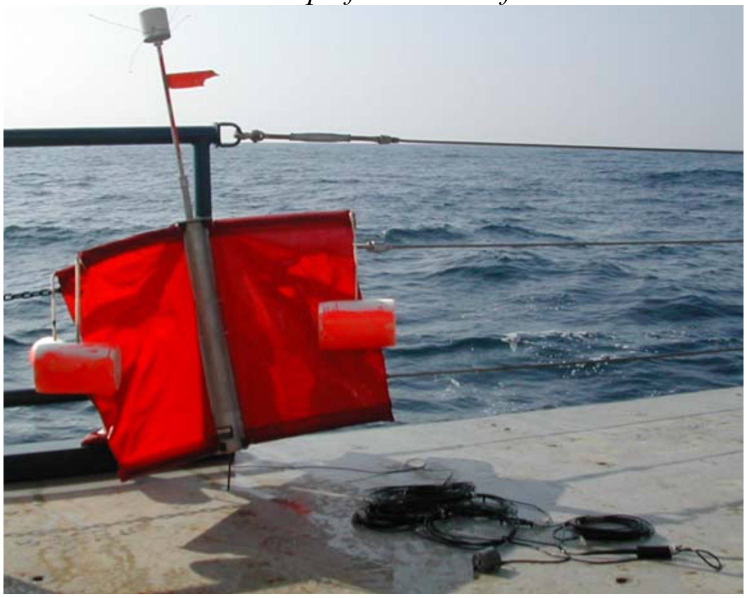


Figure 4. CODE/Tz drifter with thermistor chain.

Figure 5. CMOD (XAN-3) drifter with thermistor chain.

2.2 *Drifter Deployment and Recovery Operations*

The drifters were generally deployed at the beginning of the small scale surveys conducted with the Trisoarus towed vehicle. They were either released before the towed vehicle was put in the water or during the first leg of the survey. All drifters were deployed upstream of the mesoscale features sampled so that they stayed in the vicinity of the towed vehicle. In this way the vehicle, ship-board ADCP and drifter data were all concentrated on the same features. CODE drifters in their cardboard boxes were deployed from the starboard side of the ship while the ship was steaming at ~6 knots and towing the vehicle. All the other drifters with drogues or thermistor chains were deployed from the stern at ship speeds varying in 1-2 knots (Figure 6). These deployments were performed with the Trisoarus vehicle on deck or in the water close to the ship.

Some drifters were recovered after the vehicle had performed once or many times the full small survey. The drifter data were downloaded from the Argos telnet data distribution system using cellular and Inmarsat telephony at least on a daily basis. These provided information on the drifter location with a few hours delay. Once the ship was in the vicinity of the drifters (1-2 nm), the IESM direction finder mounted near the ship's bridge provided us with up-to-date GPS locations for the drifters equipped with GPS receivers. For the other drifters, range and direction information was used to locate them. All drifters recovered were taken out of the water using grapnels and hooks on the starboard side of the ship (Figure 7).

Figure 6. Deploying an optical drifter (SVP/OCM) from the stern.

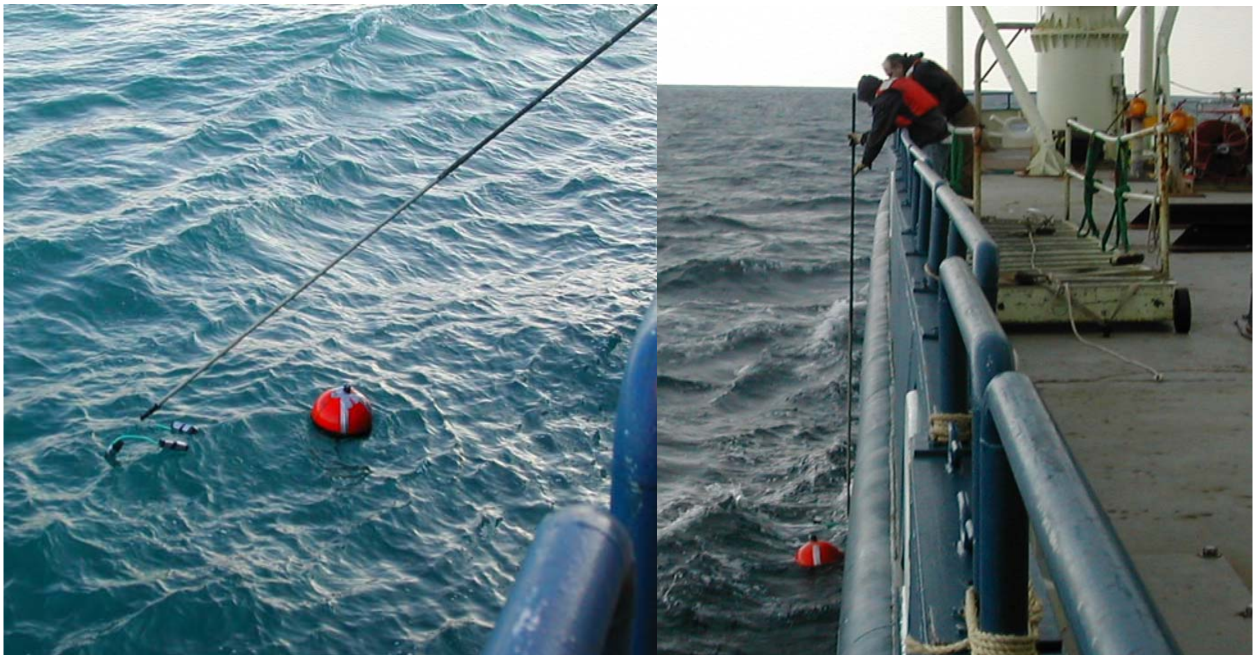


Figure 7. Recovery of a SVP/OCM drifter.

2.3 *Details about Drifter Deployment and Recoveries*

Three regular CODE drifters were deployed off the Istrian Peninsula during the initial basin-wide survey on 2 February 2003 . The deployment locations were closed to the ones where drifters were deployed in fall 2002 during the ADRIA02 cruise. The deployment coordinates are listed in Table 1.

DOLCEVITA_1- NA Deployments

Number	Type	Status	On	Deployment GMT time	Lat	Lon	SST
37740	Technocean CODE	new	1-Feb	2/2/2003 2:50	44 43.8	13 47.9	10.5
37741	Technocean CODE	new	1-Feb	2/2/2003 4:22	44 42.03	13 41.36	10.47
37742	Technocean CODE	new	1-Feb	2/2/2003 8:31	44 40.09	13 35.51	10.4

Table 1. Deployment information for the drifters deployed off Istria.

A total of 13 drifters where deployed during the mesoscale survey on the northeastern flank of the Jabuka pit on 7 February 2003 to survey the Middle Adriatic Filament. Seven drifters were successfully recovered on 8 February after having spent about 36 hours in the water. Upon recovery, we noted that one of the CODE-GPS drifter deployed with its carton box had a sail still folded on the main tubular body. Unfortunately, the Argos transmitter on the prototype drifter with the acoustic velocimeter failed to operate. We searched in the vicinity of the CODE-GPS drifters launched with the prototype drifter on 8 February afternoon and on the next morning without success. The deployment and recovery details for all the drifters deployed near the Jabuka pit are listed in Tables 2 and 3.

DOLCEVITA_1 – JABUKA DEPLOYMENTS **Deployment**

Number	Type	Status	On	GMT time	Lat	Lon	SST	SSS
34882	Technocean CODE-GPS	old	6-Feb	7/2/2003 2:26	43 38.1275	15 18.5529	13.921	38.623
35498	Technocean CODE-GPS	old	6-Feb	7/2/2003 2:26	43 38.1275	15 18.5529	13.921	38.623
P1	CODE+Aquadopp Nortek		6-Feb	7/2/2003 2 :25	43 38.1130	15 18.542	13.921	38.62
37686	Technocean CODE-GPS	new	6-Feb	7/2/2003 0:10	43 44.4496	15 11.0778	13.812	
37688	Technocean CODE-GPS	new	6-Feb	7/2/2003 1:33	43 40.5642	15 16.6947	13.581	38.63
37689	Technocean CODE-GPS	new	6-Feb	7/2/2003 3:05	43 37.6120	15 22.378	14.196	38.669
37690	Technocean CODE-GPS	new	6-Feb	7/2/2003 4:28	43 34.7734	15 27.9113	14.268	38.781
29361	WOTAN (Minimet)	new	6-Feb	7/2/2003 2:02	43 37.1681	15 17.5373	13.83	38.66
3999	Clearwater SVP 50 m	new	6-Feb	7/2/2003 1:12	43 42.0098	15 13.9494	13.765	38.694
4001	Clearwater SVP 50 m	new	6-Feb	7/2/2003 2:44	43 38.1001	15 19.5423	14.183	38.69
4002	Clearwater SVP 50 m	new	6-Feb	7/2/2003 3:58	43 36.1825	15 25.0442	14.27	38.788
33355	Metocean SVP/OCM	new	6-Feb	7/2/2003 0:44	43 44.0681	15 11.9005	14.017	38.712
33356	Metocean SVP/OCM	new	6-Feb	7/2/2003 3:30	43 34.3331	15 23.1448	14.249	38.718

Table 2. Deployment information for the drifters deployed near Jabuka Pit.

DOLCEVITA_1 – JABUKA RECOVERIES

Number	GMT time	Lat	Lon
34882	11/2/2003 06:50	43 35.2082	14 52.0229
35498	8/2/2003 13:11	43 32.5764	15 14.0978
37686	8/2/2003 15:13	43 35.0164	15 15.5278
37688	8/2/2003 16:51	43 30.8974	15 14.4145
3999	8/2/2003 16:03	43 34.3854	15 14.5804
33355	8/2/2003 14:09	43 34.6356	15 13.2065
33356	8/2/2003 15:40	43 36.6399	15 14.91

Table 3. Recovery information for the drifters deployed near Jabuka Pit.

Twelve drifters were released off the southern tip of the Istrian Peninsula (off Pula) as part of the mesoscale survey to sample the North Adriatic Filament during and after a strong Bora event. They were released on 11 February 2003 and some of them were retrieved on 15 February 2003 after about 4 days in the water. Since the local bathymetry varied near 40 m, the CMOD XAN-3 and the CODE\Tz thermistor chains were reduced to a length of 30 m. Likewise the tether of the SVP drifters were shorten to center the drogue at about 30-m depth. Deployment and recovery details are listed in Tables 4 and 5.

DOLCEVITA_1- PULA DEPLOYMENTS

				Deployment				
Number	**Type**	**Status**	**On**	**GMT time**	**Lat**	**Lon**	**SST**	**SSS**
34882	Technocean CODE-GPS	old	15:32	11/2/2003 21:44	44 29.9461	14 10.7994	12.479	38.826
37686	Technocean CODE-GPS	new	15:31	11/2/2003 20:53	44 34.6880	14 08.710912.045	13.812	38.756
37688	Technocean CODE-GPS	new	15 :30	11/2/2003 20 :02	44 39.4191	14 06.5200	10.026	38.218
37676	Technocean CODE-GPS	new	12:41	11/2/2003 19:17	44 44.2354	14 04.2871	9.8613	38.205
29360	WOTAN (Minimet)	new		11/2/2003 20:25	44 37.0567	14 07.634611.805	11.805	38.763
3999	Clearwater SVP 30 m	new	15:35	11/2/2003 19:40	44 41.7934	14 05.4044	10.144	38.269
4010	Clearwater SVP 30 m	new	15:34	11/2/2003 21:19	44 32.3114	14 09.6946	12.24	38.744
33355	Metocean SVP/OCM	new	15:09	11/2/2003 17:10	44 31.5903	14 05.8641	12.3375	38.784
33356	Metocean SVP/OCM	new	15:09	11/2/2003 18:25	44 40.988	14 01.688011.291	11.291	38.644
33353	Metocean GPS-CODE/Tz	new	16:05	11/2/2003 17:48	44 36.2148	14 03.8053	10.487	38.487
11440	CMOD Thermistor chain	new	13:24	11/2/2003 16:30	44 29.1305	14 07.0591	12.5817	38.837
11497	CMOD Thermistor chain	new	13:30	11/2/2003 18:51	44 43.4294	14 00.6325	9.832	38.231

Table 4. Deployment information for the drifters deployed south of Pula.

DOLCEVITA_1- PULA RECOVERIES

Number	**GMT time**	**Lat**	**Lon**	**Comments**
37686	15/2/03 14 :38	44 5.0374	13 21.3955	SST=11.098
33355	15/2/03 13:28	44 6.5793	13 18.8879	SST=10.347
33356	15/2/03 16:43	44 21.6173	13 6.9859	SST=10.440
33353	15/2/03 11:54	43 54.8332	13 28.9677	SST=11.753

Table 5. Recovery information for the drifters deployed south of Pula.

In the next survey concentrated on the Western Adriatic Current (WAC) in front of Rimini –Pesaro, we deployed 4 drifters along the first transect of the Trisoarus during the night of 15-16 February 2003 and two optical drifters (SVP/OCM) a day later on 17 February 2003. The two SVP/OCM were deployed near the 50 and 30-m isobaths because the drogue of these drifters extends down to about 20 m. These two drifters were recovered on 18 February after more than 36 hours in the water. Drifter 33355 was recovered in water depth less than 18 m meaning that the drogue dragged on the bottom. Significant wear of the straps connecting the top of the drogue to the tether was evident for both drifters. More information about the deployment and recoveries of these drifters are provided in Table 6 and 7.

DOLCEVITA_1- PESARO DEPLOYMENTS

			Deployment					
Number	Type	Status	On	GMT time	Lat	Lon	SST	SSS
37687	Technocean CODE-GPS	new	15/2/03 17:55	15/2/03 23:28	44 14.4696	12 56.9247	10.88	38.766
37686	Technocean CODE-GPS	used		15/2/03 21 :55	44 08.4169	12 46.1255	8.2683	37.915
37677	Technocean CODE-GPS	new	15/2/03 21:38	16/2/03 01:11	44 21.1512	13 10.0496	12.5	38.838
37678	Technocean CODE-GPS	new	15/2/03 21:35	16/2/03 02:36	44 26.6496	13 21.1694	11.943	38.838
33355	Metocean SVP/OCM	new	16/2/03 21:30	17/2/2003 00:20	44 09.7349	12 51.2320	9.978	38.568
33356	Metocean SVP/OCM	new	16/2/03 21:30	16/2/2003 23:17	44 13.9935	12 59.9947	9.943	38.451

Table 6. Deployment information for the drifters deployed near the WAC off Rimini-Pesaro.

DOLCEVITA_1- PESARO RECOVERIES

Number	GMT time	Lat	Lon	Comments
33355	18/2/03 12.55	43 56.4191	13 2.4049	SST=9.456, SSS=38.5498
33356	18/2/03 14.18	43 51.8010	13 19.0563	SST=10.4276, SSS=38.7144

Table 7. Recovery information for the drifters deployed near the WAC off Rimini-Pesaro.

Three CODE drifters were deployed in the Northern Adriatic near the Gulf of Trieste. The deployment locations (see Table 8) were chosen to match those where drifters were deployed during the R/V Alliance cruise in fall 2002.

DOLCEVITA_1- DRIFTER LIST

			Deployment					
Number	Type	Status	On	GMT time	Lat	Lon	SST	SSS
377743	Technocean CODE	new	20/2/03 00.01	20/2/03 3.31	45 33.0487	13 6.713	8.3789	38.358
377744	Technocean CODE	new	19/2/03 23.58	20/2/03 3.57	45 28.4962	13 9.4089	8.8354	38.4129
377745	Technocean CODE	new	19/2/03 23.59	20/2/03 4.22	45 23.7336	13 11.5059	8.5127	38.3215

Table 8. Deployment information for the drifters deployed near the Gulf of Trieste

A total of 5 drifters were deployed along the first Trisoarus leg of the small survey of the Po Plume on 20 February 2003. The drifters with optical sensors and thermistor chain were deployed in the plume of cold and low-salinity water. All drifters were deployed with the vehicle in the water which represents a significant time saving. The Trisoarus was brought closer to the ship and the ship decreased speed to 2 knt for the deployments off the stern (drifters with drogue or thermistor chain). Three drifters were recovered on 21 February 2003 after more than 24 hours in the water. Information about the deployments and recoveries is provided in Tables 9 and 10, respectively.

DOLCEVITA_1- PO PLUME DEPLOYMENTS

Number	Type	Status	Deployment On	GMT time	Lat	Lon	SST	SSS
37679	Technocean CODE-GPS	new	19/2/03 23.57	20/2/03 9.15	44 49.1955	12 52.7659	8.1232	38.345
37681	Technocean CODE-GPS	new	19/2/03 23.57	20/2/03 10.51	44 40.9948	13 00.5613	8.7405	38.288
33355	Metocean SVP/OCM	new	19/2/03 23.56	20/2/03 10.17	44 44.3423	12 57.393	6.4033	36.336
33356	Metocean SVP/OCM	new	19/2/03 23.56	20/2/03 9.50	44 45.8865	12 55.9261	6.2458	36.158
33353	Metocean GPS-CODE/Tz	new	19/2/03 23.55	20/2/03 10.05	44 45.0259	12 56.6495	6.7792	36.946

Table 9. Deployment information for the drifters deployed during the Po Plume survey.

DOLCEVITA_1- PO PLUME RECOVERIES

Number	GMT time	Lat	Lon	Comments
33355	21/02/03 15:57	44 50.4852	12 58.1811	SST=7.0314 SSS=37.0966
33356	21/02/03 15:14	44 46.865	12 57.9953	SST=7.0689 SSS=36.7911
33353	21/02/03 15:35	44 48.5536	12 56.7142	SST=7.4863 SSS=37.7824

Table 10. Recovery details for the three drifters recovered during the Po Plume survey.

On the last day of the cruise, 24 February 2003, a SVP 50-m drifter was recovered south of Ancona. Details are listed in Table 11.

DOLCEVITA_1 - LAST RECOVERY

Number	Type	GMT time	Lat	Lon	Comments
4001	Clearwater SVP 50 m	24/2/2003 5:27	42 59.4897	14 16.0812	SST=13.1717, SSS=38.7752

Table 11. Recovery details for the SVP drifter recovered south of Ancona.

3. Preliminary Results and Interpretation

3.1 *Drifter tracks*

Five-day long drifter trajectory segments in the northern and middle Adriatic basins are shown in Figure 8 for four consecutive periods spanning most of the cruise. Star symbols represent deployment locations, open circles denote the last drifter position for the time period considered. Black solid symbols represent recovery locations. Note that the trajectory segment may be shorter than 5 days if the drifter was deployed or if it was recovered during the period considered. Only the positions provided by the Argos Doppler system and the positions of deployment/recovery are plotted.

Figure 9 shows the deployment locations for the drifters released at the beginning of the first small scale survey on the northeastern wall of the Jabuka Pit. The tracks of these drifters are displayed in Figure 9 for the period 7-10 Feb 2003. Most drifter moved in the southwest direction. The drifters launched at the southern extremity of the array remained trapped in loops (probably inertial currents). Two drifters escaped the domain to the north and eventually turned cyclonically before splitting and showing north and southward motion trends.

The deployment locations for the drifters released on 11 February 2003 during the first occupation of the small scale survey located south of the Istrian Peninsula (Pula) are shown in Figure 10. Their tracks until 15 February 2003 are also depicted. All drifters moved rapidly westward with a typical speed of 50 cm/s in response to the strong Bora wind forcing. Upon reaching the middle of the basin, some drifters (essentially those deployed south of the front) started to veer in the south and southeast direction as they joined the WAC. Those deployed north of the front slowed down and showed some trend of northward motion.

The deployment locations and the tracks of the drifters deployed on 15-16 February 2003 upstream of the small scale survey concentrating on the WAC off Rimini and Pesaro are displayed in Figure 11. Tracks are shown until 20 February 2003. All drifters eventually joined the WAC and moved southeastward with relatively large speeds (reaching 50 cm/s). There is a tendency for the drifters to converge just offshore of Ancona. Two drifters east of the WAC showed some slow northwestward motion in the open sea.

The final set of deployments took place during the first leg of the first small scale survey of the Po plume on 20 February 2003. The two optical drifters and the CODE/Tz were deployed in the center of the plume in relatively cold and low-salinity waters. They moved to the northeast with speeds around 10-20 cm/s. The two CODE-GPS drifters that were released on each side of the plume did not move rapidly during the first day after deployment. They eventually (not shown) veered to the southwest direction.

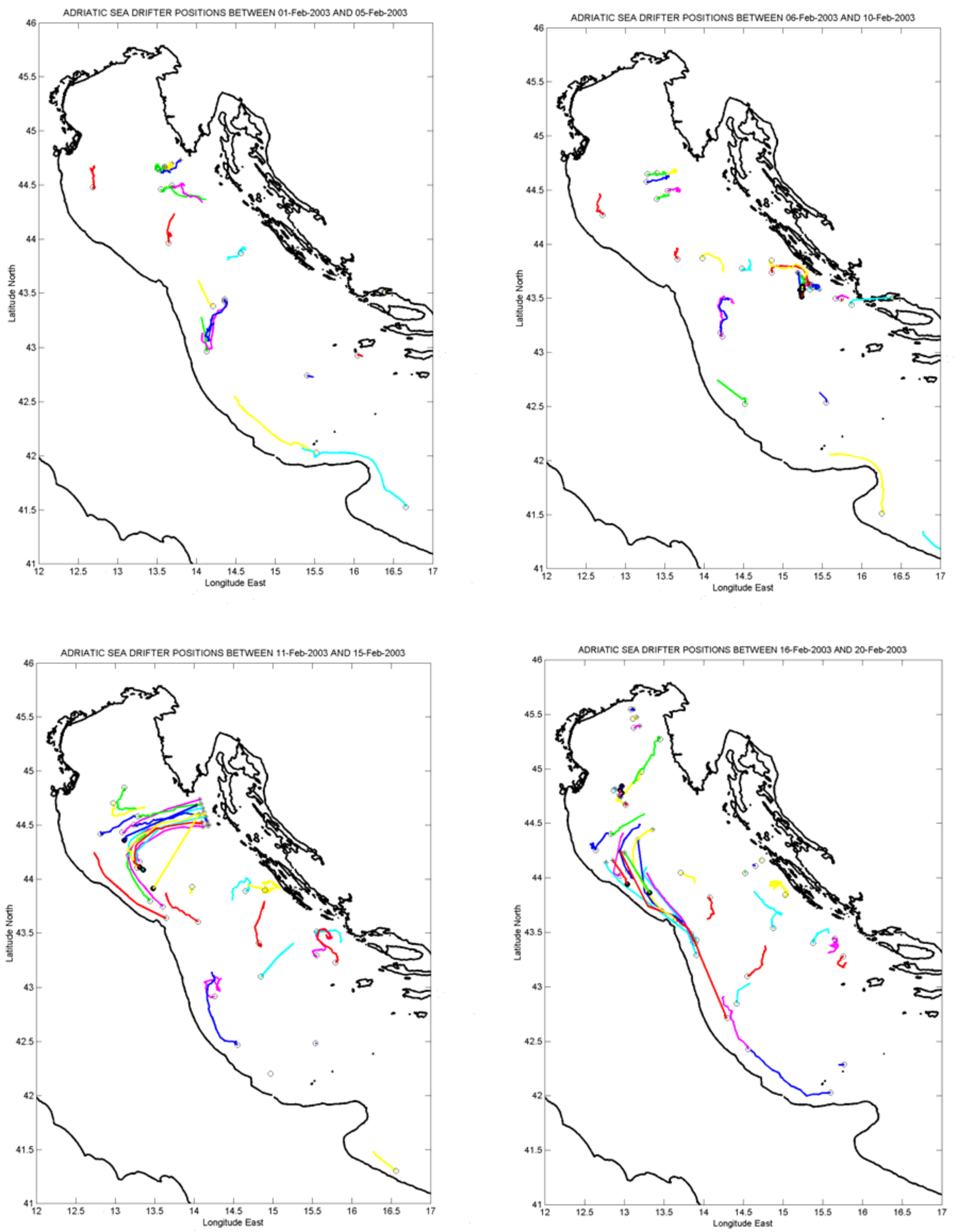


Figure 8. 5-day long trajectory segments of the drifters in the northern and middle Adriatic Sea for consecutive periods ending on 5 Feb (top left), on 10 Feb (top right), on 15 Feb (bottom left) and on 20 Feb (bottom right). See text for details.

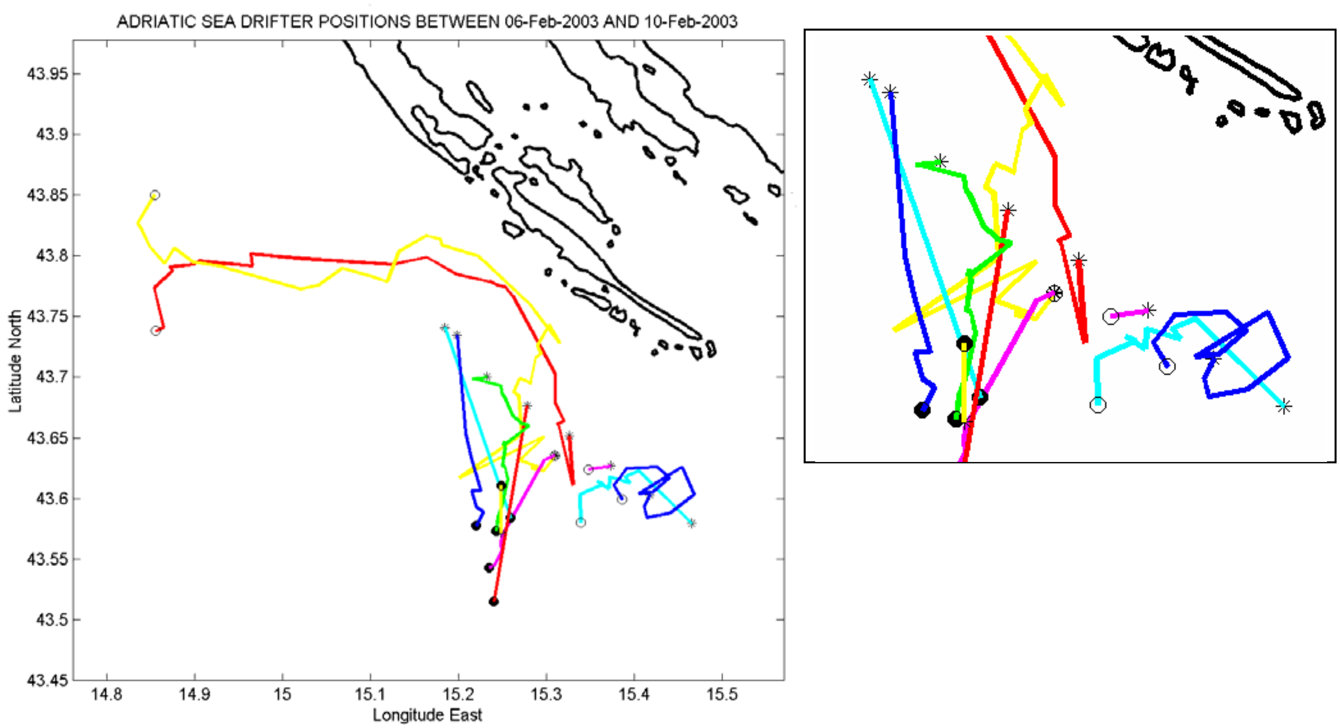


Figure 9. Drifter tracks of the drifters deployed during the first small scale survey near Jabuka pit for the period 6-10 Feb 2003, and of any other drifter in the vicinity.

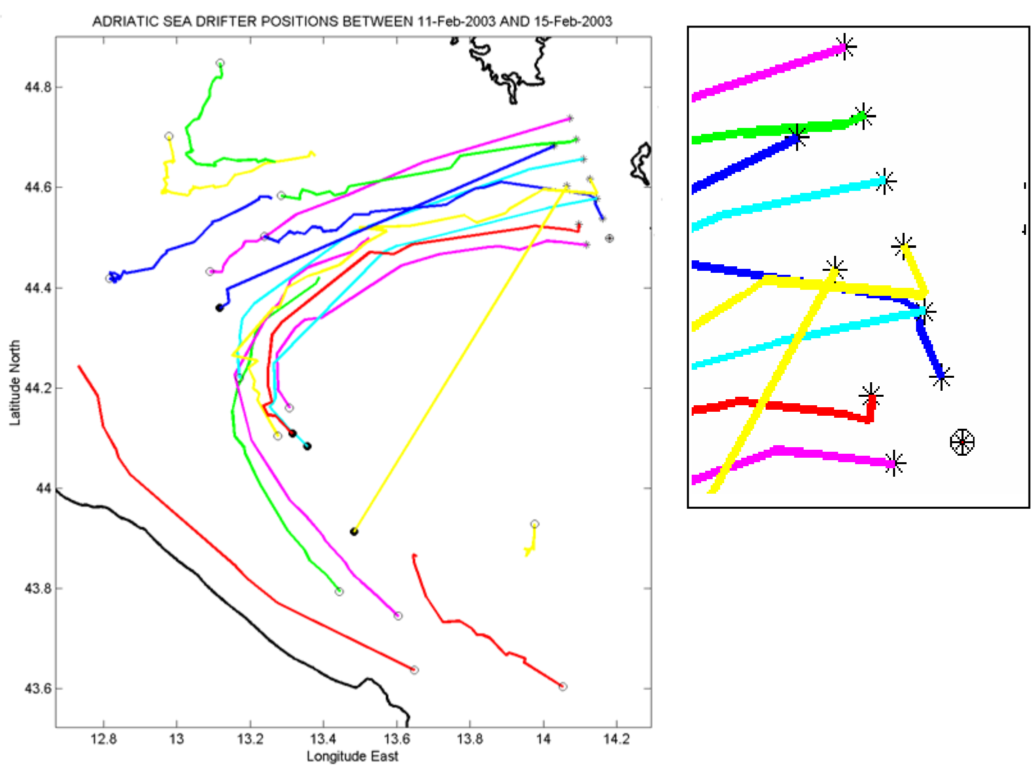


Figure 10. Drifter tracks of the drifters deployed during the small scale survey south of the Istrian Peninsula (Pula) for the period 11-15 Feb 2003, and of any other drifters in the vicinity.

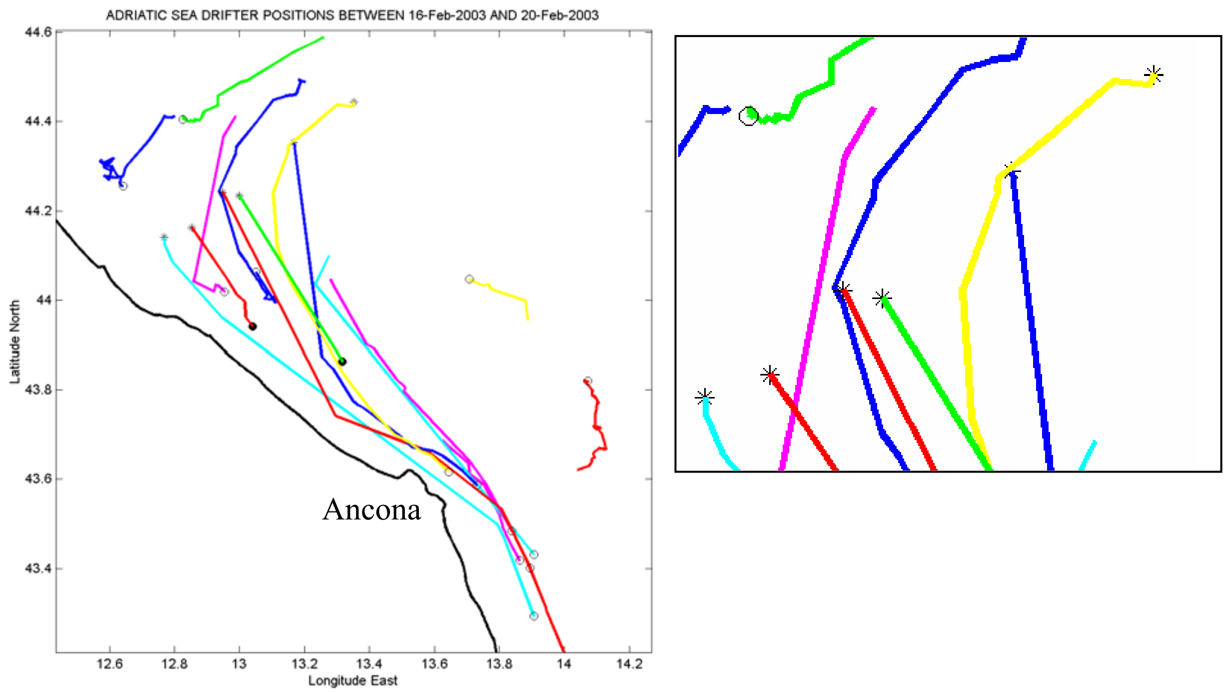


Figure 11. Drifter tracks of the drifters deployed during the small scale survey near the WAC off Rimini-Pesaro for the period 16-20 Feb 2003, and of any other drifters in the vicinity.

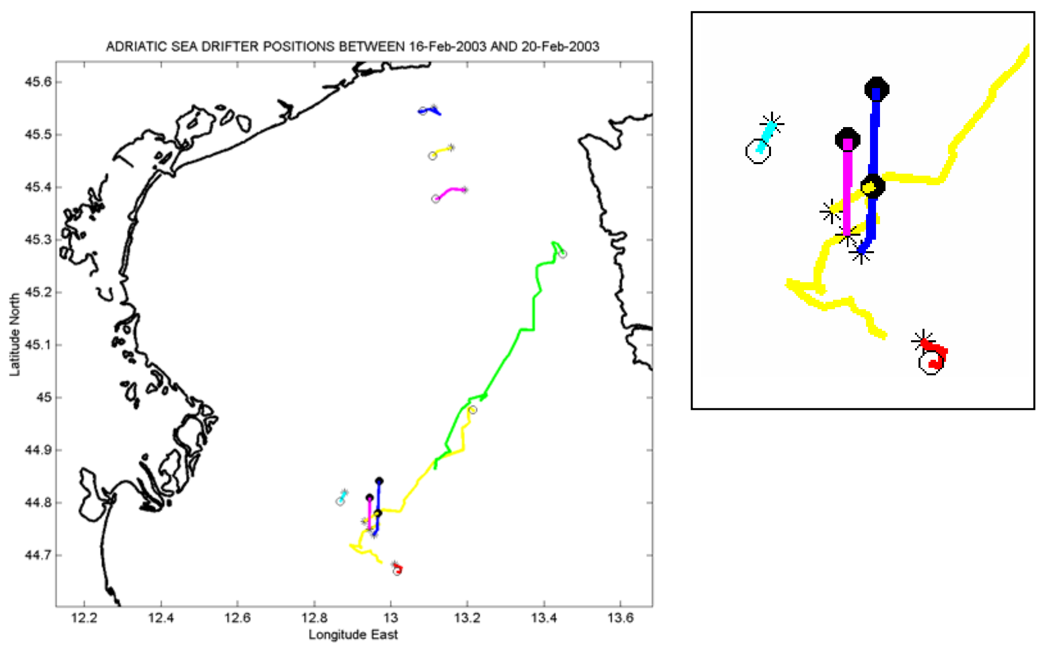


Figure 12. Drifter tracks of the drifters deployed during the small scale survey of the Po plume for the period 16-20 Feb 2003, and of any other drifters in the vicinity.

3.2 *Drifter tracks and other Data Sets*

For the surveys in the northern Adriatic, concentrating on the NAF front and on the Po plume, rather clear satellite images were available. Sequences of AVHRR-derived sea surface temperature images and of SeaWiFS chlorophyll concentration maps, with superimposed drifter tracks and ADCP near-surface currents are presented to describe the temporal evolutions of the features at daily intervals.

3.2.1 Drifter Tracks and AVHHR images

Figure 13 to 19 show SST images with 5-day long drifter trajectory segments for the northern Adriatic from 11 through 23 February 2003. The temporal evolution of the instabilities (intrusions) of the NAF thermal front south of Pula and of the Po cold plume is striking.

3.2.2 Drifter Tracks, AVHRR images, Ship-borne ADCP data and Ship SST

Three examples of SST images with overlaid currents derived from the ship-borne ADCP are shown in Figures 20 and 21. The ADCP data represent currents in a 4 m height cell centered at 11.85 m depth. The ship track is also color-coded with the SST measured by the ship underway pumping system. For the Po plume survey (Figure 21 bottom), the agreement between the satellite SST, the ship SST, and the circulation patterns estimated by the ship ADCP and drifters is remarkable. Fast northeastward currents are concentrated in (and south) of the plume.

3.2.3 Drifter Tracks and SeaWiFS images

A sequence of SeaWiFS images of the Northern Adriatic (color-coded chlorophyll concentration) is shown as Figures 22-24 for the period 18-22 February 2003. The evolution of the Po plume (high chlorophyll concentration signature) is evident.

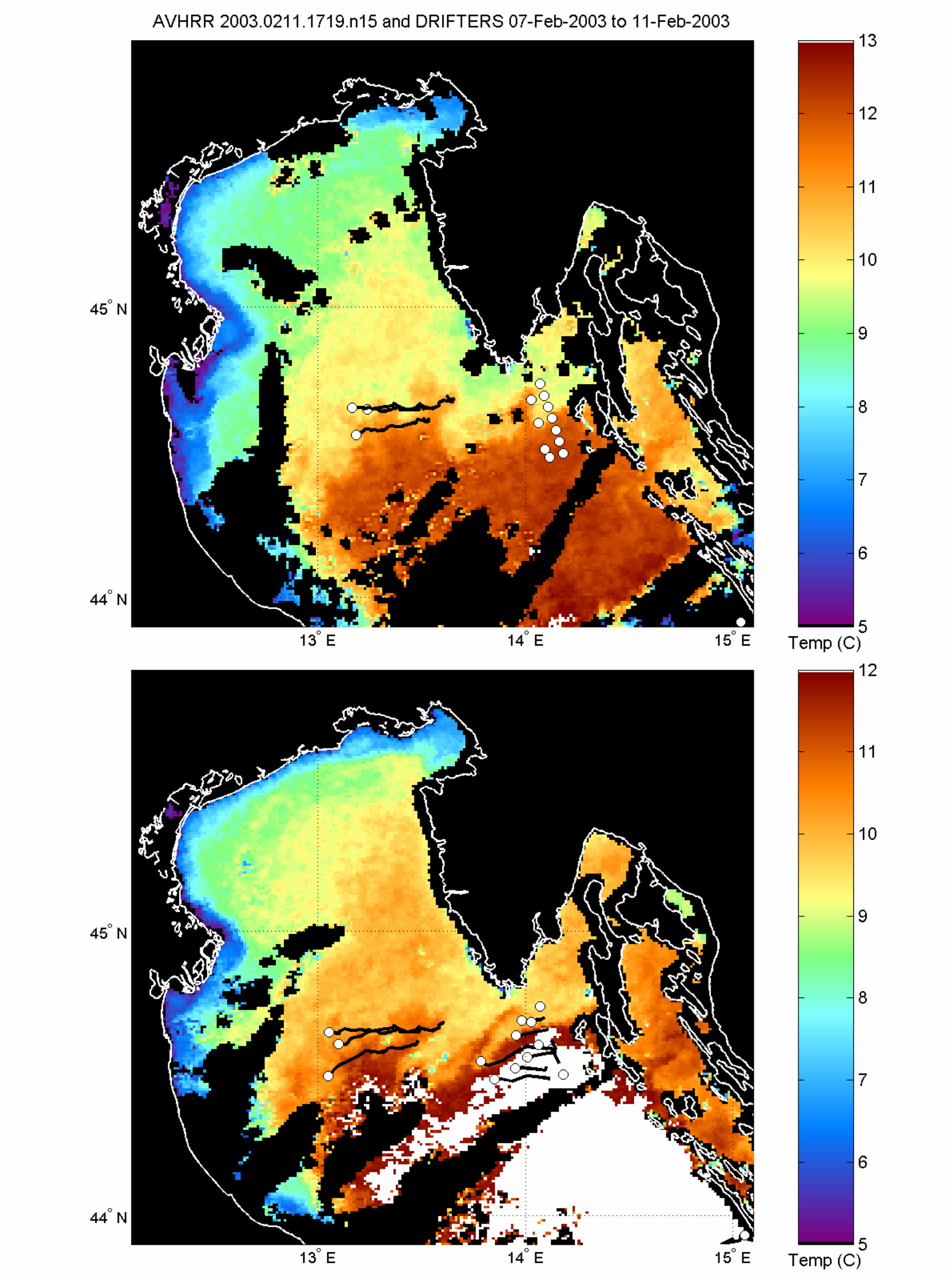


Figure 13. Color-coded satellite images of AVHRR-derived SST of the North Adriatic. Drifter tracks of the drifters deployed during the cruise are overlaid for a period of 5 days before the day of the satellite images. White circles represent the last drifter locations on the last day considered. Top (11 Feb 2003) and bottom (12 Feb 2003).

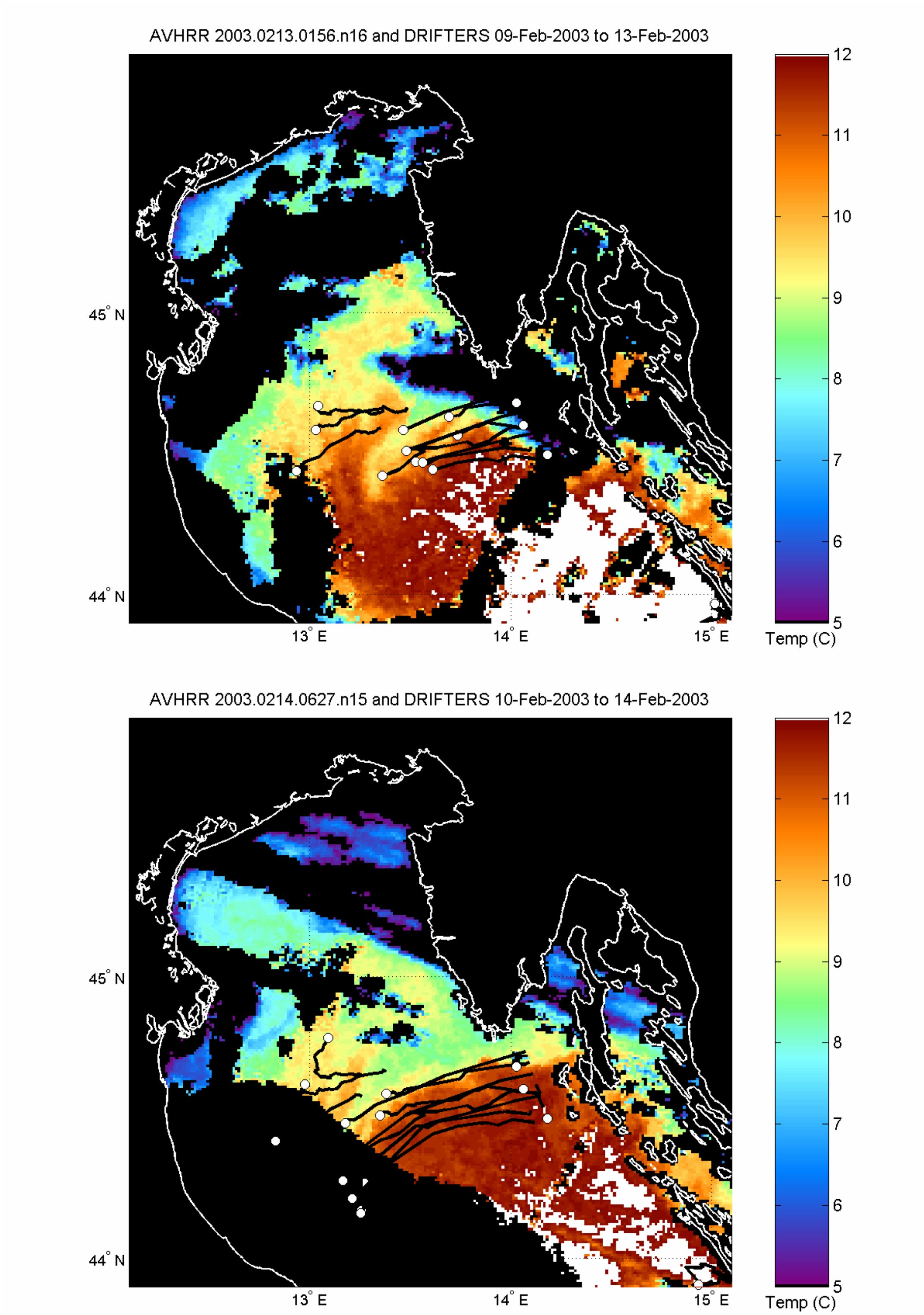
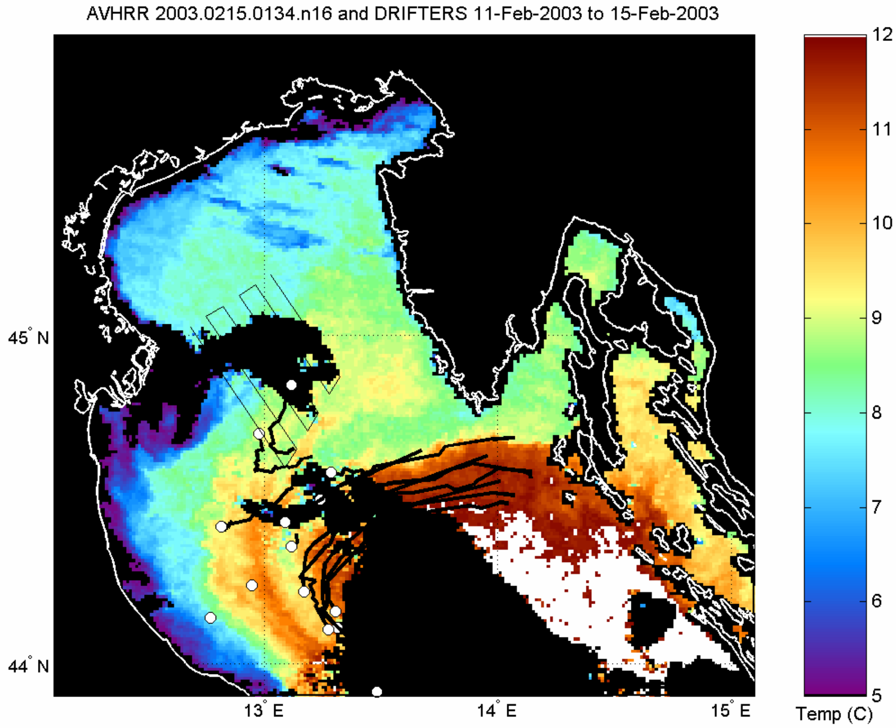


Figure 14. Same as in Figure 13 but for 13 Feb 2003 (top) and 14 February 2003 (bottom).



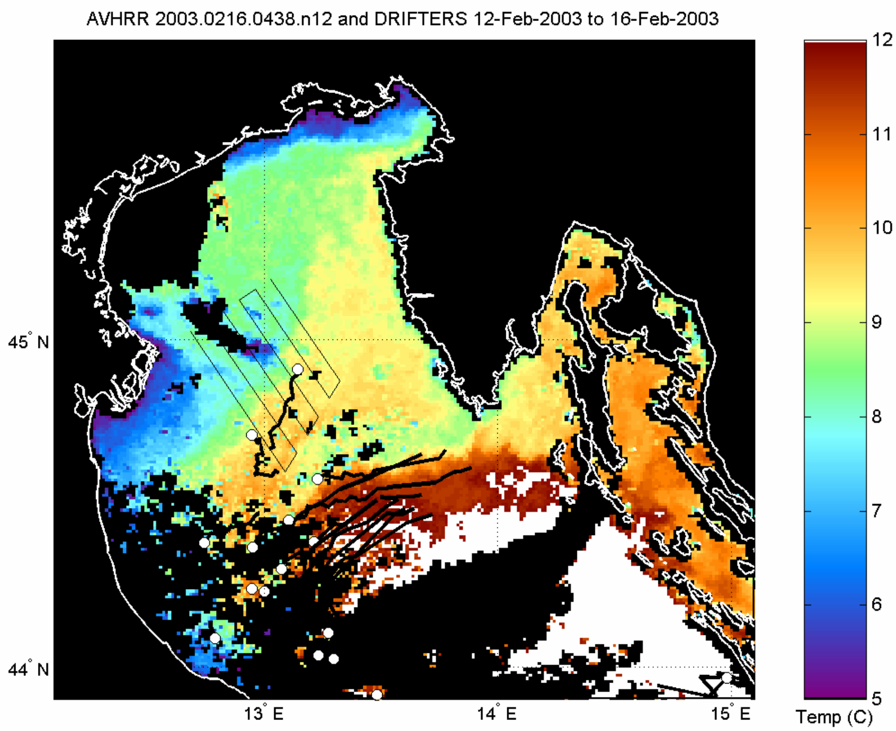


Figure 15. Same as in Figure 13 but for 15 Feb 2003 (top) and 16 February 2003 (bottom). The ship track of the small scale survey of the Po plume is also displayed.

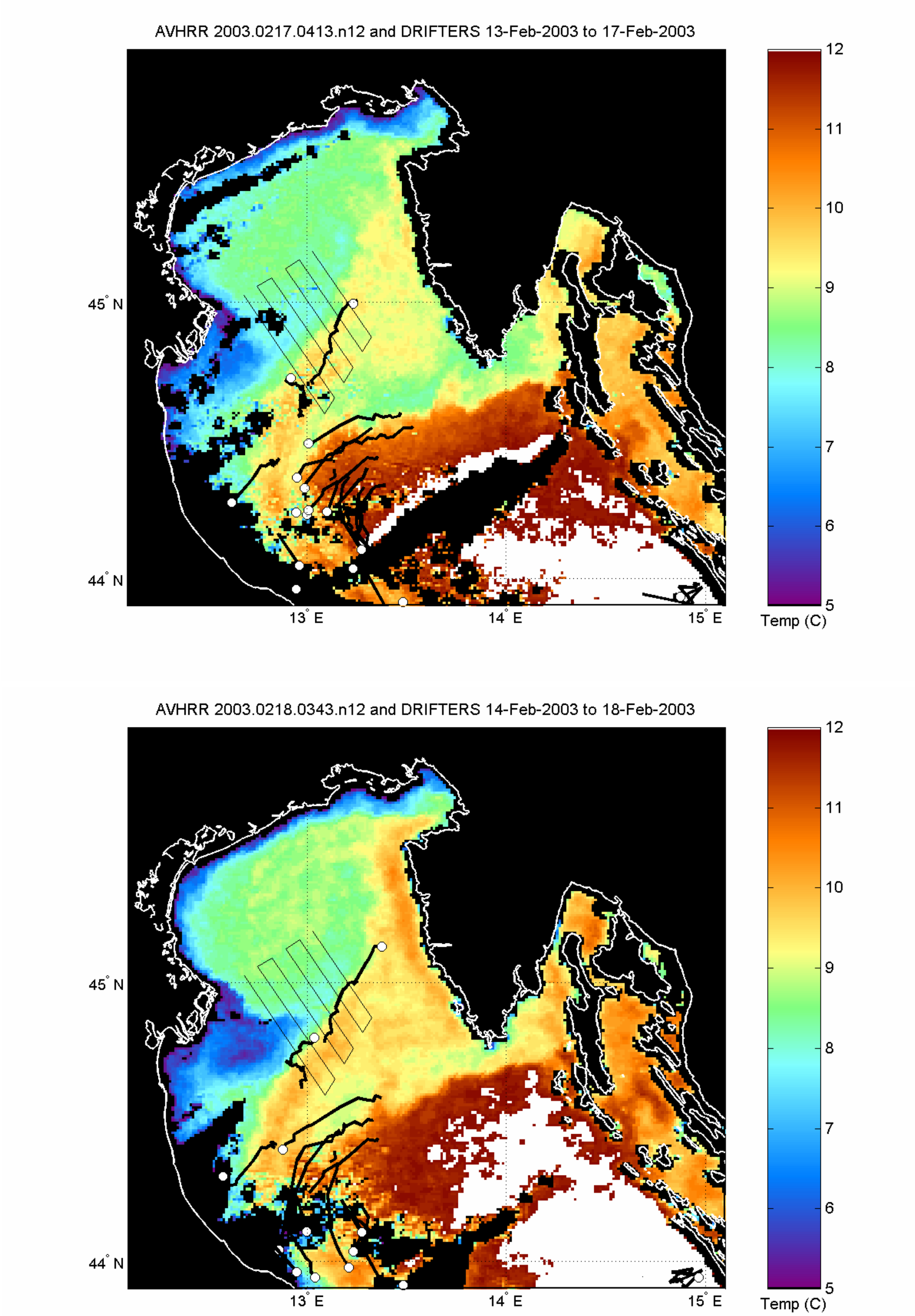


Figure 16. Same as in Figure 15 but for 17 Feb 2003 (top) and 18 February 2003 (bottom).

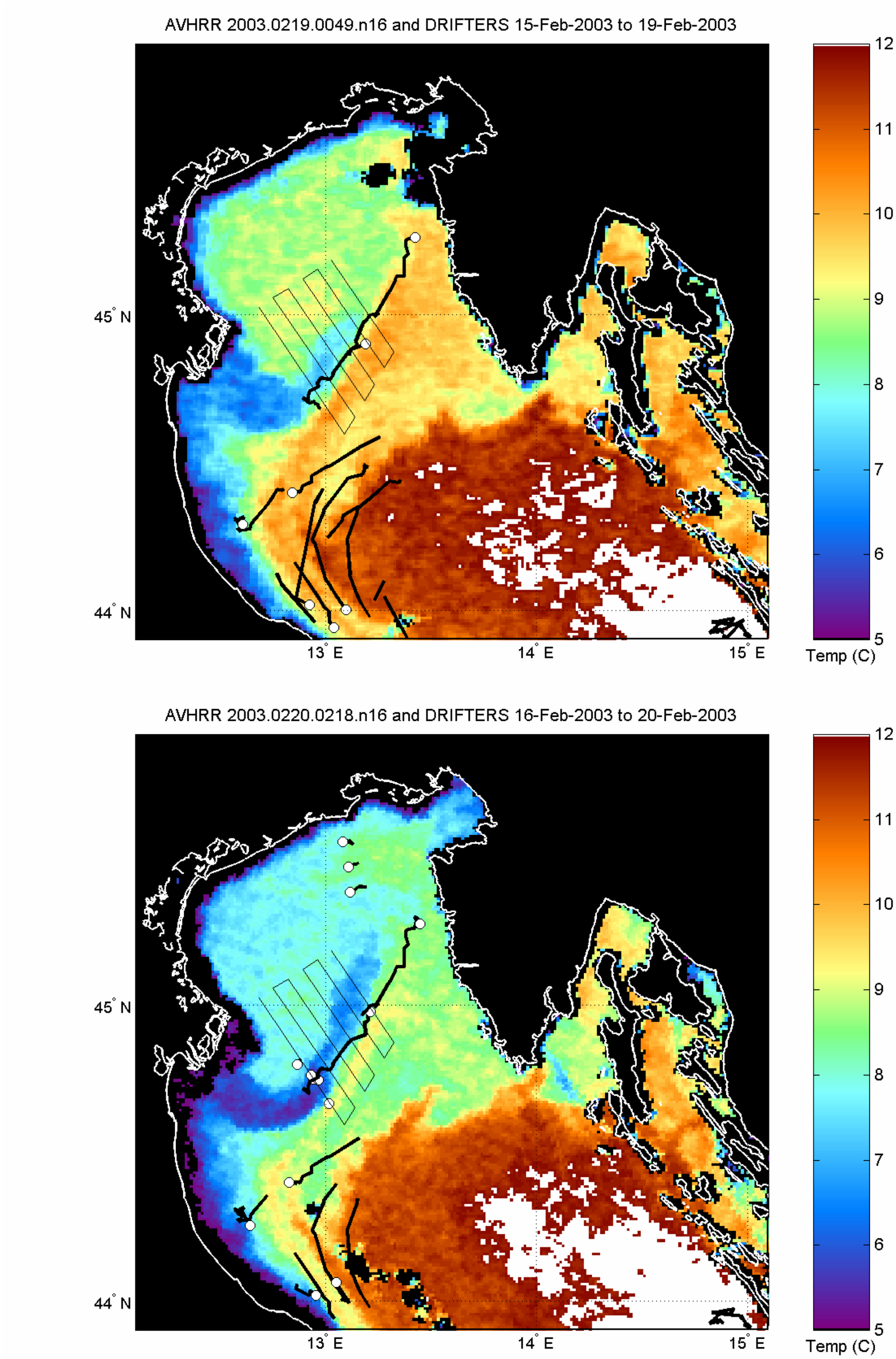


Figure 17. Same as in Figure 15 but for 19 Feb 2003 (top) and 20 February 2003 (bottom).

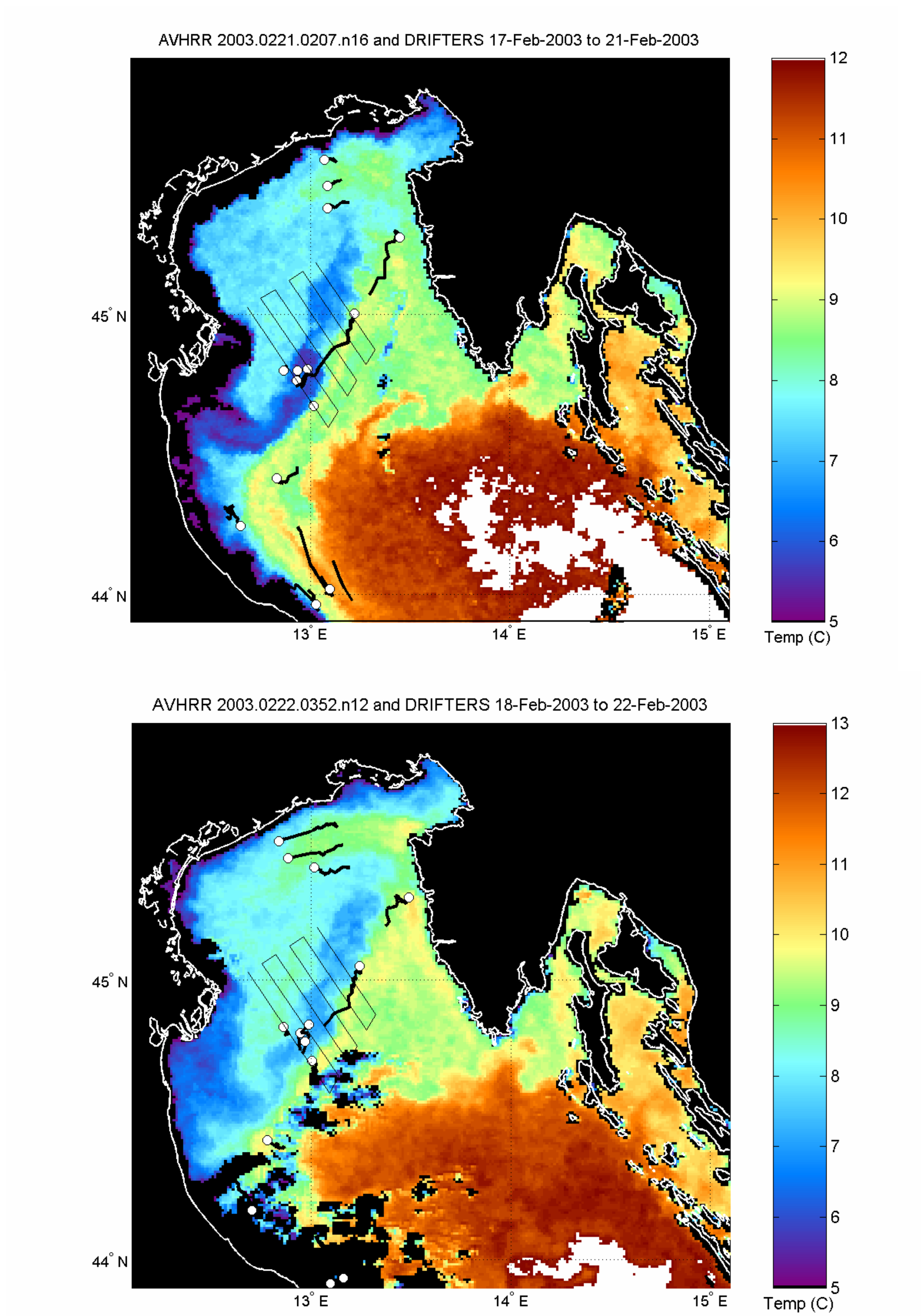


Figure 18. Same as in Figure 15 but for 21 Feb 2003 (top) and 22 February 2003 (bottom).

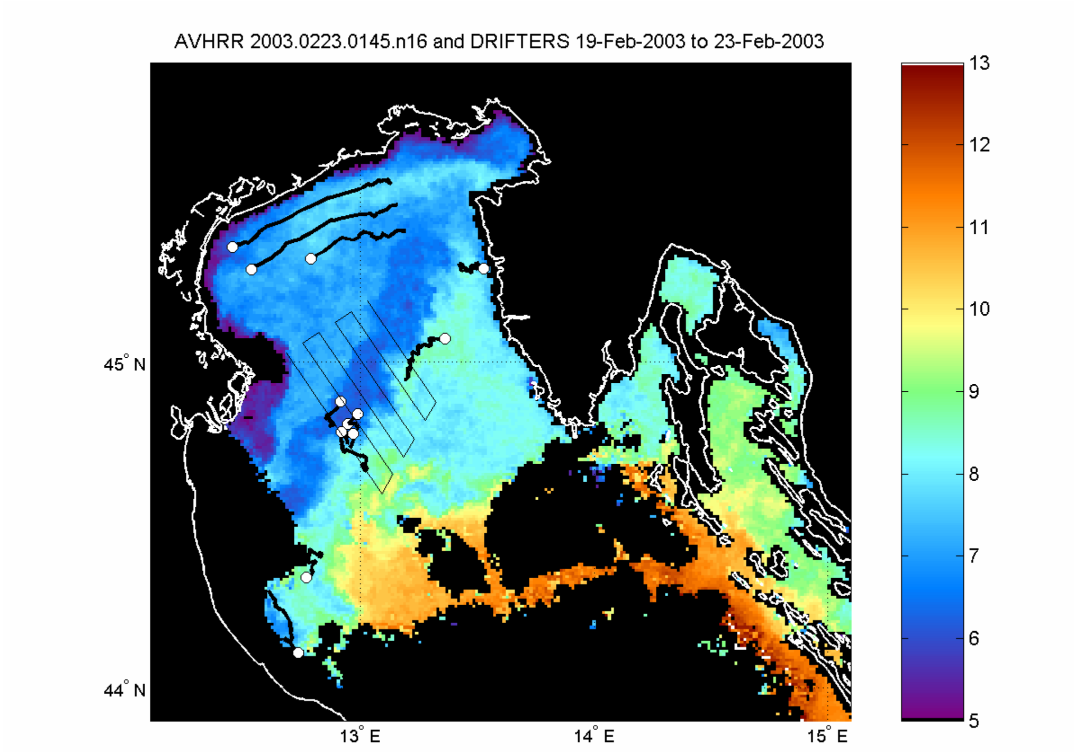


Figure 19. Same as in Figure 15 but for 23 February 2003.

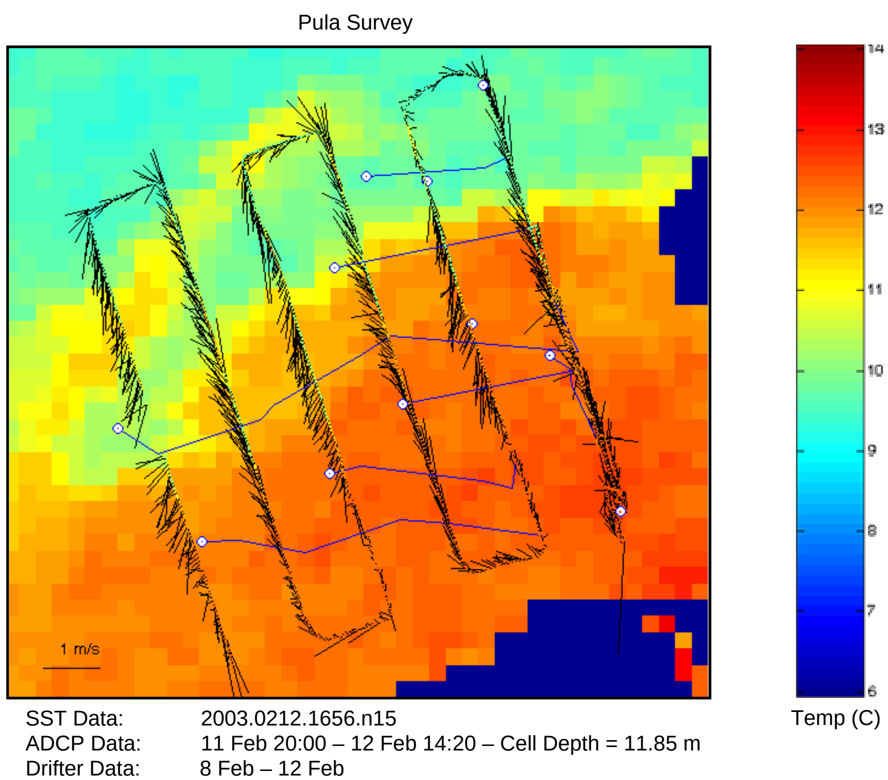


Figure 20. Color-coded SST map of the NAF front south of Pula with ship track of small scale survey, ADCP near surface currents, and drifter tracks (solid white circles represent the last positions on 12 Feb). The ship track is color-coded with the ship underway SST.

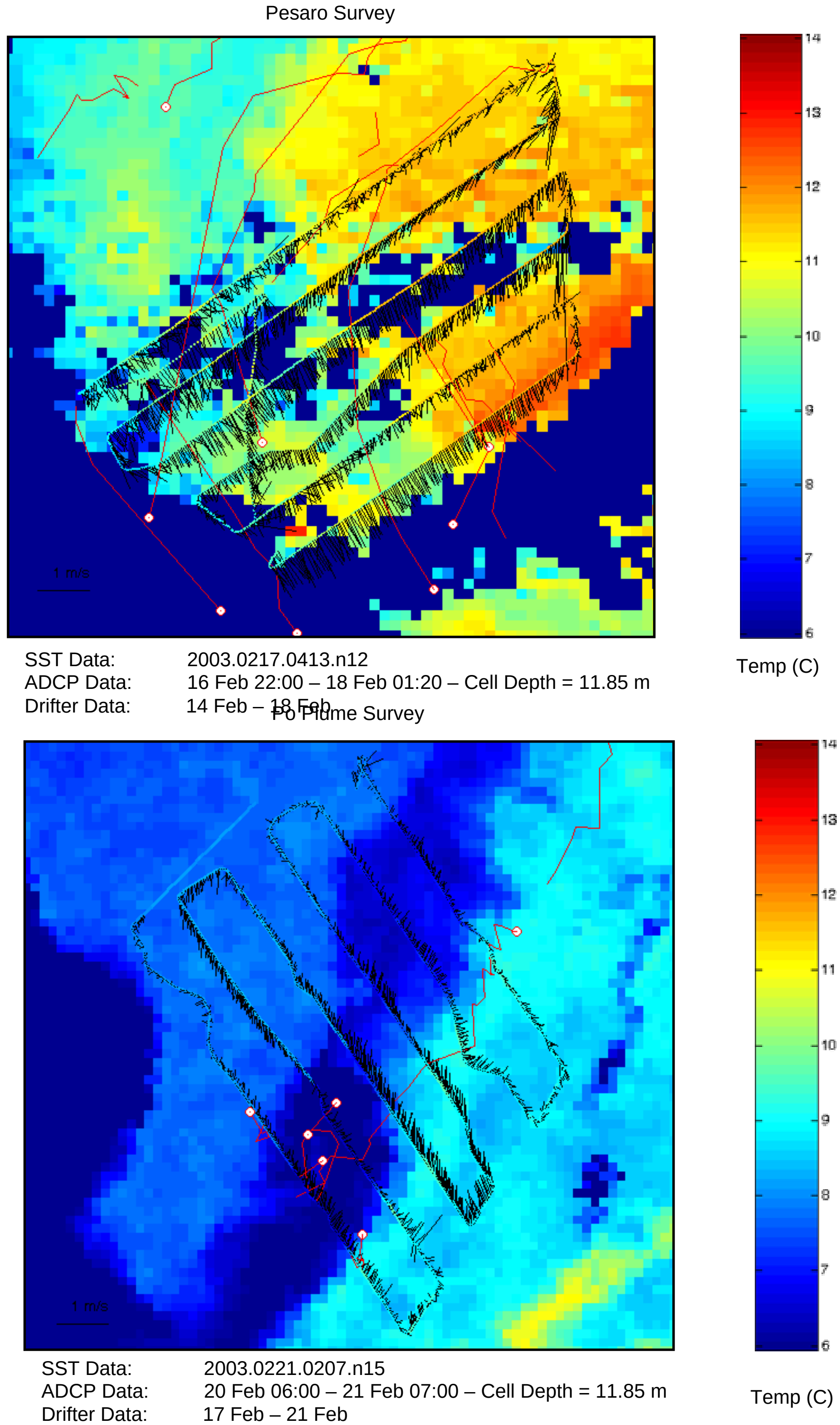


Figure 21. Same as Figure 20 but for the WAC (off Rimini-Pesaro, top) and the Po plume (bottom) surveys.

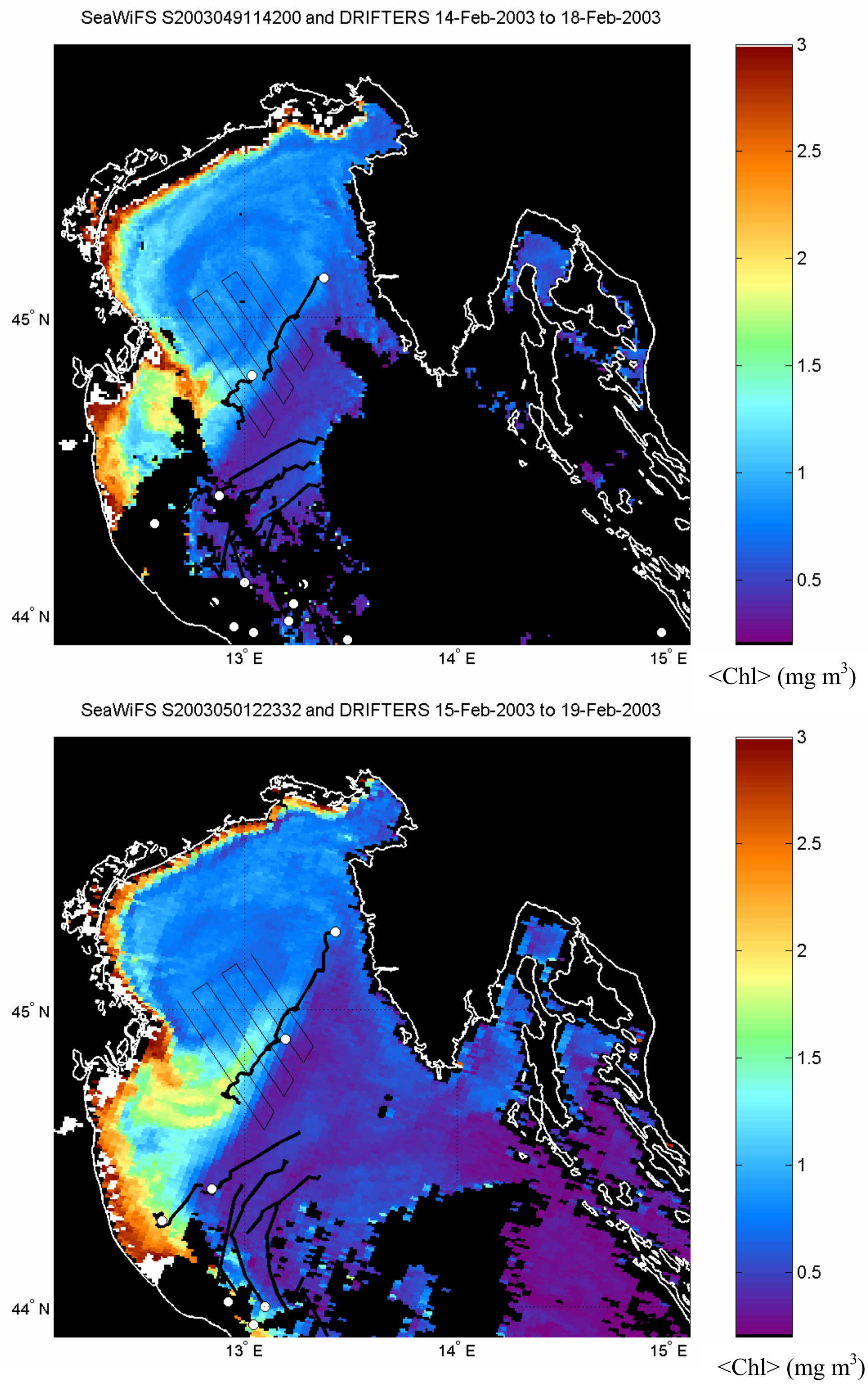


Figure 22. Color-coded satellite images of SeaWiFS-derived chlorophyll concentration of the North Adriatic. Drifter tracks of the drifters deployed during the cruise are overlaid for a period of 5 days before the day of the satellite images. White circles represent the last drifter locations on the last day considered. Top (18 Feb 2003) and bottom (19 Feb 2003). The ship track of the small scale survey of the Po plume is also displayed.

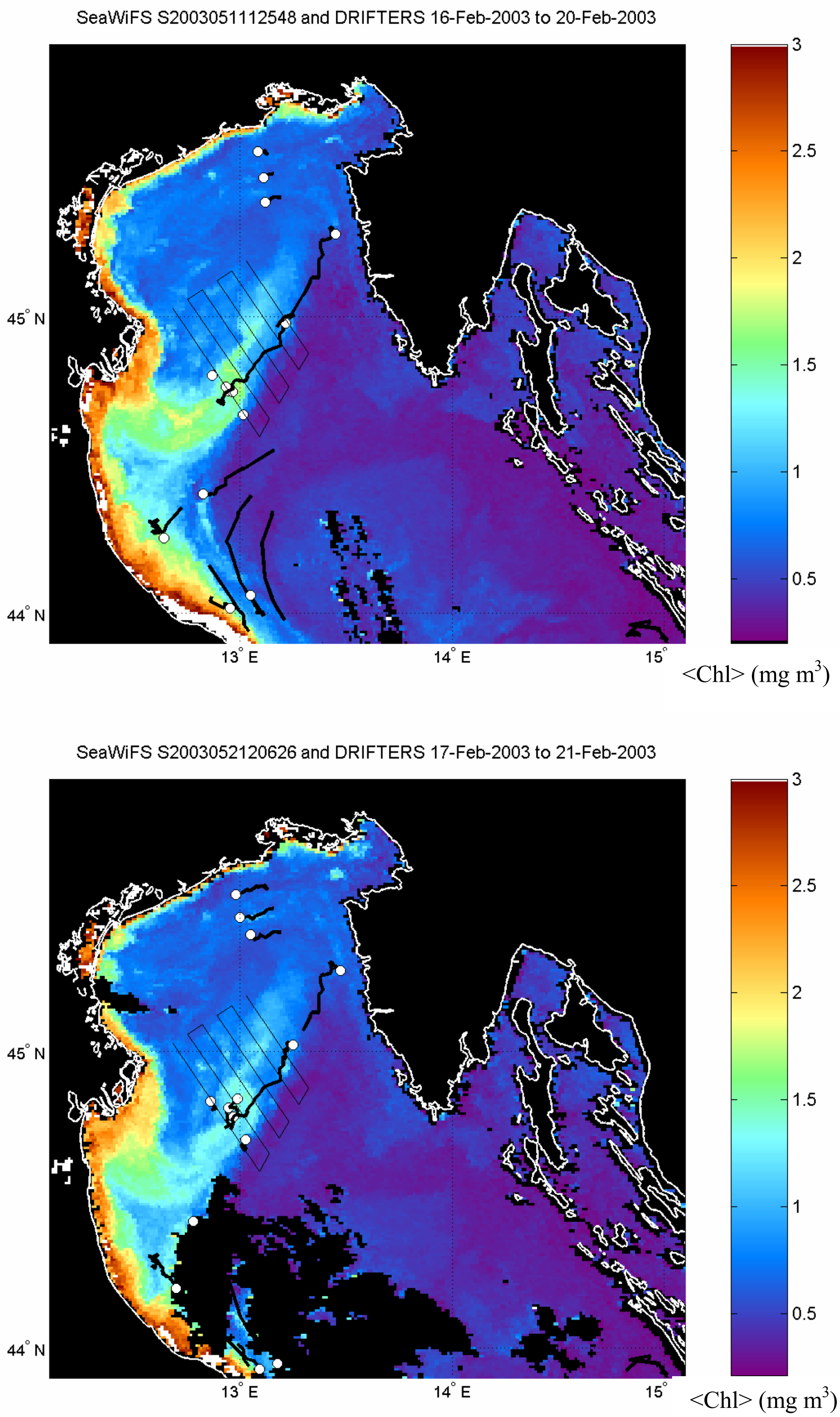


Figure 23. Same as in Figure 22 but for 20 Feb 2003 (top) and 21 February 2003 (bottom).

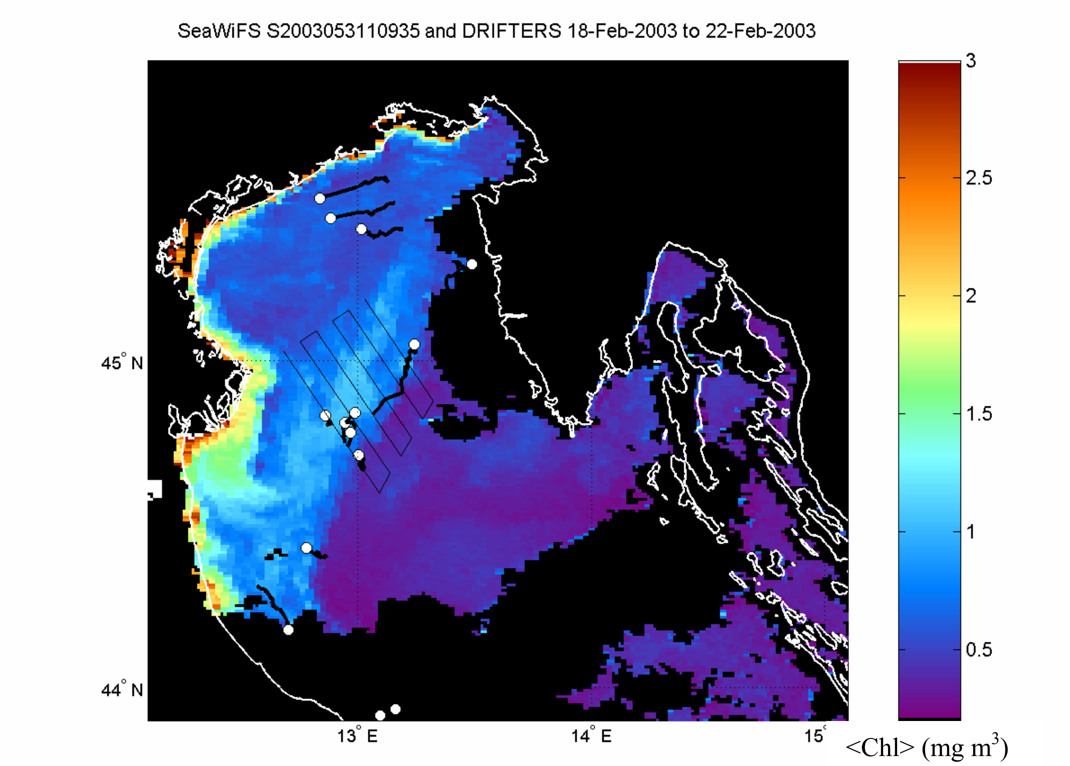


Figure 24. Same as in Figure 22 but for 22 Feb 2003.

3.3 *Drifter GPS Location Data*

Some of the drifters are equipped with GPS receivers to measure their location at hourly or half-hour intervals. An example of the drifter raw GPS data is displayed in Figure 25 during the small scale survey of the WAC off Rimini and Pesaro. It can be seen that the GPS data can be quite noisy for some drifters (see for example the yellow dots). Meticulous editing will be needed to sort out this data sets. In addition, the GPS data time series are not continuous. Intervals spanning a few hours without data are often seen. This is essentially due to the fact that the number of Argos messages per satellite pass is rather limited (2-3) with respect to what was expected (6-7).

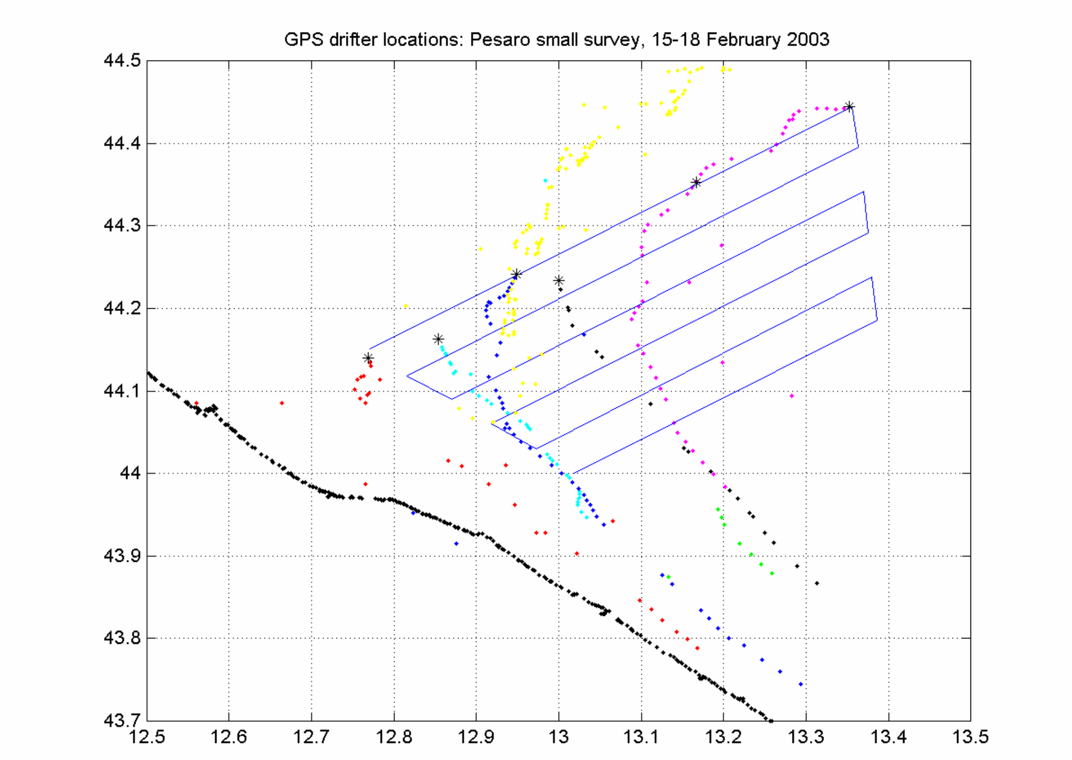


Figure 25. GPS locations of the drifters launched during the small scale survey in the WAC off Rimini and Pesaro. Star symbols indicate deployments and GPS locations (colored dots) are typically at half-hour or hourly intervals.

3.4 *Drifter Optical Data*

The two optical drifters (SVP/OCM) were operated on 7-8, 11-15, 17-18 and 20-21 February 2003 during various small scale surveys in the North Adriatic. Examples of the processed data are illustrated in Figures 26 to 28. Spectra of the □pwelling radiances are typical of oligotrophic waters for the Pula survey (Figure 26) whereas in the Po plume (Figure 27) they delineate clearly the shift of color towards green. When scaled by the downwelling irradiance, the spread of the lines due to the different hours of the day is much reduced as expected. The irradiances were calculated from the measured value at 490 nm (see its daily variation in Figure 28) and the ratio computed from optical data measured by a MicroSAS instrument installed on the ship's bow (courtesy of B. Jones).

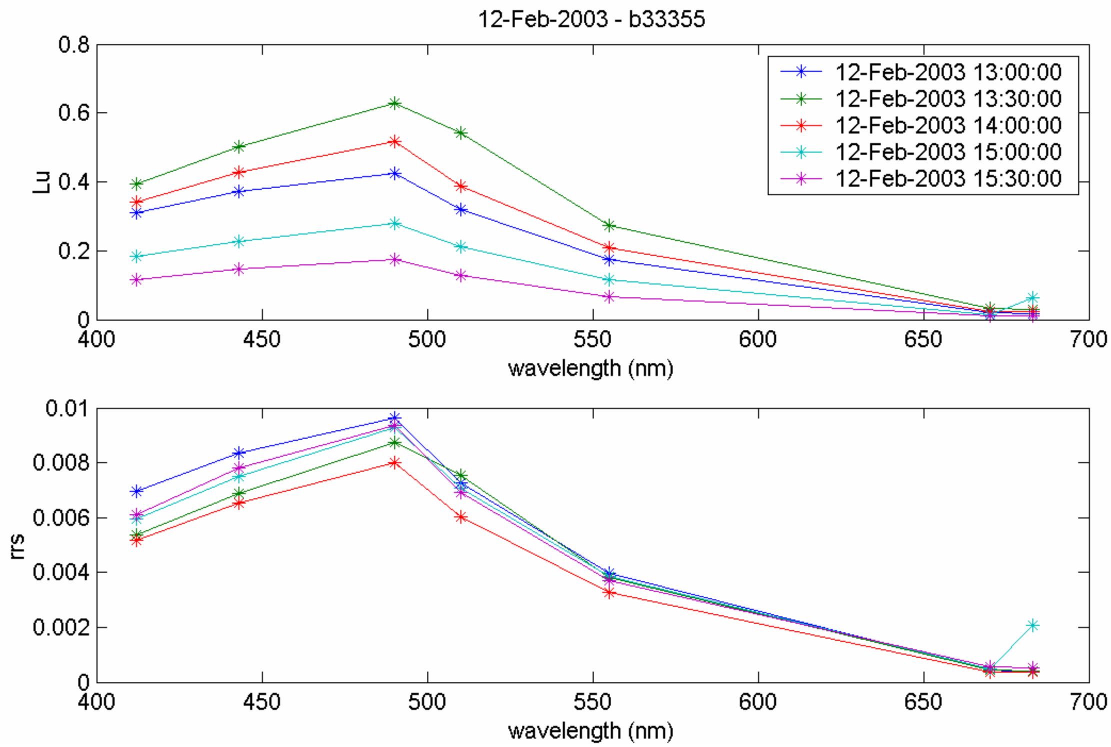


Figure 26. Upwelling radiance (μW/cm² /nm/sr) data for drifter PTT ID 33355 on 12 February 2003 for 7 channels in the visible band (top). Corresponding remote sensing reflectance (rrs).

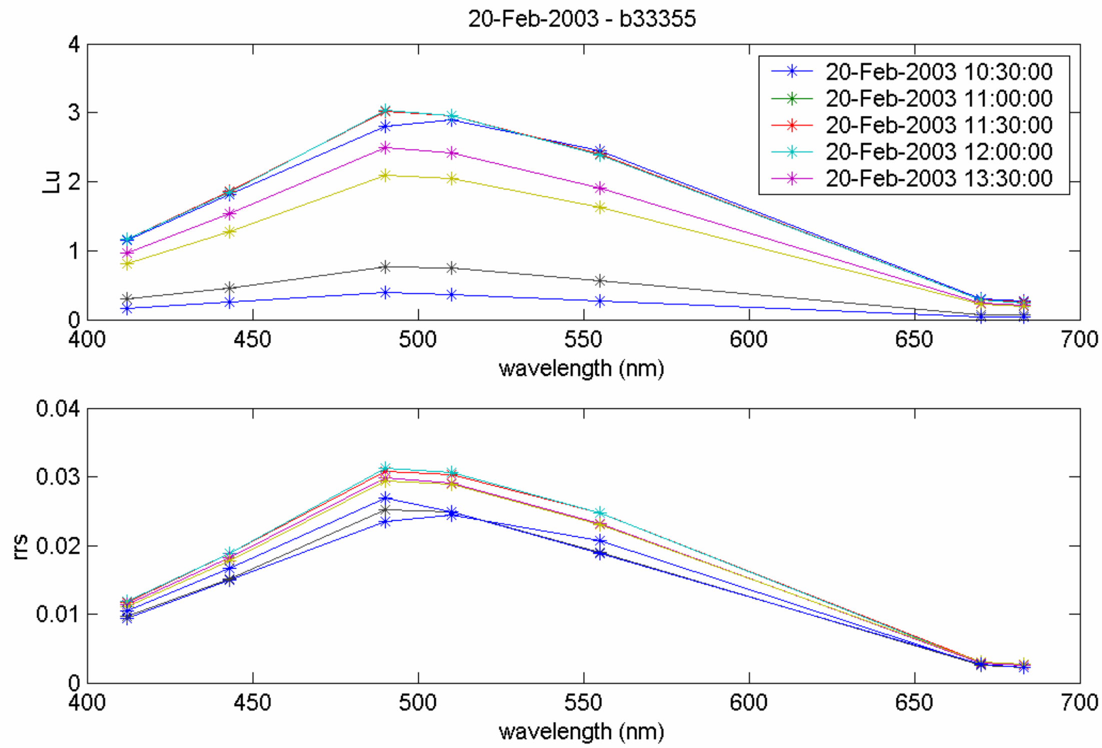


Figure 27. Same as Figure 28 but for drifter PTT ID 33355 on 20 February 2003.

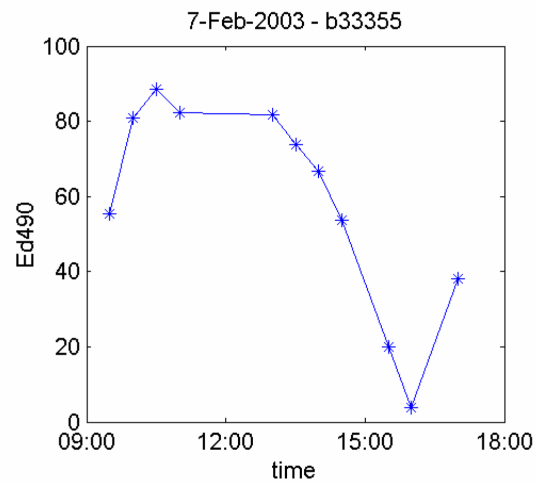


Figure 29. Downwelling irradiance (µW/cm² /nm) data for drifter PTT ID 33355 on 7 February 2003 versus GMT time.

3. Conclusions

In general, drifter operations during the DOLCEVITA-1 cruise were successful. Drifter deployment and recovery operations were very efficient especially near the end of the cruise. Some serious problems with the Metocean optical and thermistor drifters were observed. In particular, the data time series are not continuously sampled at 0.5 hour intervals as requested. The main problem is the low number of Argos message per satellite pass. We will work with Metocean to solve or reduce these problems in order to have better drifters for the DOLCEVITA-2 cruise in May-June.

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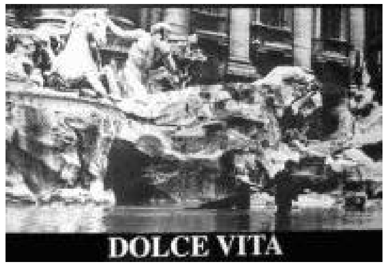

DOLCEVITA-2 CRUISE

26 May – 15 June 2003

REPORT OF DRIFTER-RELATED ACTIVITIES

by

P.-M. POULAIN AND R. BARBANTI

Project sponsored by the Office of Naval Research (ONR)

Approved for release by: ……………………………

Dr. Renzo Mosetti
Director, Department of Oceanography

TABLE OF CONTENTS:

1. Introduction

As part of the ONR-sponsored DOLCEVITA project, releases of drifters were conducted in the northern Adriatic during the DOLCEVITA-2 cruise onboard R/V Knorr between 26 May and 15 June 2003. The drifter measurements were concentrated in selected mesoscale circulation features and were made in concert with towed vehicle, hydrographic and optical measurements. This report contains a brief description of the drifter systems used, details about their deployments and recoveries, and a preliminary description and interpretation of the drifter results.

2. Instruments and Methods

2.1 *Drifter Systems*

All drifters were tracked by, and telemetered data to, the Argos satellite system. Most drifters transmitted at 90 s intervals to three satellites (NOAA 15 and 16 and ADEOS-2). In order to guarantee the transmission of all the data of the optical (SVP/OCM) and thermistor chain (CODE/Tz) drifters, these drifters were programmed to transmit every 60 s to 7 satellites (Argos-multi satellite service). Various drifter types were used during the cruise. They include:

1) CODE and CODE-GPS (Figure 1) surface drifters manufactured by Technocean, Cape Coral, FL, USA. which provide surface currents and sea surface temperature (SST). The GPS upgrade on some of the drifters allows positioning at hourly intervals.

Figure 1. Preparing a CODE-GPS drifter for deployment.

2) SVP surface drifters (Figure 2) with a holey-sock drogue centered at 50-m nominal depth manufactured by Clearwater, Watertown, MA, USA. These instruments provide currents at 50 m and SST. For operations in shallow waters, the tether was reduced to center the drogue at 30-m depth. They are equipped with GPS receivers that sample position every half hour.

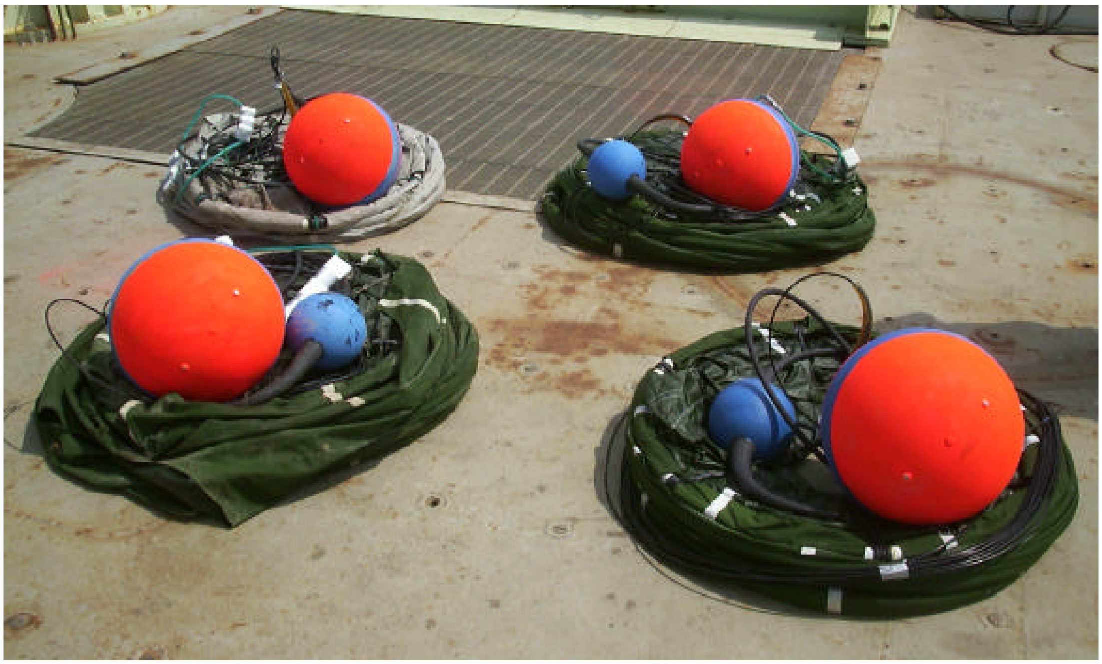

Figure 2. Four SVP drifters with holey-sock drogue (green and grey), intermediate float (light blue) and surface ball (red).

3) SVP/OCM surface drifters (Figure 3) with a drogue centered at 15-m depth produced by Metocean Data Systems Limited, Dartmouth, Nova Scotia, Canada. These drifters measure near-surface currents, SST, upwelling radiance and downwelling irradiance at visible wavelengths. They also have GPS positioning at half-hour intervals.
4) CODE/Tz surface drifters (Figure 4) with a thermistor chain manufactured by Metocean. They have 10 thermistors to measure the water temperature at 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 m. They also measure surface currents and SST. GPS fixes are sampled every half hour. For the applications in shallow water, the chain length was reduced to 30 m (see Table 1).

5) CMOD (XAN-3) surface drifters (Figure 5) with a thermistor chain manufactured by Metocean. In addition to the temperatures at various depths (2.5, 7.5, 10, 12.5, 17.5, 20, 25, 32.5, 40, and 50 m), these instruments measure surface currents, SST and surface air pressure and temperature. For the applications in shallow water, the chain length was reduced to 30 m (see Table 1).

Figure 3. SVP/OCM drifters with sock drogues. The irradiance meters can be seen on the top of the red surface balls.

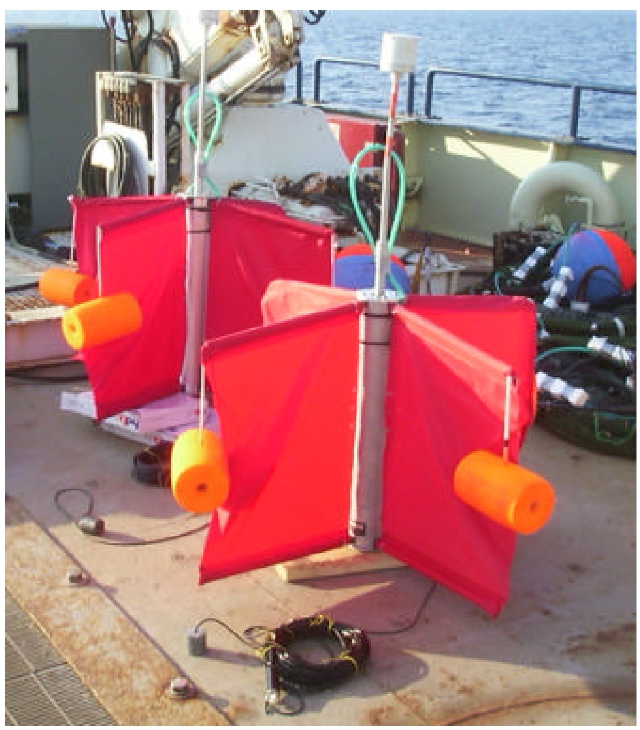

Figure 4. Two CODE/Tz drifters with thermistor chains.

Figure 5. CMOD (XAN-3) drifters with thermistor chains.

Thermistor number	CODE/Tz (33353)	CODE/Tz (33354)	CMOD
T1	5	3	2.5
T2	5	6	6.5
T3	10	9	9
T4	15	12	11.5
T5	15	15	15.5
T6	20	18	18
T7	23	21	21
T8	26	24	24
T9	30	27	27
T10	30	30	30

Table 1. Thermistors depths of the drifters for which the chain was shorten to 30 m. All depths are in meters.

2.2 *Drifter Deployment and Recovery Operations*

The drifters were generally deployed at the beginning of the small-scale surveys conducted with the Trisoarus towed vehicle. The small-scale surveys during which drifter were deployed were carried out in three areas of the northern and middle Adriatic: the Mid Adriatic Filament (MAF) or the northeastern part of the Mid Adriatic Pit (also called Jabuka Pit), the North Adriatic Filament (NAF) near the tip of Istria (off Pula), and the Po River Plume (Figure 7).

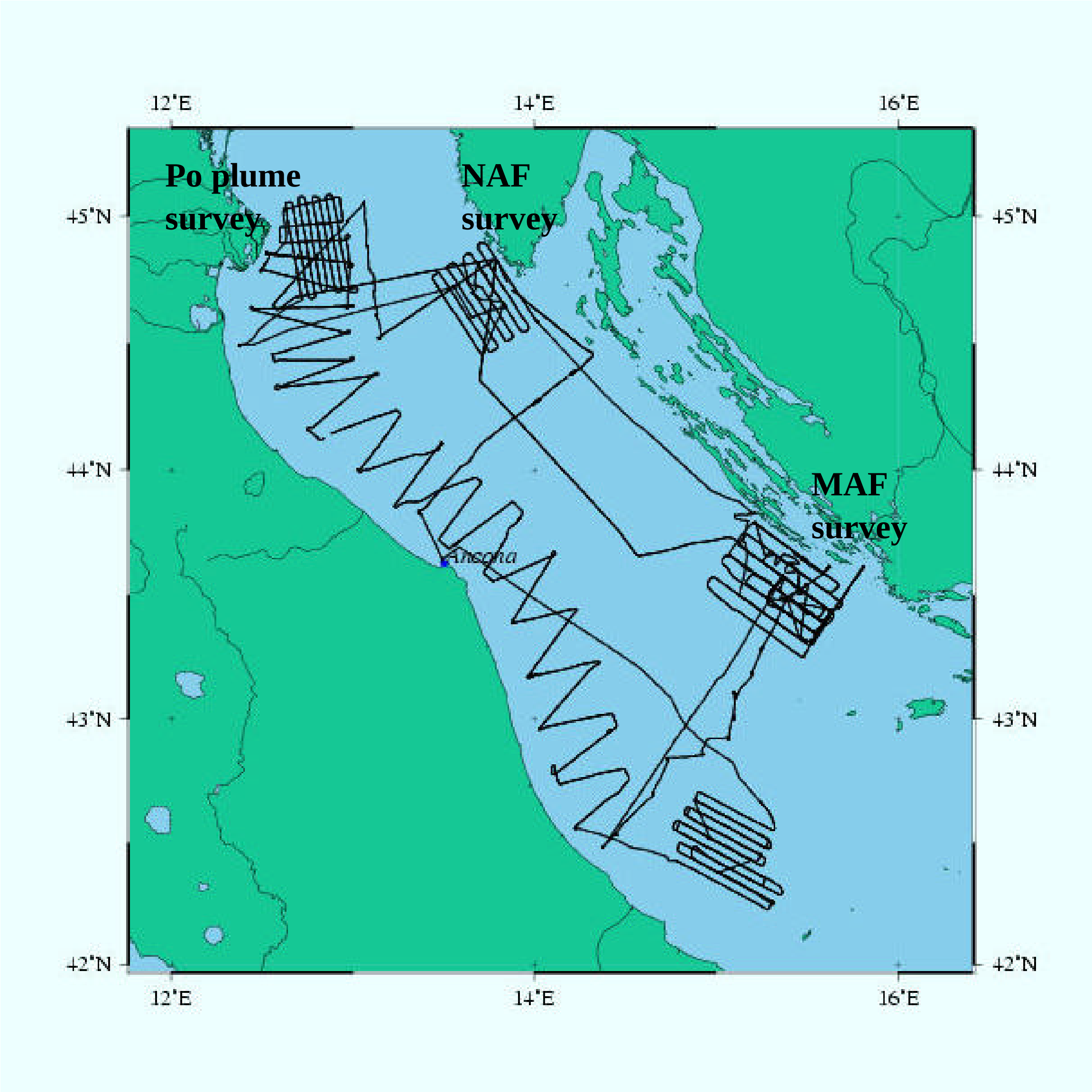

Figure 7. Ship track of R/V Knorr during the DOLCEVITA-2 cruise in the northern and middle Adriatic. The small-scale surveys are shown.

The drifters were either released before the towed vehicle was put in the water or during the first leg of the survey. All drifters were generally deployed upstream of the mesoscale features sampled so that they stayed in the vicinity of the towed vehicle. In this way the vehicle, shipboard ADCP and drifter data were all concentrated on the same features. CODE and CODE-GPS drifters in their cardboard boxes were deployed from the port side of the ship while it was steaming at ~7 knots and towing the vehicle. All the other drifters with drogues or thermistor chains were deployed from the stern at ship speeds varying in 1-2 knots (Figures 8 and 9). These deployments were performed with the Trisoarus vehicle parked in the water at a fixed intermediate depth (not profiling).

Figure 8. Deploying an optical drifter (SVP/OCM) from the stern. The drogue is being paid out before tossing the surface ball.

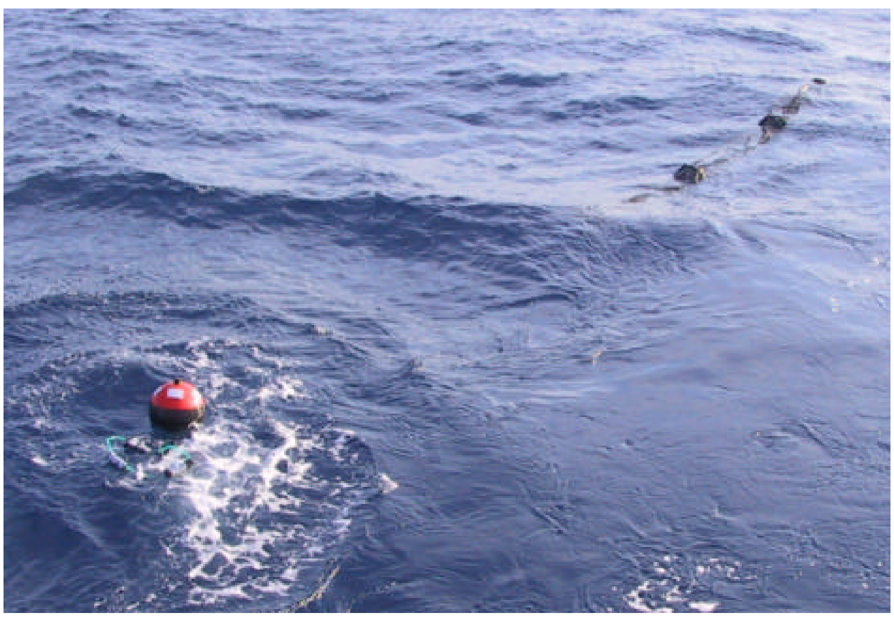

Figure 9. An SVP/OCM drifter just after deployment. The surface ball (bottom left) and drogue (before sinking, top right) are clearly seen.

Some GPS drifters were recovered after the vehicle had performed once or many times the full small-scale survey. The drifter data were downloaded from the Argos telnet data distribution system using cellular phone at least on a daily basis. These provided information on the drifter location with a few hours delay. Once the ship was in the vicinity of the drifters (1-2 nm), the IESM direction finder mounted near the ship's bridge provided us with up-to-date GPS locations. All drifters recovered were taken out of the water using grapnels and hooks on the starboard side of the ship (Figure 10).

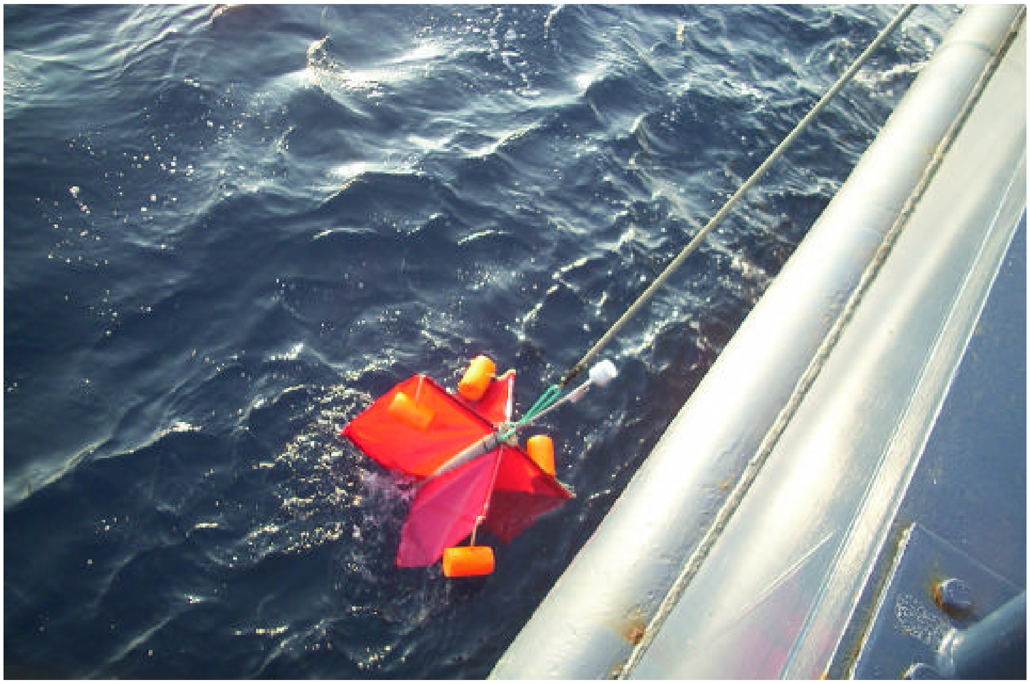

Figure 10. Recovering a CODE/Tz drifter.

2.3 *Details about Drifter Deployment and Recoveries*

Three regular CODE drifters were deployed near the Po River Delta during the initial basin-wide survey on 27-28 May 2003 . The deployment locations were close to the ones where drifters were deployed in May 2003 during the ADRIA03 cruise. The deployment coordinates are listed in Table 2.

DOLCEVITA_2- PO DEPLOYMENTS

Number	Type	Status	Switched On	Deploy date/time	Longitude	Latitude	SST	SSS
37691	CODE	Used	27/05/2003 20:50	27/05/2003 23:29	12 37.45	44 42.32	21.15	32.52
37735	CODE	Used	27/05/2003 20:50	27/05/2003 23:58	12 34.42	44 39.90	19.23	33.8
37748	CODE	New	27/05/2003 20:51	28/05/2003 1:07	12 41.43	44 40.94	19.32	34.21

Table 2. Deployment information for the drifters deployed near the Po River Delta.

A total of 12 drifters where deployed during the small-scale survey on the northeastern flank of the MAP (or Jabuka Pit) on 28-29 May 2003 to survey the MAF. Three of these drifters were successfully recovered on 31 May after having spent about 2.5 days in the water. Three CODE/GPS drifters were released on 2 June 2003 during the first execution of a smaller survey embedded in the larger survey. On 4 June 2003, three drifters were recovered after more than 6 days in the water. The deployment and recovery details for all the drifters deployed near the MAP are listed in Tables 3 and 4.

DOLCEVITA_2- JABUKA PIT DEPLOYMENTS

Number	Type	Status	Switched On	Deploy date/time	Longitude	Latitude	SST	SSS
33353	CODE/TZ	Used	28/05/2003 13:00	29/05/2003 3.05	15 27.225	43 35.468	18.26	38.2
33354	CODE/TZ	Used	28/05/2003 13:00	29/05/2003 5:31	15 19.860	43 39.496	19.08	38.35
33355	SVP/OCM	Used	28/05/2003 13:00	29/05/2003 3:28	15 23.682	43 35.377	18.85	38.39
33356	SVP/OCM	Used	28/05/2003 13:00	29/05/2003 5:11	15 19.844	43 37.441	19.12	38.38
37682	CODE/GPS	New	28/05/2003 22:30	28/05/2003 23:56	15 16.590	43 37.220	19.42	38.37
37683	CODE/GPS	New	28/05/2003 22:30	29/05/2003 0:23	15 19.970	43 35.420	19.13	38.47
37680	CODE/GPS	New	28/05/2003 13:00	29/05/2003 0:52	15 23.650	43 33.510	18.86	38.35
4001	SVP 50m	New	29/05/2003 03:50	29/05/2003 4:13	15 27.072	43 37.624	18.43	38.2
4020	SVP 50m	New	29/05/2003 03:50	29/05/2003 4:39	15 23.602	43 39.523	18.58	38.35
11605	CMOD	New	29/05/2003 01:15	29/05/2003 2:47	15 27.228	43 33.505	18.11	38.21
11629	CMOD	New	29/05/2003 01:20	29/05/2003 3:47	15 23.692	43 37.465	18.74	38.37
11915	CMOD	New	29/05/2003 01:30	29/05/2003 5:50	15 16.640	43 39.448	19.38	38.35
37680	CODE/GPS	New	02/06/2003 12:19	02/06/2003 13:01	15 34.732	43 32.844	20.83	38.25
37684	CODE/GPS	New	02/06/2003 12:24	02/06/2003 13:36	15 29.935	43 30.281	20.66	38.21
37666	CODE/GPS	New	02/06/2003 12:48	02/06/2003 14:12	15 25.010	43 32.844	20.77	37.965

Table 3. Deployment information for the drifters deployed near the Jabuka Pit.

DOLCEVITA_2- JABUKA PIT RECOVERIES

Number	Type	Recovery date/time	Longitude	Latitude	SST	SSS
33353	CODE/TZ	31/05/2003 17:24	15 28.589	43 19.163	19.17	38.28
33355	SVP/OCM	31/05/2003 18:46	15 23.588	43 29.123	19.32	38.37
37680	CODE/GPS	31/05/2003 19:42	15 22.711	43 28.802	20.25	38.27
37682	CODE/GPS	4/06/2003 06:20	15 9.484	43 42.661	21.63	38.35
4020	SVP 50m	4/06/2003 07:04	15 10.370	43 47.816	21.32	38.24
33354	CODE/TZ	4/06/2003 07:38	15 06.073	43 49.122	21.41	38.28
33356	SVP/OCM	4/06/2003 08:25	15 12.757	43 49.638	21.38	38.26

Table 4. Recovery information for the drifters deployed near the Jabuka Pit.

Fourteen drifters were released off the southern tip of the Istrian Peninsula (off Pula) as part of the small-scale survey to sample the NAF. They were released on 4-5 June 2003 and six of them were retrieved on 6 June 2003 after about 1 day in the water. Since the local bathymetry varied near 40 m, the CMOD XAN-3 and the CODE\Tz thermistor chains were reduced to a length of 30 m. Likewise, the tether of the SVP drifters were shorten to center the drogue at about 30-m depth. Deployment and recovery details are listed in Tables 5 and 6.

DOLCEVITA_2- PULA DEPLOYMENTS

Number	Type	Status	Switched On	Deploy date/time	Longitude	Latitude	SST	SSS
11535	CMOD 30m	New	04/06/2003 9:45	04/06/2003 18:59	13 45.79	44 47.50	21.98	37.75
11526	CMOD 30m	New	04/06/2003 9:50	04/06/2003 20:42	13 53.77	44 38.65	21.14	37.77
33353	CODE/TZ	Used	04/06/2003 14:42	05/06/2003 02:26	13 42.54	44 43.16	21.76	37.74
33354	CODE/TZ	Used		05/06/2003 03:08	13 46.51	44 38.92	19.55	37.72
33355	SVP/OCM	Used	04/06/2003 14:44	04/06/2003 19:26	13 47.83	44 45.17	21.78	37.73
33356	SVP/OCM	Used		04/06/2003 20:18	13 51.82	44 40.91	20.55	37.96
4020	SVP 30 m	New		04/06/2003 23:32	13 46.22	44 42.99	21.78	37.75
3999	SVP 30m	Used	04/06/2003 14:46	04/06/2003 23:09	13 48.05	44 41.10	20.87	37.89
4010	SVP 15m	Used	04/06/2003 14:45	04/06/2003 19:53	13 49.71	44 43.08	19.55	37.72
37682	CODE/GPS	New		05/06/2003 05:56	13 42.81	44 38.81	20.49	37.74
37685	CODE/GPS	New	04/06/2003 14:40	05/06/2003 06:13	13 41.12	44 40.70	21.33	37.74
37749	CODE	New	04/06/2003 14:51	04/06/2003 22:44	13 50.38	44 38.66	21.13	37.65
37750	CODE	New	04/06/2003 14:50	04/06/2003 23:57	13 44.22	44 45.26	21.75	37.72
35498	CODE/GPS	Used	04/06/2003 17:40	05/06/2003 02:47	13 44.44	44 41.09	21.84	37.74

Table 5. Deployment information for the drifters deployed south of Pula.

DOLCEVITA_2- PULA RECOVERIES

Number	Type	Recovery date/time	Longitude	Latitude	SST	SSS
33353	CODE/TZ	6/06/2003 03:36	13 39.267	44 41.902	22.21	37.63
33355	SVP/OCM	6/06/2003 03:56	13 40.865	44 40.844	22.67	37.72
33356	SVP/OCM	6/06/2003 04:38	13 49.529	44 39.748	20.49	37.7
33354	CODE/TZ	6/06/2003 05:14	13 43.924	44 37.298	20.15	37.77
37682	CODE/GPS	6/06/2003 05:42	13 39.656	44 36.227	20.26	37.42
37685	CODE/GPS	6/06/2003 06:48	13 33.133	44 43.471	21.54	37.72

Table 6. Recovery information for the drifters deployed south of Pula.

In the next survey concentrated on the Po River plume, we deployed 2 CODE-GPS drifters along the second transect crossing the plume on 6 June 2003. More information about the deployment and recoveries of these drifters are provided in Table 7.

DOLCEVITA_2- PLUME DEPLOYMENTS

Number	Type	Status	Switched On	Deploy date/time	Longitude	Latitude	SST	SSS
37682	CODE/GPS	New		6/06/2003 18:57	12 41.68	44 55.43	22.9	36.9
37685	CODE/GPS	New		6/06/2003 19:54	12 43.42	44 48.47	22.8	34.8

Table 7. Deployment information for the drifters deployed near Po River plume .

3. Preliminary Results and Interpretation

3.1 *Drifter tracks*

Five-day long drifter trajectory segments in the northern and middle Adriatic basins are shown in Figure 11 for four consecutive periods spanning most of the cruise. Plus symbols represent deployment locations, stars and open circles correspond to the first and last locations during the time period considered, respectively. Black solid symbols represent recovery locations. Note that the trajectory segment may be shorter than 5 days if the drifter was deployed or if it was recovered during the period considered. Only the positions provided by the Argos Doppler system and the positions of deployment/recovery are plotted.

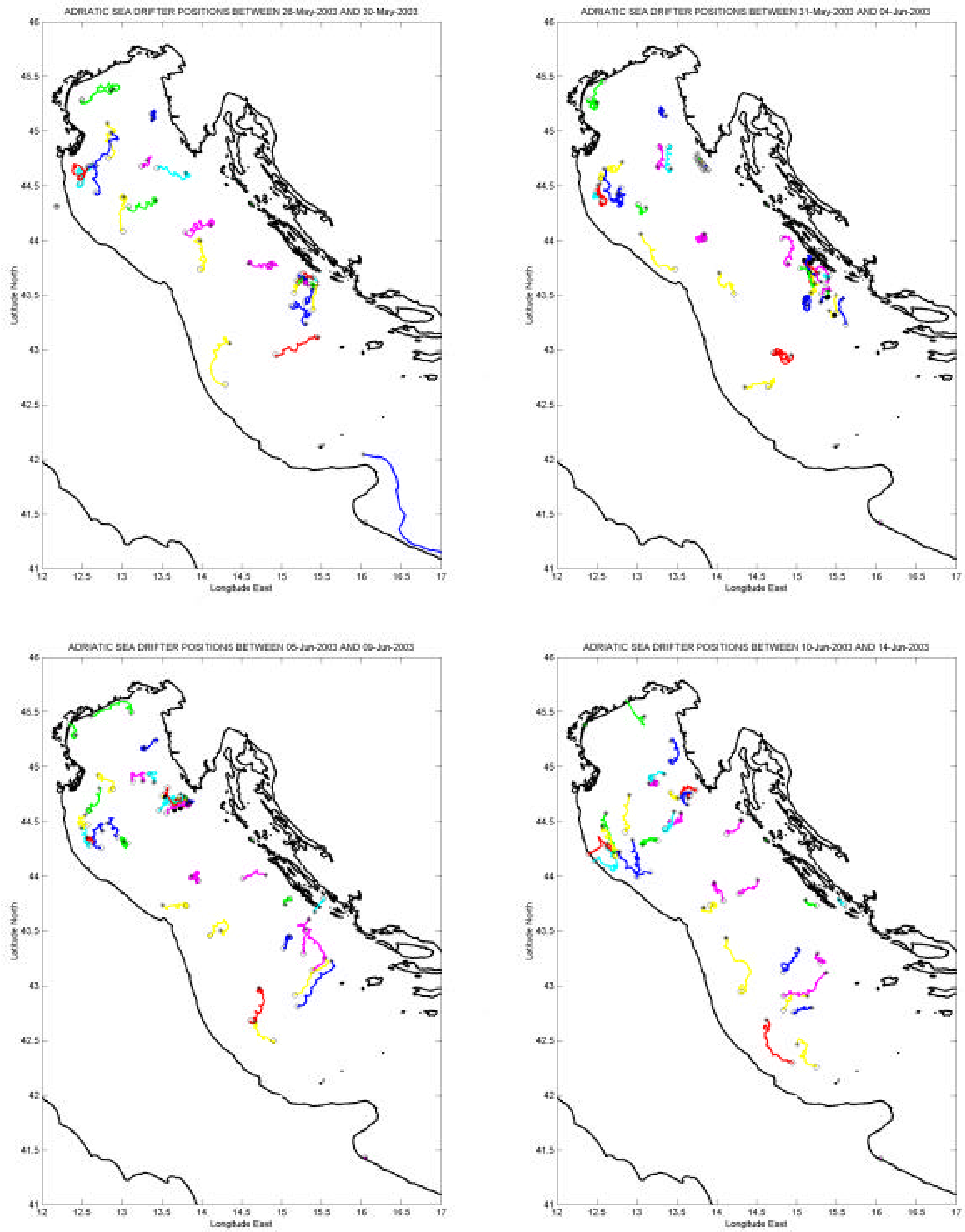

Figure 11. Five-day long trajectory segments of the drifters in the northern and middle Adriatic Sea for consecutive periods ending on 30 May (top left), on 4 June (top right), on 9 June (bottom left) and on 14 June 2003 (bottom right). See text for details.

3.2 *Drifter Thermistor Data*

Two CODE/Tz drifters with thermistor chains down to 50 or 30 m were operated on 29 May - 4 June and on 4-6 June 2003, during the MAF and NAF small-scale surveys. Examples of the processed and edited data are illustrated in Figures 12 and 13 for drifter 33354. The mean motion of the drifter was to the southwest and then to the northwest. Significant high-frequency (mostly intertial) motions are superimposed on these mean patterns. They are well resolved in the GPS positions sampled at half-hour intervals (see Figure 12)

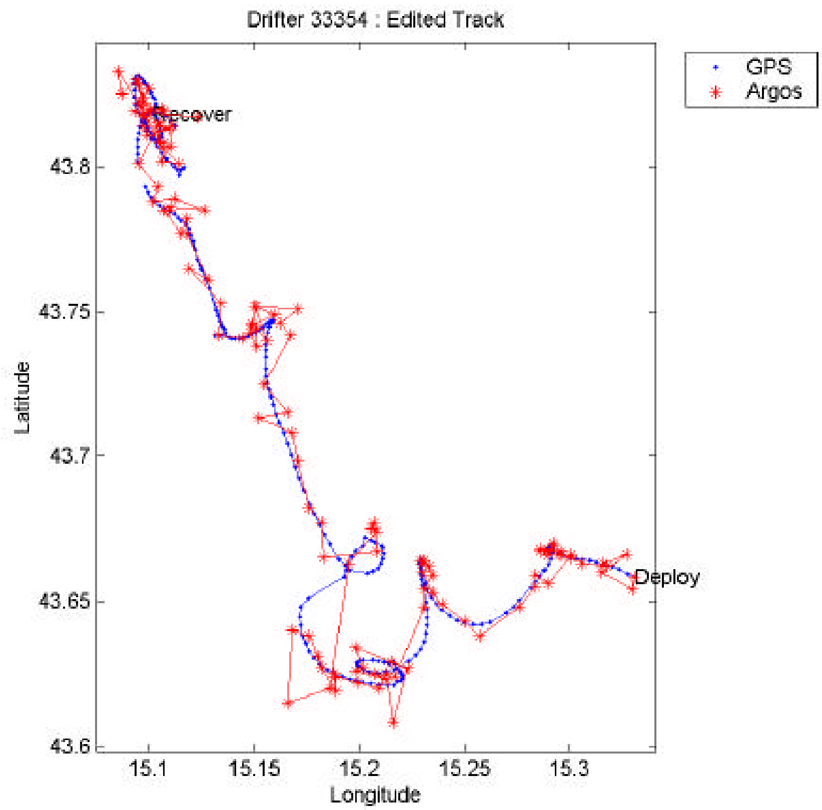

Figure 12. GPS (blue dot) and Argos (red star) locations of the CODE/Tz drifter 33354 launched during the MAF small-scale survey between 29 May and 4 June 2003. The GPS positions were sampled at half-hour intervals.

The thermal stratification of the water column above 50 m depth was well sampled by the 11 thermistors (10 units on the chain and one in the drifter body at about 30 cm below the surface;

see Figure 13). An increase of temperature from ~19 C to ~22 C is evident above 10 m during the period of observations. This trend is modulated by a diurnal signal.

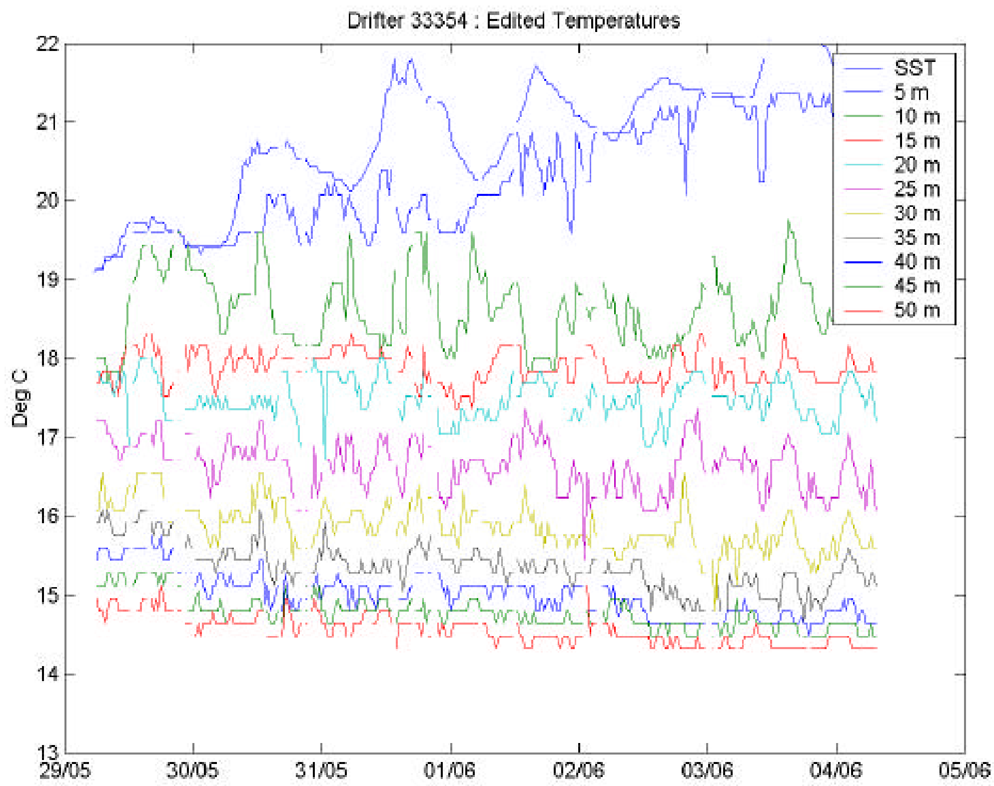

Figure 13. Temperatures versus time for drifter 33354 between 29 May and 4 June 2003 spanning the top water column between the surface (SST) and 50 m depth.

3.4 *Drifter Optical Data*

Two optical drifters (SVP/OCM) were operated on 29 May – 4 June and on 4-6 June 2003 during the MAF and NAF small-scale surveys. Examples of the processed and edited data are illustrated for drifter 33356 in Figures 14 to 17. This drifter moved to northwest with evident inertial oscillations (Figure 14). The time series of downwelling irradiance (at 490 nm) and upwelling radiances (at 7 visible wavelengths) for the period 29 May – 4 June 2003 are depicted in Figures 15 and 16. The diurnal variability is obviously striking. Spectra of the upwelling radiances are typical of oligotrophic waters (Figure 17). When scaled by the downwelling irradiance, the spread of the lines due to the different hours of the day is much reduced as expected. The irradiances were calculated from the measured value at 490 nm (see an example of their daily variation in Figure 15) and the ratio computed from optical data measured by a MicroSAS instrument installed on the ship's bow (courtesy of B. Jones).

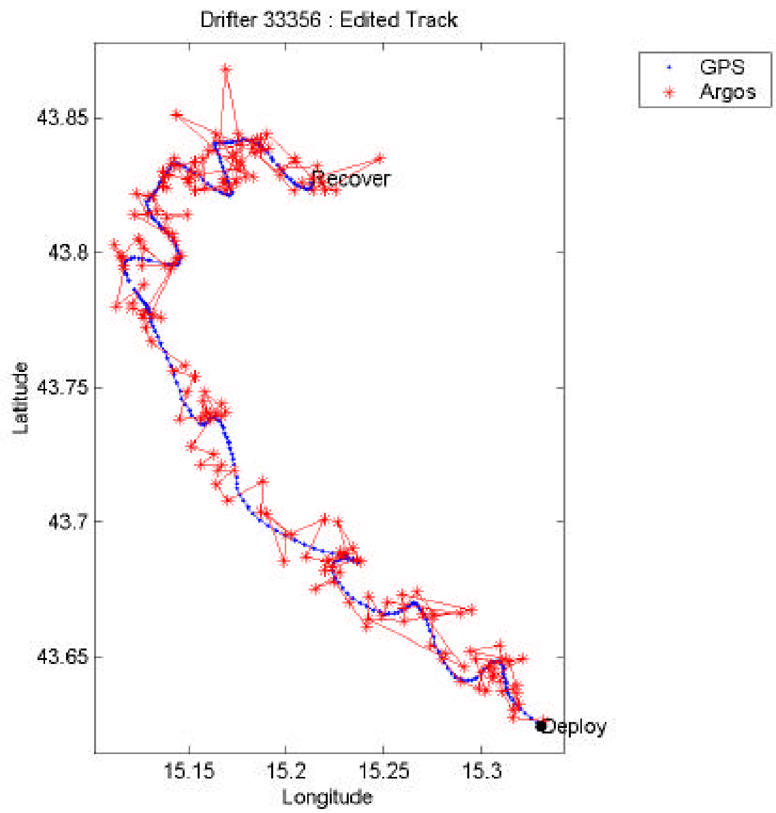

Figure 14. GPS (blue dot) and Argos (red star) locations of SVP/OCM drifter 33356 launched during the MAF survey between 29 May and 4 June 2003. GPS positions were sampled every half-hour.

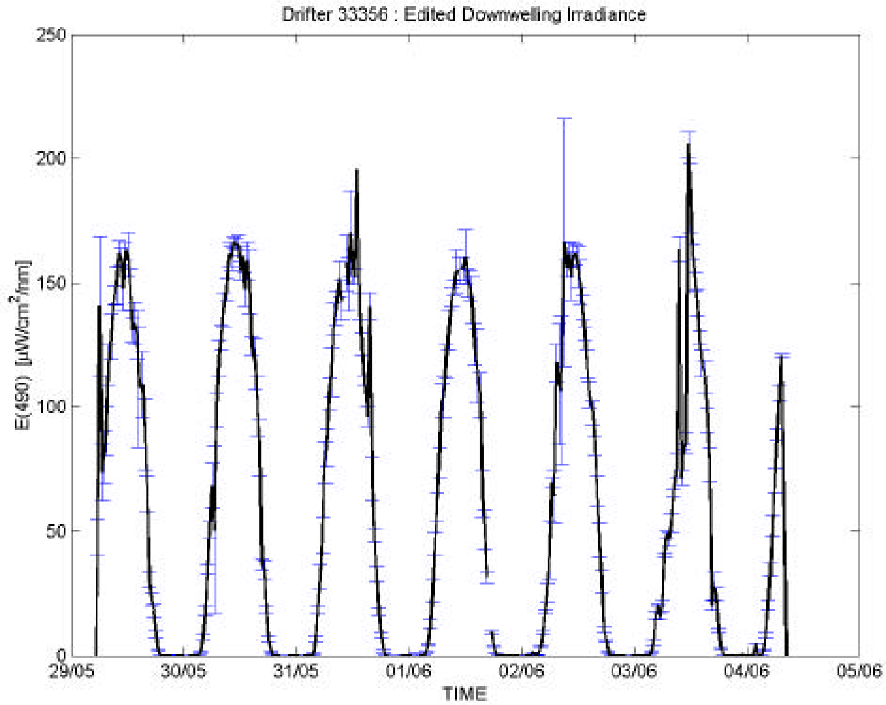

Figure 15. Downwelling irradiance at 490 nm (mW/cm^2 /nm) data for drifter 33356 between 28 May and 2 June 2003.

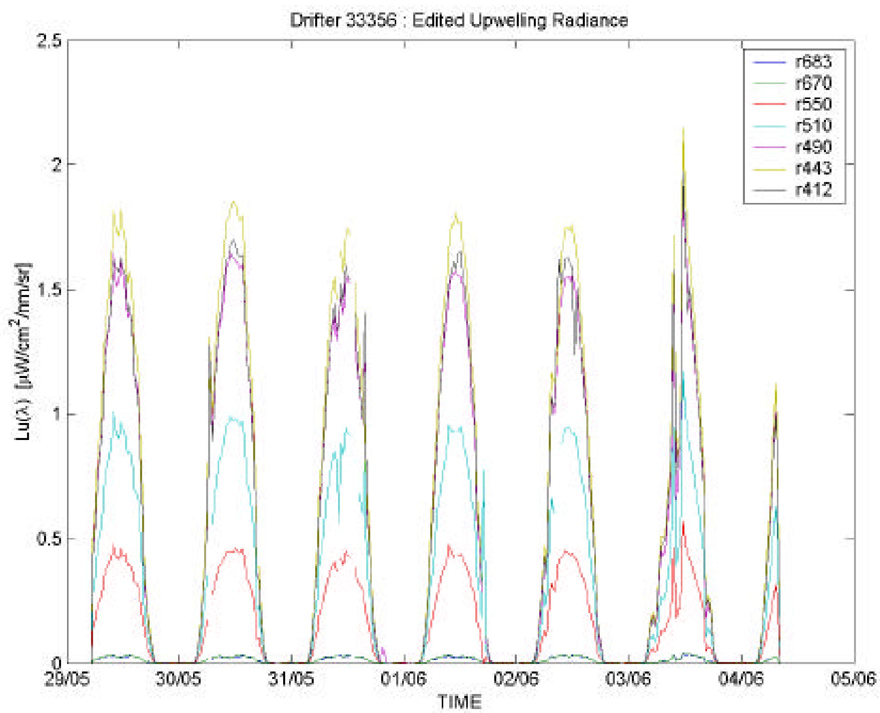

Figure 16. Upwelling radiance at 7 visible wavelengths (mW/cm^2 /nm) data for drifter 33356 between 28 May and 2 June 2003.

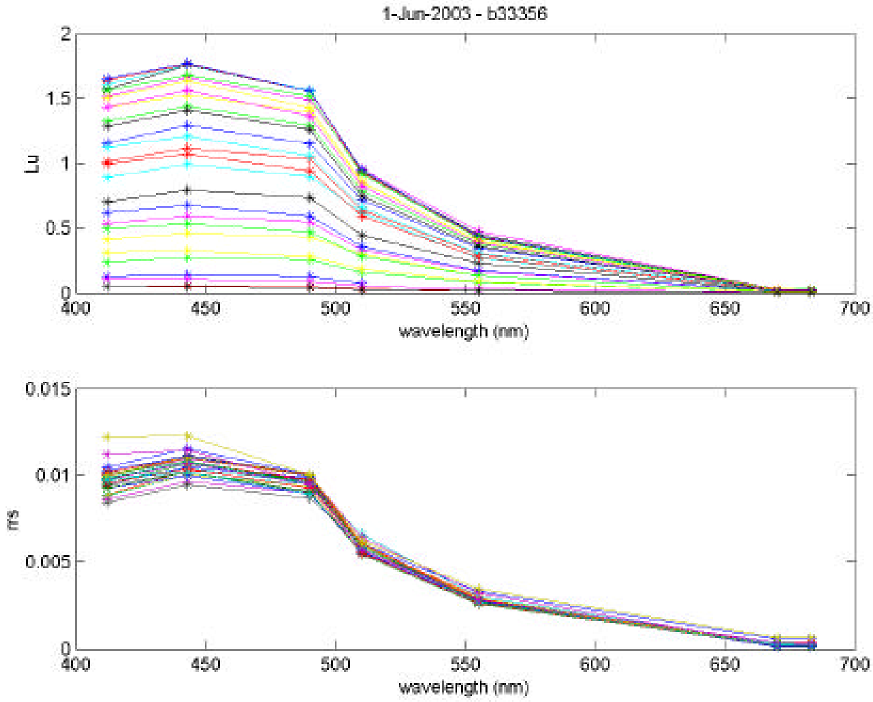

Figure 17. Upwelling radiance (mW/cm^2 /nm/sr) data for drifter PTT ID 33356 on 1 June 2003 between 4:00 and 18:00 GMT for 7 channels in the visible band (top). Corresponding spectra of remote sensing reflectance (bottom).

3. Conclusions

In general, drifter operations during the DOLCEVITA-2 cruise were successful. Drifter deployment and recovery operations were very efficient, mostly because of the good sea conditions. A total of 34 deployment and 13 recovery operations were conducted. Eighteen drifters were left in the water.

The refurbished SVP/OCM and CODE/Tz drifters manufactured by Metocean worked satisfactorily according to the requested specifications, providing continuous times series of temperatures and optical properties at half-hour intervals.

Cruise Report: *"DOLCEVITA-1"*

University of Miami Group - Hartmut Peters

R/V Knorr 172-03, 29-January to 24-February-2003, Adriatic Sea

Participants

The University of Miami (UM) group consisted of Dr. Hartmut Peters and Technical Specialist Robert Jones.

Objective

The objective of the activities of the UM group are to observe vertical *convection* in the upper ocean and *turbulent mixing* in the Adriatic Sea in relationship to mesoscale current processes and strong forcing.

Methods and Observations

The UM group employed (a) the "*Bottom Lander*" and (b) the "*Shallow Water Microstructure Profiler"* (SWAMP).

(a) The ***Bottom Lander*** is a device deployed on the ocean floor for limited periods of time. The active instruments on the Lander are (i) a 600-kHz broadband acoustic Doppler Profiler (ADCP) with five heads and (ii) a SeaBird Microcat Conductivity-Temperature-Depth probe (CTD). The ADCP measures both horizontal and *vertical* velocity profiles in the water column with a vertical resolution of 1m and a ping repeat rate of 1.25-1.5s. Under favorable conditions the turbulent Reynolds stress profile can also be determined. The CTD determines temperature and salinity 1m above the bottom. Deployments of the Lander are summarized in the following table.

```
Table 1:  Bottom Lander deployments:
====================================
#1:  Deployed      1423 UTC 11-Feb-03, 44d 33.070'N, 13d 58.810'E
                   water depth 46.5 m.  Duration of record: 67 hours.
                   Ping rate: once per 1.25 s.
     Recovered ca. 1615 UTC 14-Feb-03 (release command: 1600 UTC)

#2:  Deployed      1922 UTC 15-Feb-03, 44d 11.728'N, 13d 07.935'E
                   water depth 53 m. Duration of record: 69 hours.
                   Ping rate: once per 1.5 s.
     Recovered ca. 1730 UTC 18-Feb-03 (final release command 1658 UTC)
```

(b) The *Shallow Water Microstructure Profiler* is a loosely tethered profiler measuring microscale velocity, temperature and conductivity fluctuations as well as pressure, temperature and salinity. The device allows quantifying the turbulent mixing in relationship to the ambient stratification (from SWAMP's CTD component) and velocity shear (from the shipboard ADCP). SWAMP observations are summarized in Table 2.

```
Table 2:  SWAMP Drops
=====================
Conventions: Noon on January 1 is Yearday 1.5. Time is in UTC.
Latitude and Longitude in the SWAMP list are in decimal deg.
```

Yearday	Drop	longitude	latitude	Station	Date
43.65347	8011	13.97486	44.54995	n/a	11-Feb-03
43.65993	8012	13.96908	44.54718		
43.67516	8013	13.95596	44.54069		
43.67793	8014	13.95364	44.53954		
43.67991	8015	13.95193	44.53867		
43.68281	8017	13.94956	44.53733		
43.68507	8018	13.94772	44.53640		
44.50170	8021	14.06131	44.59796	before 28	13-Feb-03
44.50427	8022	14.05949	44.59695		
44.50642	8023	14.05806	44.59602		
44.50825	8024	14.05684	44.59520		
44.51091	8025	14.05499	44.59393		
44.51360	8026	14.05308	44.59276		
44.51571	8027	14.05170	44.59198		
44.51840	8028	14.04991	44.59084		
44.52158	8029	14.04782	44.58951		
44.52431	8030	14.04603	44.58841		
44.70216	8033	14.01196	44.68163	btw. 30 & 31	13-Feb-03
44.70697	8035	14.00628	44.68019		
44.70850	8036	14.00436	44.67979		
44.71105	8037	14.00129	44.67907		
44.71323	8038	13.99871	44.67839		
44.71523	8039	13.99628	44.67783		
44.79445	8041	14.01335	44.70957	btw. 31 & 32	13-Feb-03
44.79623	8042	14.01021	44.70861		
44.79845	8043	14.00756	44.70789		
44.80391	8045	14.00136	44.70605		
44.80684	8046	13.99810	44.70493		
44.80991	8047	13.99463	44.70393		
49.27957	8053	13.00151	44.15941	34	18-Feb-03
49.28205	8054	13.00025	44.15826		
49.28466	8055	12.99893	44.15711		
49.28678	8056	12.99776	44.15625		
49.28896	8057	12.99650	44.15540		
49.29121	8058	12.99525	44.15446		
49.29426	8059	12.99354	44.15310		
49.29586	8060	12.99263	44.15235		
52.39162	8062	12.90468	44.91128	38	21-Feb-03
52.39332	8063	12.90416	44.91157		
52.39486	8064	12.90363	44.91183		
52.39633	8065	12.90315	44.91208		
52.39770	8066	12.90267	44.91227		
52.39909	8067	12.90215	44.91251		
52.40051	8068	12.90164	44.91271		
52.40190	8069	12.90114	44.91291		

First Results

Some of the observations are illustrated in the following. Explanations are given in the figure captions.

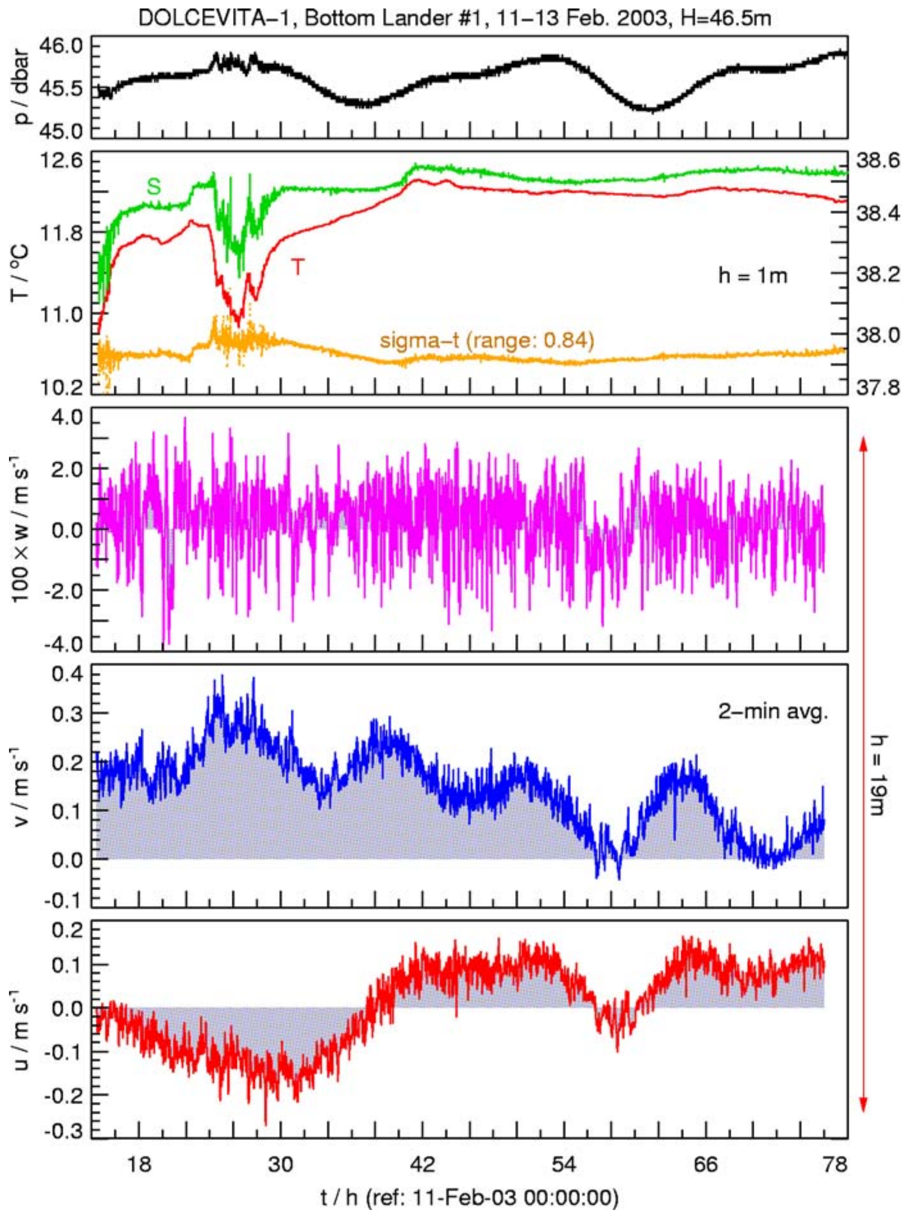

Figure 1: Summary plot, Bottom Lander deployment #1. Panels from the bottom: East component of the horizontal velocity (u) 19m above the sea floor; ditto, north component (v); vertical velocity (w); temperature (T), salinity (S) and density (σ_T) 1m above the bottom; bottom pressure (p). The effect of the mixed diurnal / semidiurnal tide is obvious. The mooring was initially deployed close to a front which subsequently moved north away from the Lander, which thus saw relatively high T and S. Vertical velocities attained typically about 1 cm/s. Extended periods of the order of an hour of upward and downward motions are visible.

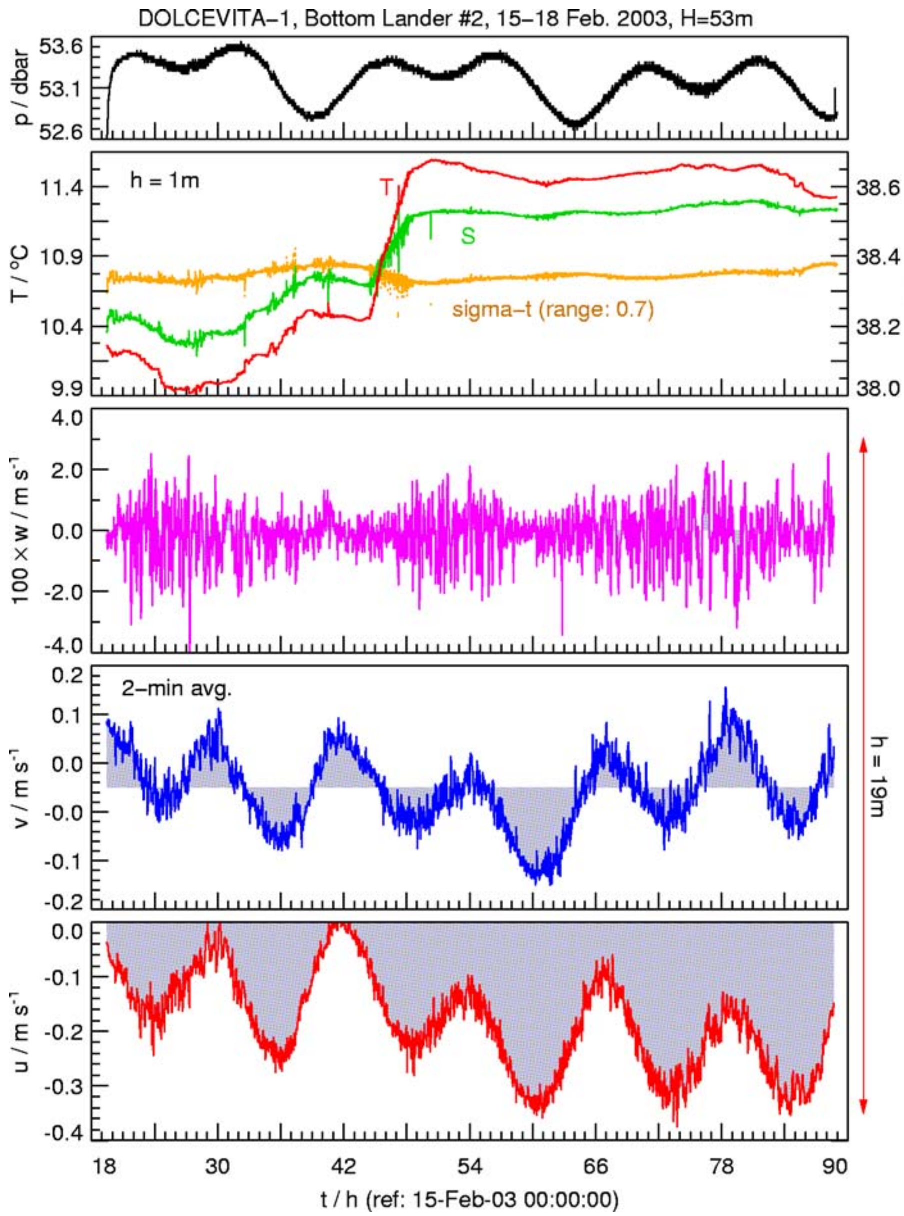

Figure 2: Summary plot Bottom Lander deployment #2. The layout and symbols are the same as in Figure 1. Note the more dominantly semidiurnal tide and the modulation of the vertical velocity.

At this point, the data from SWAMP need screening for contaminated segments in the microstructure records. Nevertheless an example of the observations is presented in Figure 3. The dissipation rate in the upper 15 m need a closer examination. The drop was taken under bora conditions in winds of about 35 knots.

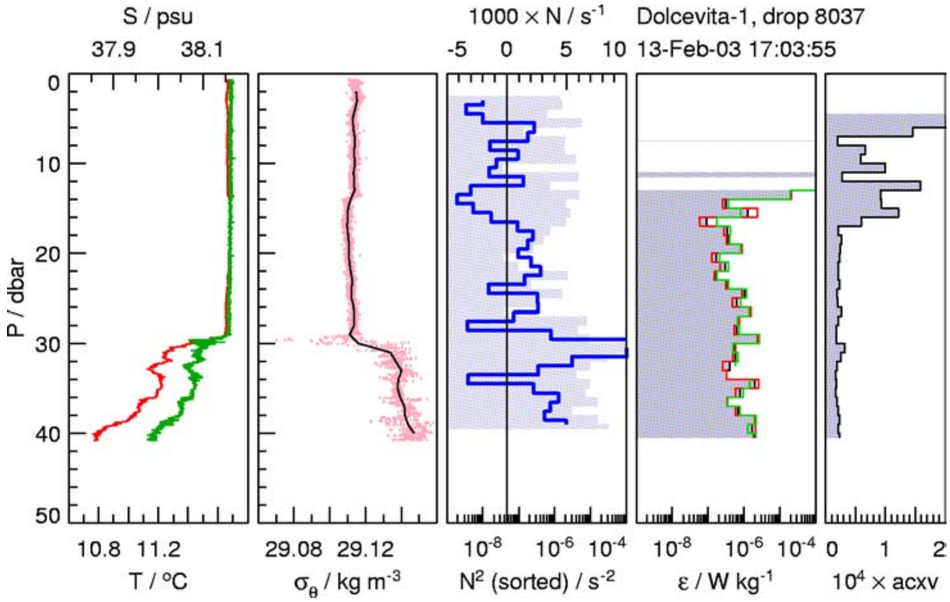

Figure 3: Example microstructure profile (drop 8037). Panels from left: Temperature (T; red) and salinity (S; green), potential density (σ_θ; raw values and 1-m average); buoyancy frequency (N; blue – ignore the shaded curve); turbulent dissipation rate (ε); variance of the acceleration, an indicator of possible signal contamination. The drop was taken near a 100-200m wide front with mostly density-compensating T-S contrast and density maximum *in* the front. The anomalously dens water apparently spread at the bottom away from the front creating a stratified water column in an environment of otherwise vertical homogeneity. The high ε in the stratified layer implies considerable mixing and significant vertical turbulent salt and heat fluxes.

Other Activities

H. Peters took responsibility for the s*hipboard ADCP*, setting up the system configuration and the realtime data display that proved to be a useful tool for guidance for of operations.

Acknowledgments

The effort of the UM group is funded by the United States Office of Naval Research. We thank Program Officer Dr. Steven Murray for his guidance from an original project in the Strait of Hormuz, that had to be abandoned for reasons of world politics, to the Adriatic Sea. We are grateful for the highly competent and efficient work of the Master and crew of the R/V Knorr, especially Captain George Silva, First Mate Kelly Sweeney and boatswain Peter Liarikos. Our observations could not have been carried out without the help of our scientific colleagues on the Knorr; a big thank you to them! We thoroughly enjoyed their company both in social and scientific ways. It was a great group and a good cruise.

NRL Cruise Report:
La Dolce Vita, Feb 2003
Adriatic Sea

Donald Johnson and Wesley Goode

Objective: There were three goals for Naval Research Laboratory (NRL) participation in this cruise.

1. Provide real-time satellite imagery reception from SeaWIFS and AVHRR for the purpose of finding and mapping wind generated ocean circulation patterns in the central and northern Adriatic Sea, especially focusing on those patterns generated by Bora Winds.

2. Determine the relationship between sea surface inherent optical properties and environmental forcing in the wind generated circulation phenomena of the Adriatic Sea.

3. Determine the relationship between in-water constituents and color signatures of spectral optical satellites for the Adriatic Sea.

Methods:

1. Real-time satellite reception. A TeraScan Satellite receiving system was mounted on the R/V Knorr with an S-band antenna on top of the hanger on the after-deck. A Sun Ultra-10 workstation was used for reception and initial processing. The data was transferred to a Silicon Graphics-02 workstation which used Automated Processing System (APS) software for warping, navigation and algorithm application. Overlay of ship tracks, stations and bathymetry were part of our capabilities along with compositing (latest imagery and warmest pixel), creating movie loops and contrast enhancement. The analysis products were placed on the ship's internet system for use by the science team members.

2. Surface inherent optical properties (absorption and scattering). Two ac9's (Wetlabs, inc.) were mounted in seawater cooling tubes (PVC pipes) in the wet lab of the R/V Knorr and water sampled continuously from the ship's flow-through system. The intake of the flow-through system was at 5 m depth (nominally 4.9 m), mounted at the bottom of the bow bulb. Over the first four days of the cruise (year day 31-35), both ac9's were sampled. We sampled ac9_104 with no water filter and ac9_133 with a 1 micron pre-filter and a 0.2 micron filter in line. On yd 35 we loaned ac9_104 to Burt Jones for the optical profiling system and began switch-filtering ac9_133. Nominally the filter was placed in-line for 5 minutes every hour, although the actual timing varied considerably. Tubes were cleaned 11 times and calibrations with the ship's millipore water done 5 times.

3. Surface reflectances. 34 surface reflectance measurements were made using a Spectrix spectrometer (custom built). The measurement was made with respect to the optimal

sun position relative the bow of the ship. Some of the spectra were taken to coincide with Burt Jones' rail mounted spectrometer system to provide linkage with the continuous system.

Results

Figures 1 and 2 show examples of chlorophyll-a and sea surface temperature from SeaWifs and NOAA-12 AVHRR images, respectively. Ship sample-grid tracks and profiling stations are superimpose here as they were planned from such images. These images were received in real-time onboard ship on 21 February, after moderate Bora winds had been blowing for some time. They show the remarkable counterclockwise circulation pattern established in the shallow waters of the northern Adriatic. A plume of fresh, cold, high chlorophyll water from the Po River outflow has been pulled off from the coast and is extending northeastward as part of the Bora induced cyclonic circulation. Inherent optical properties of absorption and scattering make the plume easy to track from in-situ measurements and provide the bases for understanding linkages between in-water constituents and satellite measured reflectances. 275 such images were received and deemed suitable for archiving. It is clear from the way the grid and profiling stations fit the plume extension, that real-time onboard satellite reception was of high value in cruise planning for wind-forced events.

In Figure 3 we show cross-plume data from the shipboard flowthrough system in comparison to SeaWifs retrieved chlorophyll-a using the OC4 algorithm. Data along the westernmost track shown in Figs. 1 and 2 are plotted versus latitude. Both in-situ measured optical absorption at 412 nanometers (a412) and chlorophyll-a retrieved along the same track are remarkably similar showing that satellite data has value in retrieving accurate mesoscale features. It should be noted, however, that a412 is dependent on absorption by phytoplankton as well as by dissolved organics and non-organic particles. In the same manner, the SeaWifs algorithm needs adjustment to exclude dissolved and non-organic optical materials from its chlorophyll algorithm. A part of our effort from this cruise will be directed toward improving the satellite algorithms.

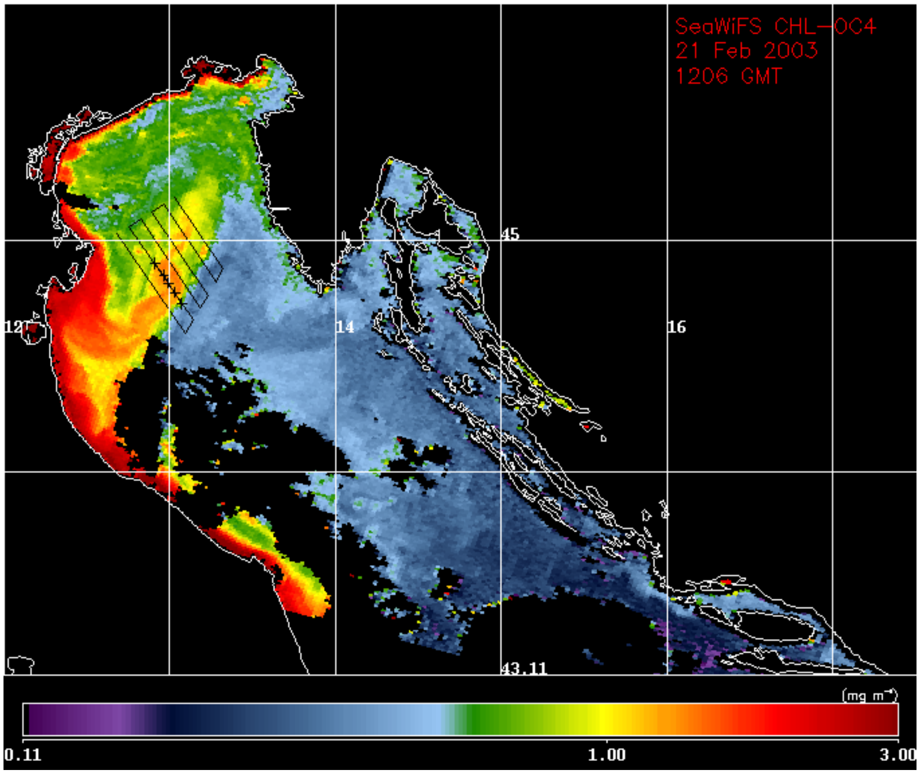

Figure 1. SeaWiFS chlorophyll-a image from 21 Feb 2003

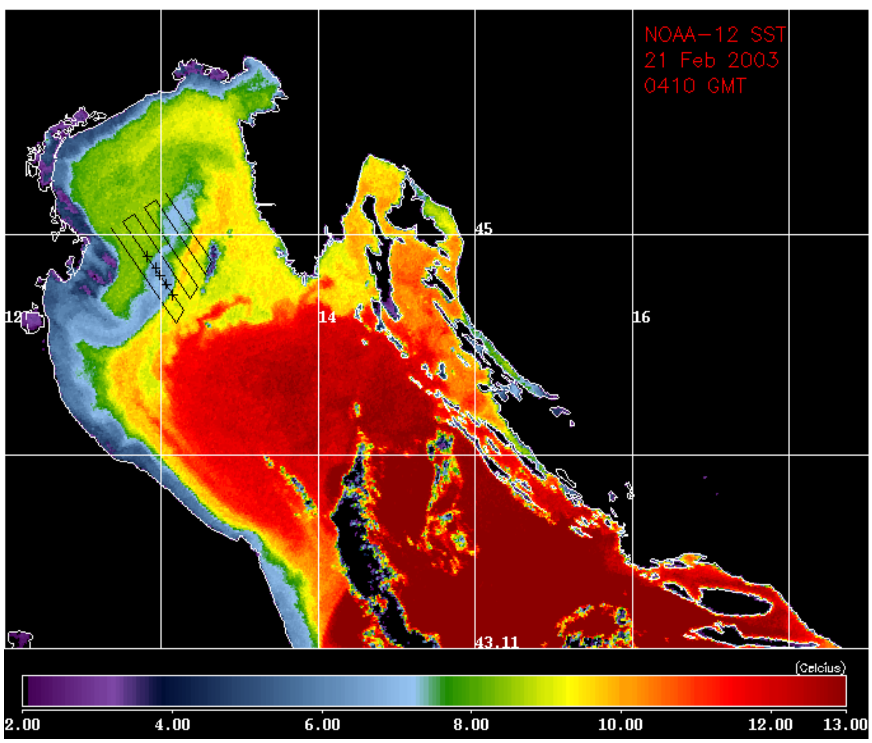

Figure 2. AVHRR SST image from 21 Feb 2003.

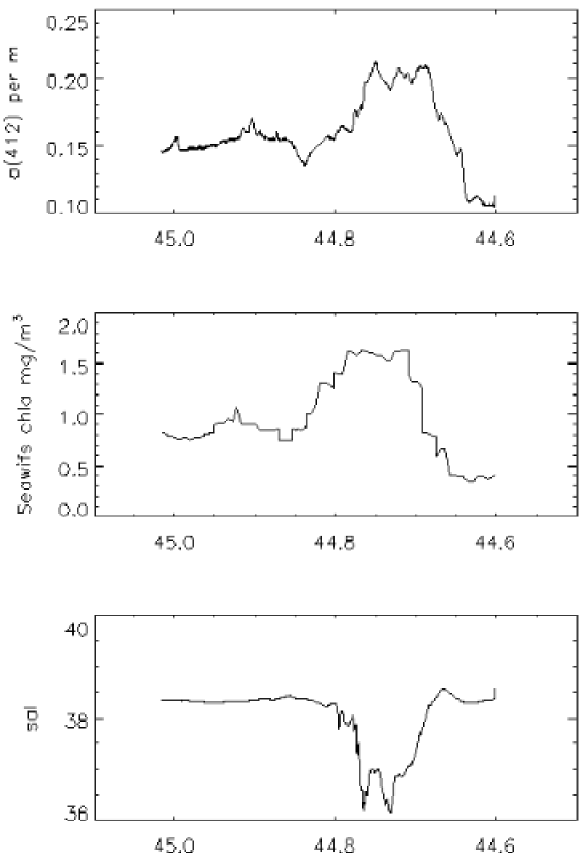

Figure 3. (a) Optical absorption at 412 nanometers from the flowthrough ac9 vs latitude. This is from the western cross-plume track in Fig.1. (b) Chlorophyll-a extracted from SeaWifs image across the same track as above. The OC4 algorithm was used. (c) Cross-plume salinity from R/V Knorr flowthru system.

DOLCEVITA I

DYNAMICS OF LOCALIXED CURRENTS AND EDDY VARIABILITY IN THE ADRIATIC

31 Jenuary-24 February 2003
R/V Knorr

ISMAR-CNR
ANCONA

Alessandra Campanelli
Paola Fornasiero
Federica Grilli
Mirco Di Marco
David Bigazzi
Luca Bolognini

Report:

Parameter: distribution of pigments, nutrients and dissolved oxygen in the Adriatic Sea.

Scientific goal in this cruise

The physical structures of the Northern Adriatic are mainly influenced from winds. During winter, Bora causes strong vertical mixing and leads to the formation of dense water masses and downwelling processes. The input of fresh water, mainly due to the Po river, is also an important stratification element.

Our purpose in this project is to define biochemical characteristics of the different water masses due to these processes in the Adriatic system.

In these cruise different water masses were found. We are going to study the following survey's areas:

1) Big survey of Northern and Middle Adriatic (since 01 Feb. 03 to 06 Feb 03)
2) Pomo survey (since 06 Feb 03 to 09 Feb. 03)
3) Pula survey (since 12 Feb.03 to 13 Feb. 03)
4) The River Po front survey (since 15 Feb. 03 to 18 Feb. 03)
5) The River Po plume survey (since 20 Feb.03 to 21 Feb. 03)

Methods

The sampling strategy was decided according to satellite images and Trisoarus surveys. Water samples were taken at the surface using the bucket at half an hour frequency, along sections of interest and throughout water columns using rosette sampler.

We collected 276 chlorophill samples, 263 nutrients samples and 80 dissolved oxygen samples (Tab.1).

Sea water samples for dissolved oxygen and nutrients were analyzed on board.

Nutrients analysis, DIN (Dissolved Inorganic Nitrogen), PO_4^- and $Si(OH)_4$, was performed by colorimetric method (Strickland and Parsons, 1968) modified by Bran Luebbe, using autoanalyzer (TRAACS 800, Technicon). Water samples were filtered (GF/F Whatman , 25mm) and stored on -70 °C in polyetilen vials.

We used Winkler titration (1888) for dissolved oxygen analysis. Sea water samples were immediately fixed and stored in the dark. Then, they were analyzed by potentiometric method with platinum electrode, within 24 hours.

For pigment analysis we filtered 4 L of sea water through GF/F Whatman, 47mm. Filters were stored on -70 °C. Pigment analysis will be made in laboratory (ISMAR-CNR Ancona) using HPLC method (Wright *et al*., 1991).

Tab.1: Number of samples and dates

Profile	N. of bucket samples		N. of rosette samples			Date of sampling February 2003
	Nutrients	*HPLC*	*Nutrients*	*HPLC*	O_2	
Senigallia-Susak	10	10	0	0	0	01
Pula-Rimini	14	14	0	0	0	02
Rimini-Po	7	8	0	0	0	02
Po-Novigrad	12	12	0	0	0	02-03
Longitudinal transect	16	16	9	9	8	03-05
Pomo Survey	14	33	37	35	37	05-09
Pula Survey	26	26	19	19	19	12-13
Po River Survey	23	23	15	15	15	15-18
Po River Plume	39	34	22	22	22	18-21
Total	161	176	102	100	101	

Preliminary results

Fig.1 shows the surface distribution of nutrients sampled with bucket. Preliminary results are pointing to decreasing gradient of DIN and orthosilicates from Northern to Southern Adriatic and also from West to East in the North Adriatic.

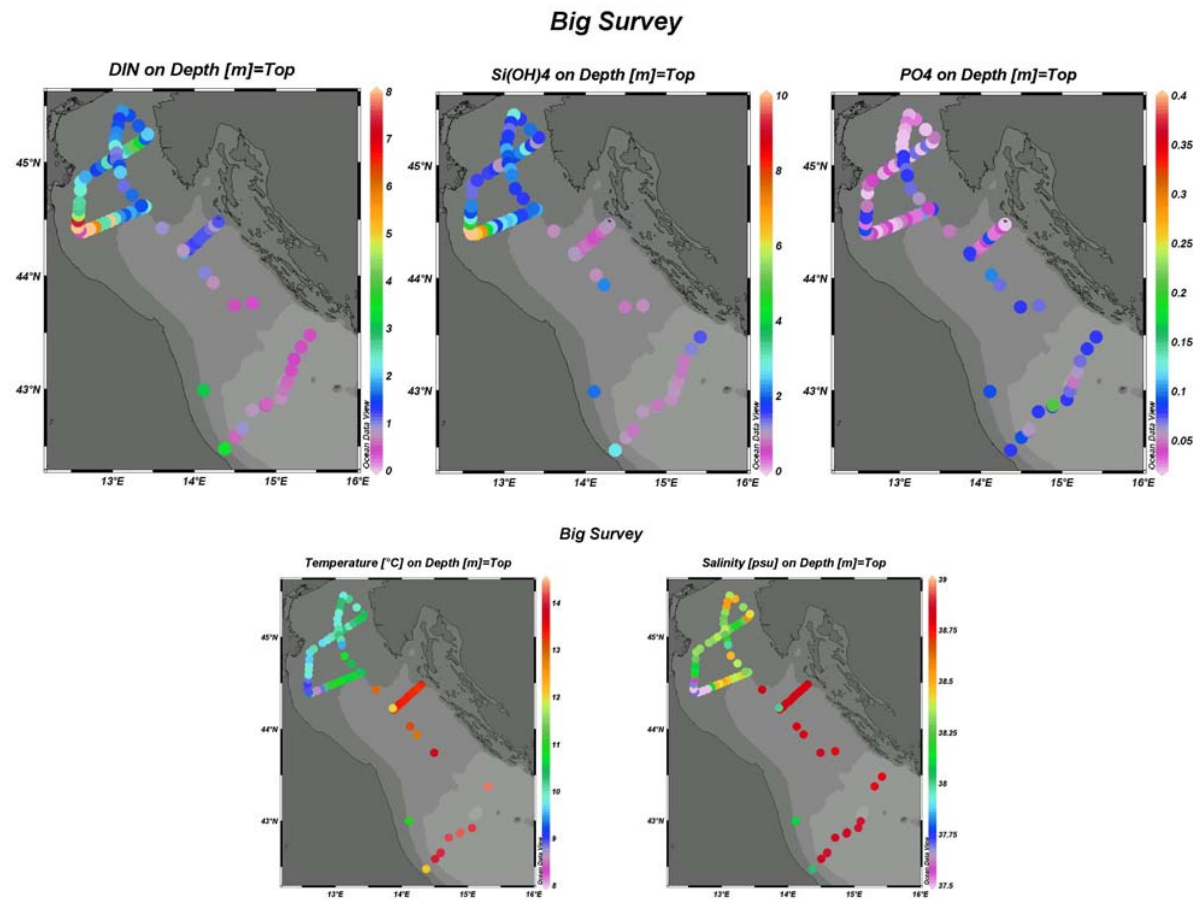

Fig. 1: Surface maps of nutrients (DIN, PO_4^-, $Si(OH)_4$) in μM, temperature and salinity sampled with bucket during the Big Survey.

Fig.2 shows a vertical distribution of nutrients and oxygen percentage saturation sampled with rosette. Our results shows two different water masses. The upper layer is saturated with oxygen (100-110%) and is poor of nutrients. The bottom layer has higher concentration of nutrients and is undersaturated with oxygen.

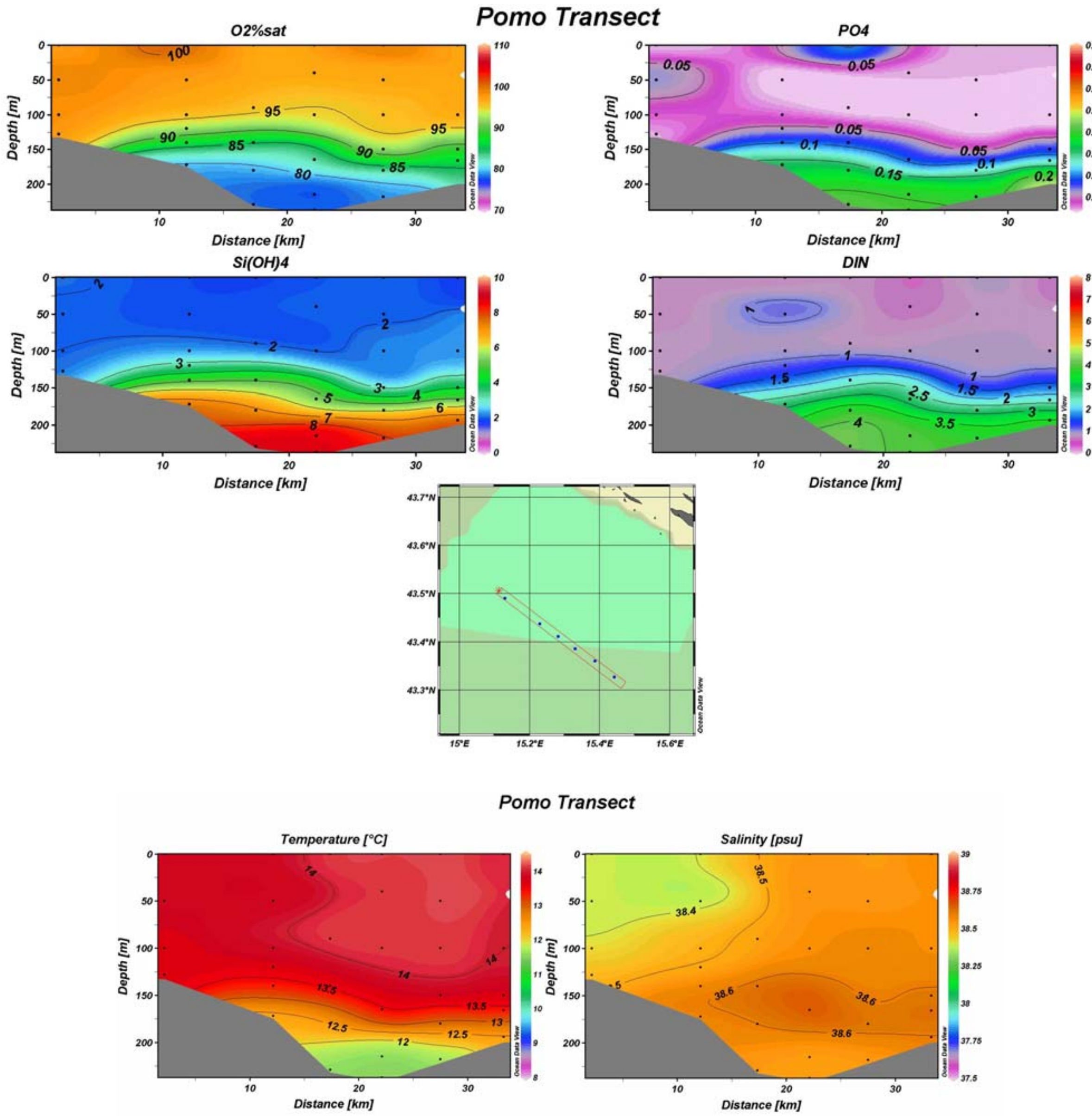

Fig. 2: Section maps of nutrients (DIN, PO4, Si(OH)4) in μM and temperature and salinity sampled with rosette during the Pomo Survey.

Fig.3 shows bucket sampled distribution gradients of nutrients. This distribution conforms to the separation of water masses by the front SE of Pula.. DIN and orthosilicates concentrations were increased to the north of the Pula front while orthophosphates have a different distribution.

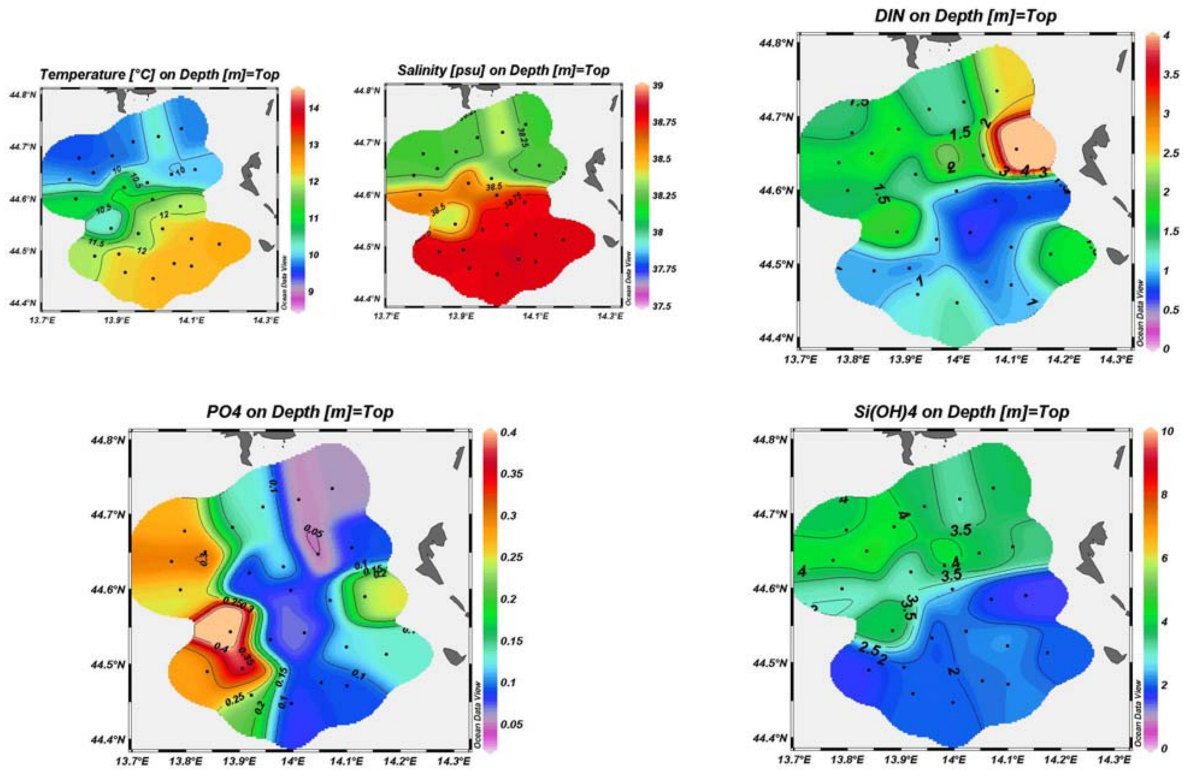

Fig.3: Surface maps of nutrients (DIN, PO4, Si(OH)4) in µM and temperature and salinity sampled with bucket during the Pula Survey.

Fig.4: shows rosette sampled distribution gradients of nutrients and oxygen percentage saturation. Distribution of DIN, orthosilicates and oxygen conform to the vertical separation of water masses by the front SE of Pula, while orthophosphates have a different range of distribution

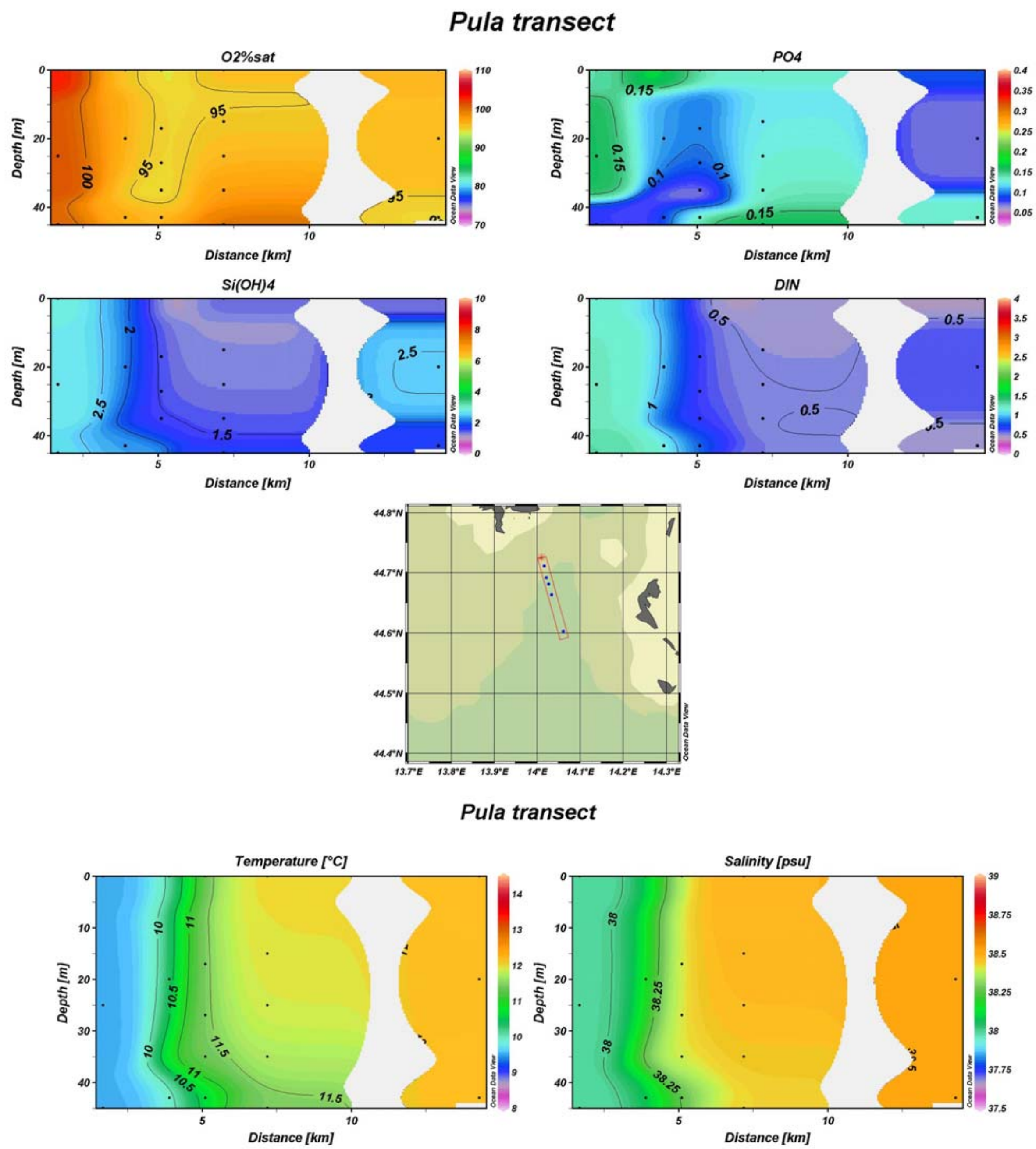

Fig.4: Section maps of nutrients (DIN, PO4, Si(OH)4) in µM and temperature and salinity sampled with rosette during the Pula Survey.

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Strickland J.D.H. & Parsons T.R., 1968. A practical handbook of seawater analysis. *Bull. Fish. Res*. Bd. Canada, 167-310.

Winkler L.W., 1888. Die Bestimmung des im Wasser gelosten Sauerstoffes. *Chem. Ber*., 21: 2843-2855.

Wrighit S.W., Jeffrey S. W., Mantoura R.F.C., Llewellyn C.A., Bjornland T., Repeta D., Welschmeyer N.,1991. Improved HPLC method for the analysis of chlorophylls and carotenoids from marine phytoplankton.. Mar. Ecol. Prog. Ser, 77: 183-196.

R/V KNORR Febrruary 22, 2003.
Winter Adriatic Sea cruise
January 1 to February 24, 2003
Project: Adriatic circulation experiment – mesoscale dynamics and response to strong atmospheric forcing.
Principle Investigator: Craig M. Lee

REPORT

Parameter: Distribution of phytoplankton abundance and taxonomy
Participants: Damir Vilicic, Ivona Cetinic, University of Zagreb, Division of Biology, Rooseveltov trg 6, 10000 Zagreb, Croatia

Scientific goal and hypothesis:

Each water mass in the oceanic system has characteristic composition and abundance of phytoplankton. Distribution of phytoplankton is influenced by the dynamic of water masses. The physical structure of a shelf sea front controls associated biochemical gradients. From the mid-1970s, alongside the physical oceanographic studies of fronts, it was recognized that enhanced levels of phytoplankton biomass were often seen in the frontal surface water. The availability of satellite remote sensing of surface chlorophyll now provides dramatic evidence of these frontal accumulations of phytoplankton.

Our field of interest in the project is:

A) to define possibly three phytoplankton assemblages, which we expect to exist during the cruise: first one in the less saline and colder water mass to the north of the Istrian front (in the northernmost part of the Adriatic), second one to the south from the Istrian front (in the northwesterly ingoing current along the eastern Adriatic coast) and the third one in the coastal Kvarner region;

B) to find out differences in phytoplankton composition and abundance along cross sections and throughout the water column of:

1) the **Istrian front** (SE of the Istrian peninsula) (February 12 – 13, 2003),
2) the **River Po front** (area of Rimini) (February 2 – 3; 15 – 18, 2003),
3) the **River Po plume** (February 2, 2003); Venice profile (February 18 – 19; February,21, 2003),
4) **Longitudinal Adriatic profile** (February 3 – 5, 2003),
5) the **Jabuka Pit** section (middle Adriatic depression), from Italian to Croatian side (February 5 – 9, 2003).

Methods:

Distribution of water masses and position of fronts were determined by satellite imagery and continuous measurements of temperature and salinity (by undulating sensor profiler). Water samples were taken 1) at the surface, using bucket at half an hour frequency, along sections of interest, and 2) throughout water column using rosette sampler.

During the February 2003 Knorr cruise, we collected 171 phytoplankton samples: 119 from the surface, 49 during water column sampling and 2 net samples (Tab. 1, Fig. 1).

Table 1. Number of phytoplankton samples and dates

Profile	Number of samples collected exclusively at the surface	Number of water column samples	Net samples	Date of sampling (February 2003)
Senegalia - Susak	0	0	1	01
Pula – Rimini	14	0	0	02
Rimini – Po	8	0	0	02
Po – Mirna (Novigrad)	12	0	0	02 – 03
Longitudinal profile (N. Adriatic – Jabuka)	16	9	0	03 – 05
Jabuka Pit	14	21	1	05 - 09
Istrian front	26	19	0	12 – 13
River Po front	22	0	0	15 – 18
Venice profile	6	0	1	18 – 19
River Po plume	0	17	0	21
TOTAL	**118**	**66**	**3**	

The oblique net hauls (53 µm pore size) were performed in the surface (upper 50 m) layer. Net samples will be used for qualitative expertise of microphytoplankton.

Phytoplankton samples were conserved with 2 per cent formaldehyde (final concentration). Subsamples of 50 mL will be prepared for microscopy, after 24 hours sedimentation. The counting will be performed by the standard Utermohl method, using Zeiss Axiovert 200 inverted microscope, using phase contrast, within one month after the cruise. Cells longer than 20 µm will be designated as microphytoplankton, cells 2–20 µm as nanoplankton. Cells will be counted at a magnification of 400 X (one transect for more abundant microphytoplankton and less abundant nanoplankton) and 200 X (transects along the rest of the counting chamber base plate, for less abundant microphytoplankton). Abundant, recognizable nanoplankton (cryptophytes, small dinofalgellates, small coccolithophorides and larger chlorophytes,) cells will be counted in 20 randomly selected fields of vision along the counting chamber base plate, at a magnification of 400 X.

Expected results:

We shall present horizontal distribution of phytoplankton (different taxonomic groups and size fractions) along the trophic gradients and around northern Adriatic frontal zones as well as along the Jabuka Pit transect. At hydrographic stations, vertical distribution will be presented. At the Istrian front, we shall try to use phytoplankton (and particular taxa) as tracers of different water masses that participate in formation of deep water during strong bora cooling. The same could be done along transects traversing veins of water masses of different origin.

Cruise Report for 31 Jan - 24 Feb, 2003

Clive Dorman
Scripps Institution of Oceanography

1. Scientific Goals

A major goal of this project is to investigate the marine boundary layer during the high speed, cold air, "Bora" wind blowing off Croatia. The structure of the gusts and the depth of the marine layer are of especial interest. Related to this is the quantification of the heat flux and its role in maintaining the atmospheric boundary layer.

Another goal is to establish the low level mesoscale meteorological conditions during the Bora wind events. The measurements made on the KNORR will help establish conditions over water that will be made in conjunction with automated meteorological stations on Italian Gas Platforms and land stations.

2. Methods

To measure the heat flux and basic meteorological conditions, an automated meteorological station was set up on the KNORR forward mast Included is a sonic anemometer that will sample at one second intervals to capture the wind gust variations which are believed to be unique with the Bora. The other sensors (air temperature, humidity, short and long wave radiation) will be used to construct the heat fluxes and stress from bulk formulas.

A ceilometer is being used to measure the cloud base height. This is partly an experiment to see if this device can produce useful information on the clouds and marine layer depth while at sea.

3. Installation

Scripps Engineer Doug Alden installed the basic meteorological system on the RV KNORR at WHOI in December and finished while it was in port at Ancona, Italy. This way the sensors would start fresh in the Adriatic and avoid the ware experienced by crossing the Atlantic. This automated meteorological station was installed on the forward mast (Fig. 1). Air temperature, humidity, pressure, long and short wave radiation data were logged in a special logger on the yard arm. The sonic anemometer was connected via a ship cable to the dry lab where the one-second data was logged on a laptop.

A Handar 450 B ceilometer was mounted on top of an after observation cabin (Fig. 2). This was connected by direct cable to the data logging laptop computer in the dry lab.

Unfortunately, the downward longwave sensor quit before the RV KNORR cast off from Ancona. The wiring was checked twice but no fault could be found. The cause could not be determined.

The sonic wind sensor stopped reporting for about 12 hours on one light wind day early in the cruise. A ships technician climbed the forward mast to check on the sensor, but no fault could be found. Later that same day, it spontaneously started and reported properly for the rest of the cruise.

4. Preliminary Results

At times there is a marine boundary layer over the Adriatic that is intensified with subsidence and capped by an air temperature inversion. The setting sun can help to make this layer visible (Fig. 3). Early in the cruise, there was a light Bora with unstable conditions over the Adriatic. These unstable conditions generated showers in a squall line with water spouts extending from the cloud base to the sea surface (Fig. 4). Under stable conditions, a Bora will clear the sky over Croatia and nearby coastal water, forming a sharp cloud edge (Fig. 5).

The major meteorological target is the moderate to strong Bora wind regime. A partial Bora was experienced on the first day of the cruise (1 February). A second Bora event occurred 11 - 13 February. The extreme Bora gusts were observed during both of these. After run -up the wind speeds for about 20-30 seconds, it died down quickly to half the maximum value for another 20- 30 second. Several light wind Bora's also occurred during the cruise.

Heat flux on the strong Bora of 11-13 February clearly was extreme with wind speeds reaching 20 m/s, moderate humidity of 56 % , air temperature at 3o C and a sea temperature of 11.6 o C. In addition, the Bora has jet maximums that extend out over the Adriatic and are set by the topography. The KNORR was mostly in the Bora jet extending from the Croatian coastal town of Senj.

The KNORR wind measurements may be compared with the Croatian "Aladin" mesoscale meteorological model simulations and forecasts. A Bora example is on 11 February when the KNORR steamed from south to north along the Croatian coast. The ship winds are shown along the cruise track in Fig. 6. The two digit numbers to the right of the track is the UTC time. Initially at 00 UTC, the KNORR mesasued winds were moderate off Sibenik and then weak along the rest of the coast until reaching the Senj area where the winds were strong. The Aladin model analysis and forecasts at 6 hourly intervals are shown in Figs. 7a-d. The model analysis at 00 UTC correctly has moderate winds off Sibenik . However , the model has strong winds developing by 06 UTC off Zadar which was not observed. The model does correctly forecast stronger winds off Senj at 12 UTC and 18 UTC which was observed by the KNORR on the northern end of its track. The model forecast maximum winds of 17 m/s off Senj which were a little under the ship measured values of 20-23 m/s. Overall, the Aladin model does a realistic job simulating the surface wind fields along the Adriatic.

Figure 1. Meteorological sensors on forward mast arm. The sonic wind sensor is the third sensor right side. The cup and vane devices on both ends of the arm belong to the KNORR.


Figure 2.   The ceilometer is the 1.2 m high gray, rectangular box on top of an observation cabin.

Figure 3. The shallow marine layer over the Adriatic is made visible by the setting sun.

Figure 4. Instability over the Adriatic causes heavy showers and water spouts. The finger of cloud extending downward into the light area in the lower center is a water spout that touches the sea surface.

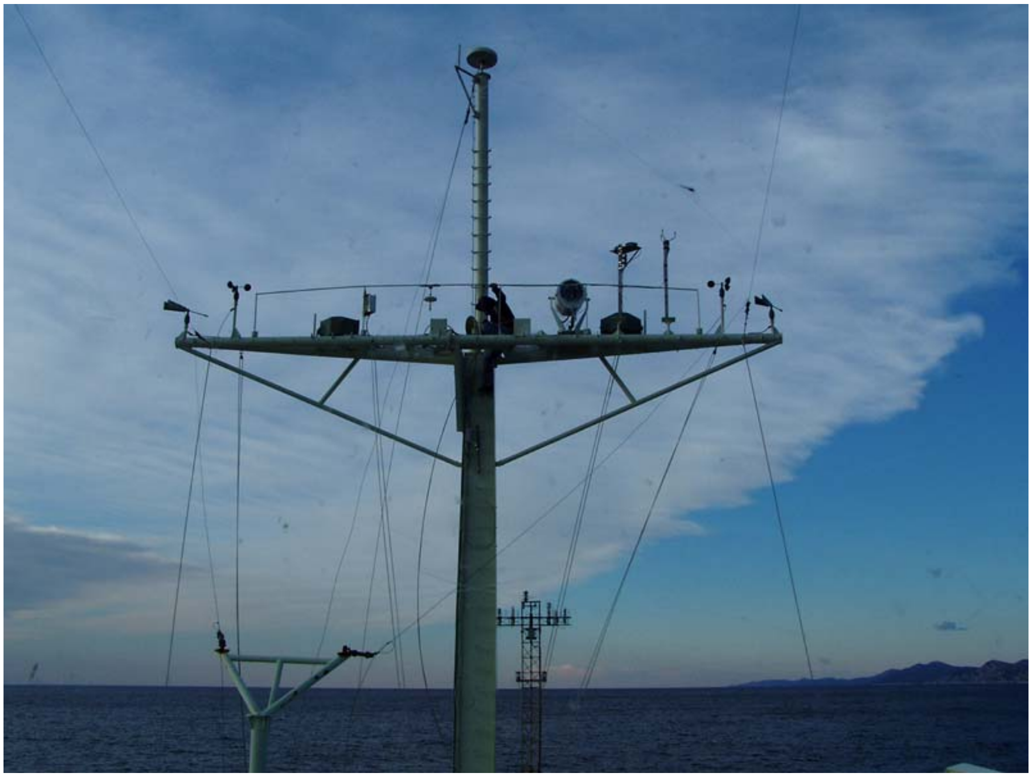

Figure 5. The sharp cloud edge with clearing on the right over Croatia is due to a weak Bora wind pushing offshore and subsiding.

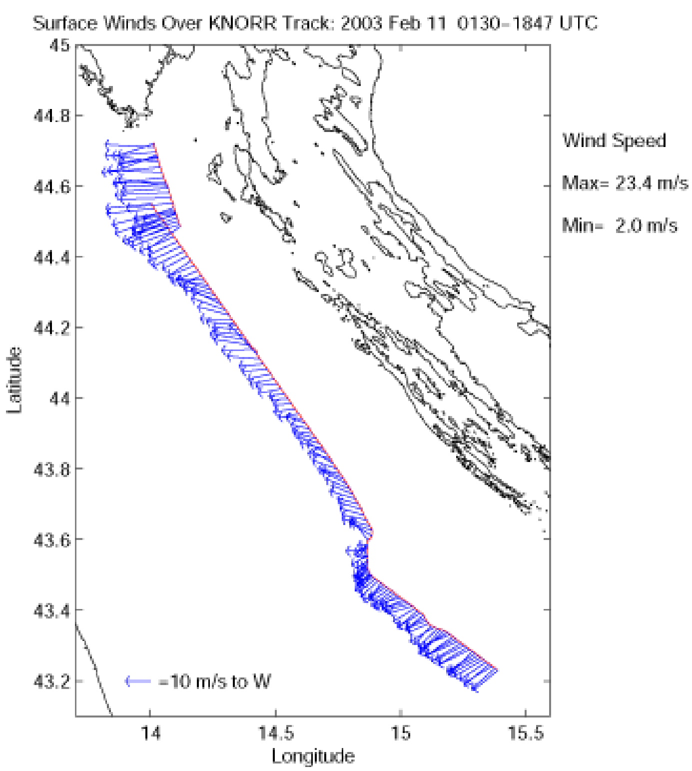

Figure 6. KNORR ship track and measured winds during a Bora event on 11 February 2003. Numbers to the right of the track is the UTC time.

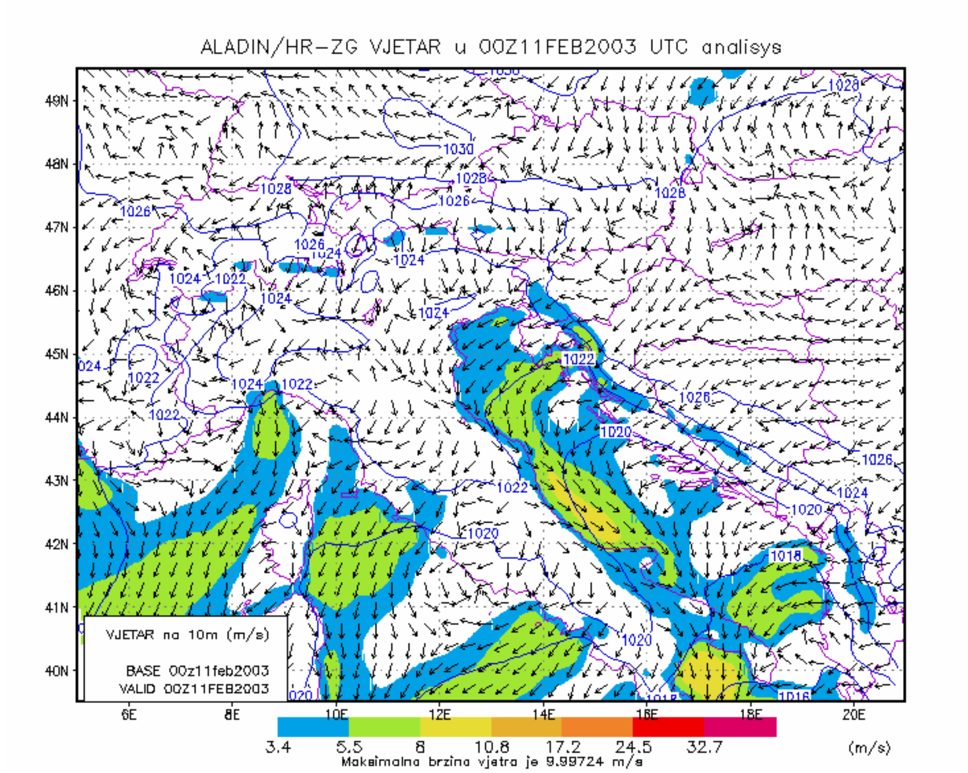

Figure 7a. Croatian Aladin model analysis of 10 m winds at 00 UTC 11 February 2003.

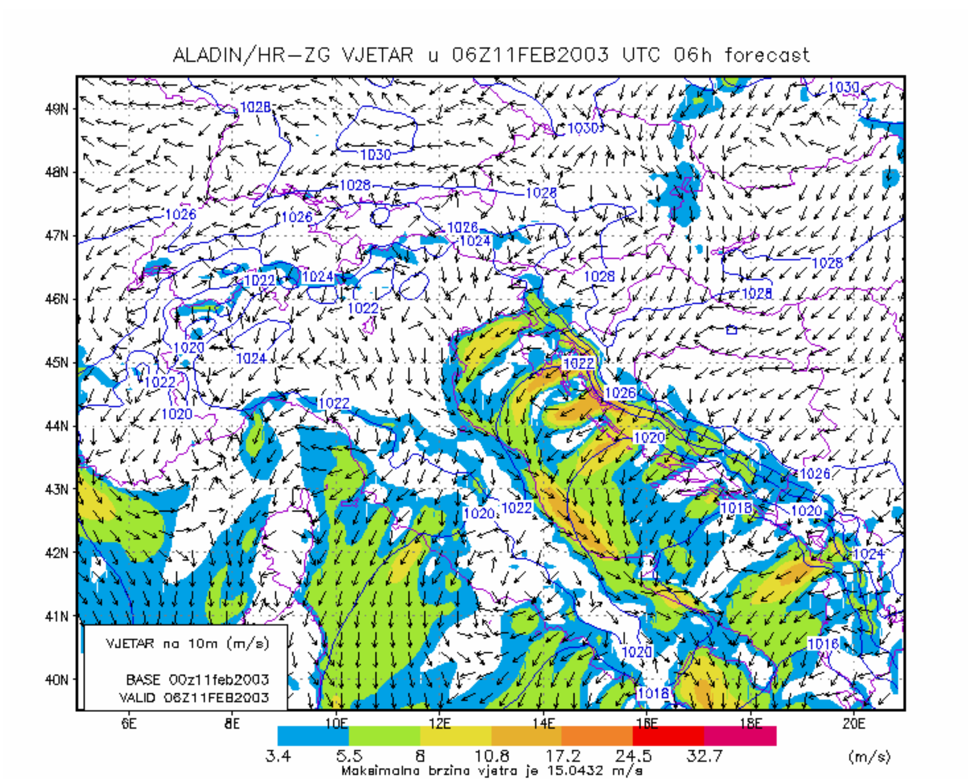

Figure 7b. Croatian Aladin model analysis of 10 m winds at 06 UTC 11 February 2003.

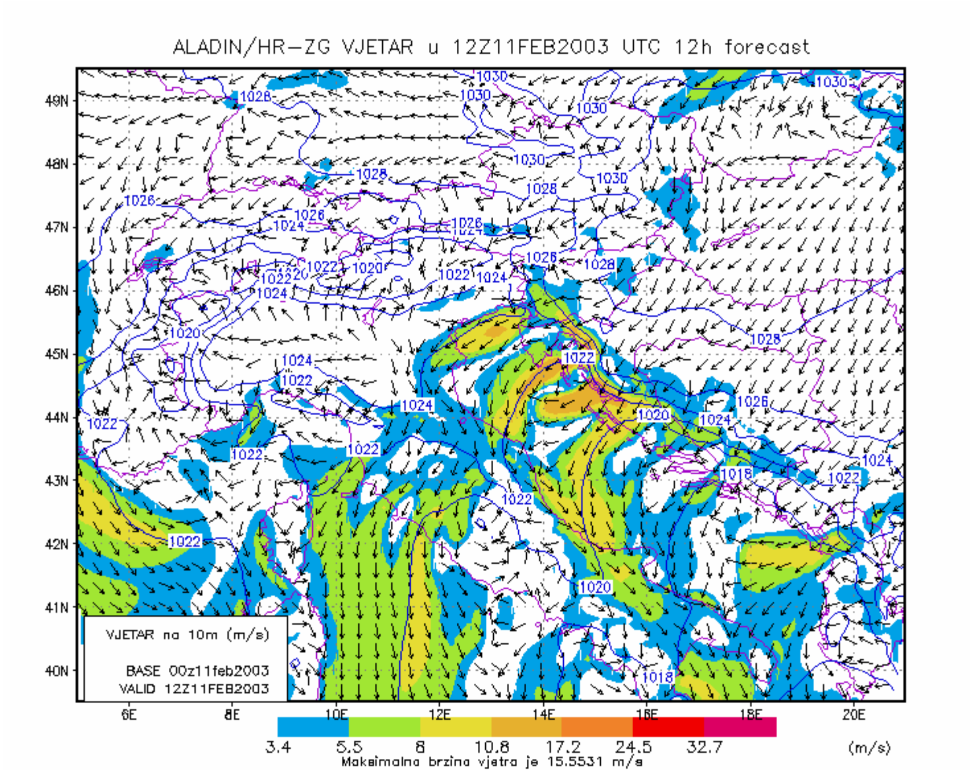

Figure 7c. Same as for 7b but at 12 UTC.

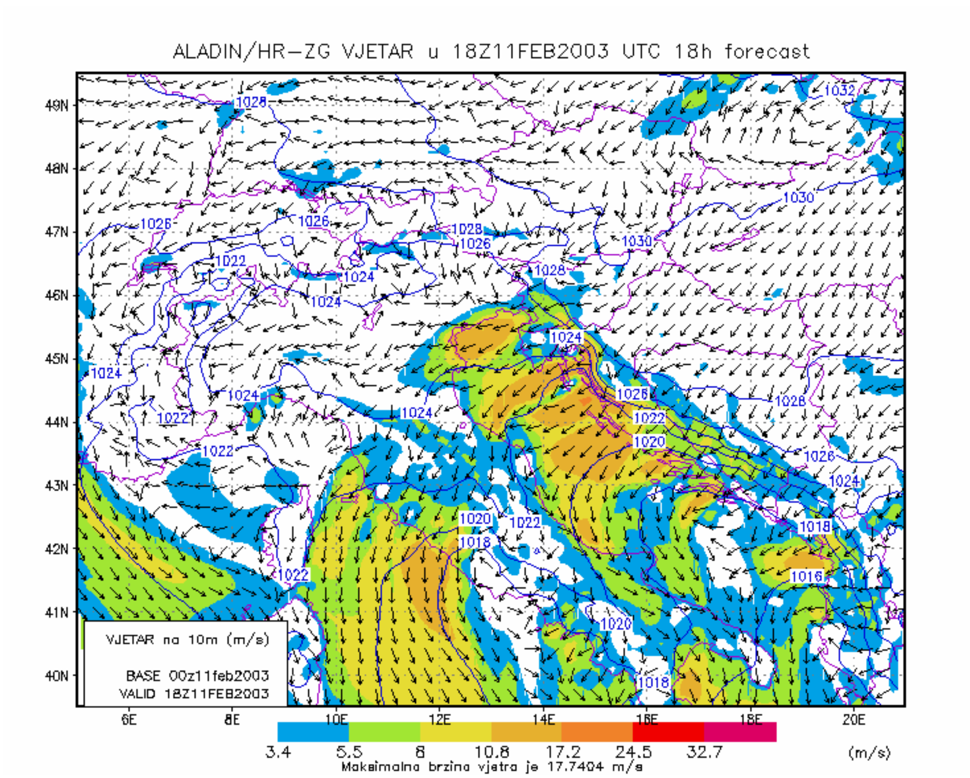

Figure 7d. Same as for 7b but for 18 UTC.

Weather forecasting on board of the KNORR during DOLCEVITA 1 from Jan. 31th to Feb. 24th 2003

R/V KNORR, Adriatic Sea Feb 22th, 2003

Dietmar Thaler, Austrian Military Weather Service
Wetterberatungsstation, A-8911 Aigen im Ennstal
E-mail: wbs_a1@oebh.at or dietmar.thaler@telering.at

1. Problem

Why weather forecasts?

Dolce Vita 1 was focused on getting information about the response of the Adriatic sea to atmospheric forcing. The reaction of the northern Adriatic sea to strong wind events such as Bora were of special interest. The appropriate meteorological advice was necessary for the one to three day in advance planning to get to the most interesting sites. A shorter time range (less than 12 hours) turns out to be not of special importance because of the inertia of both the sea and the research vessel to faster changes in space and time.

Usual operational environment of a modern forecasting station

Modern weather services that cover all aspects of weather forecasting from nowcasting (0-6 hours) to middle range forecasting (5 to 10 days) are heavily relying on real time access to classical observational data (surface, soundings), to remote sensing data (satellite images, weather radar data) and to many fields of different types of numerical weather prediction models (mesoscale nested models for day 0 to 2, global models for day 2 to 4, ensemble forecasts for day 5 to 10). The daily data flow is measured in gigabytes.

Expected Environment on board of the KNORR

Quite early during the planning phase it became obvious that data connection facilities on board R/V KNORR cannot manage this huge amount. For economic reasons an affordable data flow is limited to the order of magnitude one megabyte per day, that is 0.1 % (!) of the usual amount.

For this reason one definitely could not think of nowcasting which is very data expensive (frequent satellite images, radar data, ...). But with assistance from land based expert there is a good chance to meet the planning demands, say forecasts within a time range of 12 to 72 hours (half a day to 3 days), especially if they mainly restricted to one weather element (wind), whereas other weather elements (cloud, precipitation, temperature) are of minor forecasting interest for the oceanographers.

2. Preparation

To do any forecasting both analysis and observational data as well as forecasted fields are needed. Some of this material is freely available at the Internet. But especially high quality material such as fine meshed limited area models for short range forecasting (12 to 48 hours) and ensemble prediction fields for middle range forecasting (4 to 10 days) are only accessible via an professional public weather service. Gratefully, the Hydro meteorological Institute of the Republic of Croatia (DHMZ) in Zagreb was fully cooperating. They made available a huge amount of different forecast material covering:

- local analysis and observational data from the surroundings of the Adriatic (weather maps and rawinsounds)

- European wide analysis data (surface and upper level charts) from the DWD (Deutscher Wetterdienst)

- Meteosat IR-Images

- The Croatian operational model run of Aladin/Hrvatska with several fields and meteogramms

- DWD forecast maps for several fields of the global GME-Model

- ECMWF forecasts of the operational middle range model with several fields

- ECMWF Ensemble Prediction System (EPS): fields of probability density of thresholds of different quantities (wind, precipitation, temperature).

The access was possible by http/ftp-protocol from a password protected server with an periodical update. No data were kept longer than 24 hours on the server until they were overwritten by new ones.

Freely available Internet forecast products are not necessarily of lower quality. Especially the GFS (Global Forecasting System?) model by the American National Weather Service performs very well. Each six hours there is a new update available with the most recent analysis. It is available at one specially designed for European purposes at www.wetterzentrale.de by Georg Mueller, and is most conveniently accessible at www.westwind.ch by Markus Pfister. Some of this models fields were regularly used.

Before the beginning of the cruise the available data base was well stocked. Also DHMZ agreed in daily phone calls between the KNORR forecaster and the DHMZ forecaster in duty. Additionally Dr. Vlasta Tutis of DHMZ promised to send from Monday to Thursday a weather outline emphasizing on a middle range outlook based on ECMWF-EPS.

3. Performance

Data acquisition

Operational forecasting began on 2003-Jan-30 after the forecaster having arrived in Ancona. Fortunately there was at the beginning and on the day of departure at Jan 31 the chance for rather comprehensive data downloading via a broad band Internet access at ISMAR-CNR (Marine Science Institute of the National Research Council) at Ancona. A very comprehensive data set was available.

On the KNORR until Feb 13 there was the opportunity of a rather fair data download in the radio office via Nera Fleet 77/Xanthic high speed satellite connection with direct Internet access. This nice and convenient way ended rather abruptly when the download costs became obvious (about $ 130.- per 20 minutes Internet connection time).

From Feb 14 onwards a data pipe was installed via the Seanet system. A cronjob setup by John Dunlop at APL/Seattle retrieved a very small data set via ftp (actually wget) and sent it to a WHOI/Woodshole server, from where it came to KNORR. The data pipe was closed on Feb 22 and so operational forecast ended with the same day.

Phone calls were uncomplicated as long as there was reasonably good cell phone contact. The satellite system was a bit unreliable for calls to Croatia, but at the same time it did well with Austria (who knows why).

Forecast schedule

After some initial spin up a rough schedule was established:

0830-0900: data retrieval

0900-1000: raw data were put to KNORR/WHOI server "mike" without comment accessible via www.knorr.whoi.edu/wxdata/start.html (within an HTML-framework)

1000-1100: preliminary written forecast put in the net

1200-1300: Mon to Thu weather e-mail by Vlasta Tutis

1300-1500: phone call to DHMZ Zagreb (via cell phone or satellite communication IMARSAT), alternatively, when no connection to Zagreb could be set up and if necessary a phone call to the military weather center Austria.

1400-1500: final written forecast (detailed forecast for day 0 to day 2 with a further outlook for at least d3 to d4/d5; probability forecast table for certain weather events for day 0 to day 3) put in the ship net

1900: oral briefing at science meeting (occasionally with some animated weather charts)

Direct weather information was given to the chief scientist and whoever was interested at any occasion.

Typically available weather information:

Following material turned out to be a reasonable minimum to meet the accuracy purposes for experimental planning:

- Daily Surface analysis with fronts and isobars (e.g. by DWD from 00 UTC)

- Analysis of 500 hPa geopotential (e.g. GFS 00 UTC)

- Daily Meteosat IR satellite image (covering the whole of Europe)

- Aladin surface wind maps (Analysis 00 UTC to forecast +48 hours in 6 hours distance)

- 24 to 36 hour surface forecast Europe (consistent with the Analysis, e.g. DWD d+1, 12 UTC)

- Wind forecast charts for the next few days (global model, e.g. GFS surface Wind +36 h, + 60 h, +84, +108 h)

- 500 hPa geopotential and surface pressure for, say, until 1 week in advance (e.g. GFS d+1 to d+9 forecast).

- precipitation fields for about 1 week in advance to be watch for a possible heavy precipitation event that influences the behavior of the Adriatic sea (e.g. GFS d+1 to d+9 forecast).

Some additional maps had been of advantage for down scaled planning, e.g. the Aladin wind forecasts for a special target area (Senj,..) and related information (e.g. wave heights by an ECMWF driven model turned out to be reasonably well during the longer fetch of Jugo or Tramontana. It performed poorly during Bora).

It must be mentioned that the Wind forecasts by Aladin were of a rather good quality. As far as can be seen now the major features of the Bora wind field were met. Also, the over all performance of global GFS model was quite satisfying.

Less data than outlined above would only be sufficient if no major surprise can be expected during a very stable conditions (which actually is to be known only afterwards).

As can be seen by the attached figure (wxdownload.ps) the (estimated) daily download rates changed several times due to changes in the download system. The initial peek dropped to about 1.5 to 2 MByts per day as long as the Nera Fleet 77/Xantic-Satellite Internet connection could be used. This data amount is about the minimum for responsible forecasting as long as not to many weather elements are to be covered.

After Thu 13 Feb the quote sank to about 750 kByte. That's the lowest provided there is slowly changing calm and relatively quiet weather.

The final drop to an almost zero data rate (only very few and coarse maps of the British "Fleet weather and oceanographic center, Nortwood, England" via long wave transmission) was a quite definitely too little.

4. Conclusions

Weather forecasting on board of a research vessel by an forecaster is suffiecient provided

a) careful preparation in cooperation with a public met. service,

b) reasonably fast and safe electronic data link (to the www),

c) a land based expert for oral communication and

d) a reliable phone connection.

During Dolce Vita 1 conditions a) and c) were fully met and condition d) was reasonably well met. Deficiencies were experienced in condition b).

Outlook for Dolcevita 2:

Dolcevita 2 is going to happen at the end of May and the beginning of June. This means for the Adriatic generally a less stable weather situation that is probably effected both by mesoscale convective systems as well as by mid latitude moving disturbances. The predictability of the atmosphere is generally lower partly because of the weaker northern hemispheric latitudinal gradients. Therefore more emphasis should be made on additional forecast charts concerning vertical stability and atmospheric humidity. The overall meteorological data is expected to increase.

Appendix:

1. The full set of of forecast charts together with a html wrap around is delivered at "/data/images/wxdata@mike". For 30 Jan until 02 Feb only forecast chart are available (forecasts were given orally). From 03 Feb to 07 Feb at least one daily written forecast is available as file "dv_fcst????.html". From 08 until 22 Feb there is full html support to the main products. More weather charts are eventually available in the directories of the form "dvyyyymmdd", were yyyy,mm,dd denote year, month and day.

2. A daily outline of general synopsis and a short weather description will be delivered later.

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As part of the Office of Naval Research sponsored DOLCE VITA (Dynamics of Localized Currents and Eddy Variability in the Adriatic) program, a team of U.S., Italian, Croatian and Austrian investigators conducted two research cruises in the Northern Adriatic Sea designed to investigate mesoscale and submesoscale response to intense, small-scale Bora wind forcing and buoyant riverine discharge. A winter cruise (February 2003, R/V *Knorr* 172-03) observed the response of the largely unstratified northern basin to Bora forcing, which extended over the entire duration of the measurement program. Winter sampling centered on quasi-synoptic, three-dimensional surveys of physical and optical properties conducted using a towed, undulating profiling vehicle (TriSoarus). Additional measurements were made using a bottom-moored five-beam Acoustic Doppler Current Profiler, a free-falling microstructure profiler, surface drifters and conventional hydrographic sampling. Dedicated synoptic meteorological forecasts allowed us to focus wintertime sampling efforts on mesoscale features during periods of intense forcing. The summer cruise (May–June 2003, R/V *Knorr* 172-11) sampled during a period of weak winds and anomalously weak river discharge. This report presents preliminary results from both field efforts.

14. SUBJECT TERMS
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